Huawei Singapore

Response to the IMDA Consultation paper:

"5G MOBILE SERVICES AND NETWORKS"

FOR THE ATTENTION OF:
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Summary

Huawei welcomes the opportunity to comment on this important consultation paper "5G Mobile Services and Networks".

Huawei is in the view that 5G will need spectrum from below 1 GHz, 1-6 GHz as well as above 6 GHz frequency bands to support various new service and applications. We share the IMDA's view on the Estimated Deployment Phases as provided in Figure 3 of the consultation paper for the Singapore market. We appreciate the efforts of the IMDA and the Singapore administration in making spectrum available for mobile communications. We support the IMDA to continue the process to release new frequency bands for 5G deployment, in particular the extended C-band, the L-band and the millimetre wave bands.

This response document contains two parts:
Part I: Huawei's response to the questions of the consultation paper
Part II: brief introduction to Huawei Singapore and Huawei's activities on 5G development

If the IMDA requires any clarification to Huawei response, please do not hesitate to contact:

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Part I

5G Technology and Use Cases

1) *IMDA would like to seek views and comments on the estimated timeline for the deployment of 5G. Besides ensuring that spectrum is made available in a timely manner, what other regulatory measures could assist in facilitating the deployment of 5G technology and applications? What other use cases should IMDA take note of when developing the regulatory framework?*

Huawei's comments:

The Figure 3 in the consultation document provides a good estimation of the deployment phases that would be adopted in Singapore market.

- Technologies supporting applications of Internet of Things, such as NB-IoT, are being deployed now.
- The first release of 3GPP 5G standard (Rel-15) is scheduled to be finalised by June 2018 including both standalone and non-standalone 5G New Radio (NR) specifications. The deployment of 5G NR network will follow soon after that, starting from frequency bands below 6 GHz, such as 3.4-3.6 GHz. Availability of 700 MHz band before year 2020 is important for provision of 5G services with wide coverage as well as to support massive machine type communications (mMTC). MNOs may deploy either evolution of LTE-Advanced or 5G NR technology on the 700 MHz band.
- WRC-19 (Oct. 2019) will make regulatory decisions under the Agenda Item 1.13 on which frequency bands in portion(s) from 24.25 GHz to 86 GHz are identified for IMT-2020. 5G eco-systems of millimetre wave (mmWave) bands are being developed now to support early deployment from year 2018 in some leading markets. Starting to deploy mmWave 5G system after year 2020 can enable Singapore to take the advantage of the WRC-19 decisions and benefits from global and regional harmonization of mmWave bands for 5G, the established eco-systems, and experiences from leading markets on regulatory, technical, operational and business aspects of 5G on mmWave bands. As always, investment in network development highly depends on market demand.

In addition to timely availability of spectrum for 5G, it is also important for IMDA to develop national 5G policy that promotes and guides Singapore's 5G networks and services development.

2) *To facilitate and understand potential spectrum requirements for IoT deployments in Singapore, IMDA would like to seek views on the following:*
   i) *Based on the current spectrum allocated for mobile services in the sub-1 GHz frequency bands, are there further suitable spectrum resources that could be released to support both IoT and LTE services?*
   ii) *How will future generations of mobile networks (e.g. high capacity, low latency) support the growth of IoT and what would be the spectrum requirements?*

Huawei's comments:

The sub-1 GHz spectrum is important for low power wider area IoT applications to provide coverage over long

distances and deep penetration. The cellular IoT technologies (e.g. NB-IoT, eMTC) can be deployed on IMT frequency bands, e.g. on guard-band, in-band, or as a stand-alone network.

i) The NB-IoT operating bands specified in 3GPP[1] are as below:

NB-IOT Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	HD-FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	HD-FDD
5	824 MHz – 849 MHz	869 MHz – 894MHz	HD-FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	HD-FDD
12	699 MHz – 716 MHz	729 MHz – 746 MHz	HD-FDD
13	777 MHz – 787 MHz	746 MHz – 756 MHz	HD-FDD
17	704 MHz – 716 MHz	734 MHz – 746 MHz	HD-FDD
19	830 MHz – 845 MHz	875 MHz – 890 MHz	HD-FDD
20	832 MHz – 862 MHz	791 MHz – 821 MHz	HD-FDD
26	814 MHz – 849 MHz	859 MHz – 894 MHz	HD-FDD
28	703 MHz – 748 MHz	758 MHz – 803 MHz	HD-FDD

The Band 8 and Band 28 have been assigned to MNOs in Singapore (noting that Band 28 the 700 MHz band is not yet available to MNOs), and NB-IoT can be deployed on these two bands by reusing LTE network infrastructure. It's also noted that the 800 MHz band is considered by IMDA for mobile (expected for 2021), which may also be used to support IoT applications using cellular IoT technology but 3GPP will need first to address the use of this spectrum.

ii) It is expected that the cellular IoT technologies (e.g. NB-IoT) will play a more and more important role in supporting IoT applications in the coming decade; it is capable to fulfil the market demand in coming years. Nevertheless it's expected that 5G use cases with higher demands than what is achievable today, e.g. higher data capacity, higher data rate, lower power consumption, and more link budget by multi-hop communication, will appear on the market some years in future; the specific technical requirements and potential technologies are being considered in 3GPP. It is also expected that spectrum demand of IoT applications will increase, and may increase a lot after early years of successful NB-IoT business.

3) IMDA would like to seek views and comments from industry on what they consider will be the key technologies for 5G and whether current regulatory frameworks sufficiently facilitate the deployment of such technologies.

Huawei's comments:

5G is expected to support a number of new applications and technologies, such as massive MIMO, IoT, network slicing, mmWave and vehicle communications. Additional regulatory efforts may be required in order to enable deployments of the new technologies. For examples:

- IoT device management;

[1] TS36.802 v13.0.0, http://www.3gpp.org/ftp/Specs/archive/36_series/36.802/36802-d00.zip

- acquisition of small cell sites;
- additional regulation for vehicle to vehicle communication system;

It is expected that 5G will adopt additional new technologies in its life-time which is expected to be longer than 20 years; and 5G networks will support new applications that we have not imagined today. Those new technologies and new applications may require additional work on regulatory aspect.

In case of Singapore, there are some challenges for 5G indoor scenario. As we know now indoor coverage is mainly supported by combined antenna system (CAS) with single-in-single-out (SISO) technology which cannot smoothly evolved to 5G. Obviously now we have to consider how indoor network should evolve to 5G that needs to support massive MIMO.

5G will be deployed on multiple frequency bands, e.g. 700 MHz, the L-band, the extended C-band and mmWave bands. As of today, a rooftop site of one operator's may have 6 antennas; and the number of antennas goes much higher if four operators share one site location. Multi-band antenna is therefore necessary for 5G. However, the antenna height of most multiband antenna is more than 2 meters which is higher than the 1.5 meters – the maximum value in HDB scenario. We recommend IMDA to review the related regulation to enable innovation and to facilitate 5G deployment.

Below 1 GHz Frequency Bands

4) IMDA would like to seek views and comments on whether going forward, there is a need for further spectrum below 1 GHz to be identified and release for mobile services?

Huawei's comments:

Huawei supports IMDA's plan to re-farm 800 MHz band and then to release to MNOs using one or combinations of the 3GPP band plans (i.e. band 5 and band 27, or band 26). In addition, the 600 MHz band is being considered for mobile service by some countries in APT as well as in Region 2. Several countries joined the footnotes during WRC-15, and AWG is now developing a frequency arrangement for this band. In the U.S. 600 MHz will be commercialized for MBB around year 2020. We recommend IMDA to put the 600 MHz band in its long term planning for mobile service.

1 – 6 GHz Frequency Bands

5) IMDA would like to seek views and comments on following:

i) The frequency arrangement that is better suited for adoption in Singapore for the L band (i.e. SDL, TDD or FDD) and the supporting reasons; and

ii) The timeline for access to the L band and the availability of the equipment (specifically whether it will be available earlier or later than 2020).

Huawei's comments:

i) For Singapore, we believe that SDL band plan would be the best solution when the L band is combined with 700 MHz band or other bands below 1 GHz. This indeed would enable operators to use the full L-Band capacity for downlink transmission while taking advantage of: (1) the under used uplink capacity in lower bands (below 1GHz) and (2) the extended UL coverage of band below 1GHz (700, 800, 900MHz). SDL is a good solution for asymmetrical traffic. It optimizes the spectrum use efficiency as it does not waste spectrum for duplex gap as needed by the FDD option.
From ecosystem perspective, Singapore can benefits from the economy of scale of L-band development in Europe. The sub-band 1452-1492 MHz (3GPP band 32) is already harmonized in Europe for SDL (with EC and ECC decisions). It has been auctioned in several European countries. Base stations and user equipment are already available in the market. Europe will soon finalize the SDL frequency arrangement for the extended L-Band 1427-1517 MHz (1517-1518 MHz is a guard band), for both 4G and 5G (technology neutral). Final approval of the extended L band regulations is expected for Q4 2017. This will provide flexibility to operators to deploy such band either for LTE or 5G NR. Main European operators are strongly supporting specification of such SDL band in 3GPP.

ii) As indicated above, base stations and user equipment are already available for the sub-band 1452-1492 MHz, i.e. 3GPP band 32 for SDL. 3GPP is currently developing specifications for LTE SDL (90MHz and related carrier aggregation with 700/800MHz), LTE TDD (90MHz) and LTE FDD (2x43MHz) operation over the extended L-Band range (1427-1518MHz). The specification work is expected to finalize by Sep. 2017. The extended L-Band is also one of the 5G NR bands to be developed in Rel-15 (target completion June 2018). Equipment supporting the extended L-band will likely be available for regions interested in deployments before 2020, while this timeline is subject to R&D progress and market demand.

6) Considering the spectrum bands within the range of 1-6 GHz to support the deployment of enhanced mobile broadband services, IMDA would like to seek views on whether all of the 91 MHz of spectrum in the L-band should be allocated for IMT to address Singapore's data demand and growth.

Huawei's comments:

In order to meet the comprehensive requirements of 5G, including ultra-high capacity, deep coverage, ultra-high reliability, ultra-low latency, etc., operators would need spectrum from different frequency ranges, i.e. low frequencies (below 1 GHz, 1.4 GHz), medium frequencies (e.g. 3.4-3.6 GHz, 2.6 GHz, etc.) and high frequencies (mmWave bands). We believe that allocating all of the 91 MHz of spectrum in the L-Band to IMT in particular as SDL mode would be a great opportunity for operators in Singapore to deploy 5G services while offering the perfect mix of good deep coverage (Indoor, rural, etc.) and higher capacity.

7) If it is only the extended C-band that is considered for IMT, would the migration of existing satellite users to the other parts of the C-band (i.e. 3.7-4.2 GHz) impact their service provisioning?

Huawei has no comment.

8) Considering the challenges of co-channel deployment of FSS and IMT services in the extended C-band, IMDA would like to seek views and comments on the coexistence measures for adjacent bands and cross border operations.

Huawei's comments:

Most of the 5G leading markets consider a portion of C-band as 5G primary band. Considering that the extended C-band, 3.4-3.6 GHz, is identified for IMT in almost every countries of the world; and the adjacent bands 3.3-3.4 GHz and 3.6-3.8 GHz are available for mobile in a large number of countries, there is a great momentum to deploy 5G over this part of C-band. Many countries are working to make available 300-400 MHz contiguous bandwidth in C-band for 5G with a target of at least 100 MHz of contiguous spectrum per MNO within the 3.3-3.8 GHz range. 3GPP is studying 3300-4200 MHz and 4400-4990 MHz as 5G NR bands in Rel.15. A great momentum of 5G development over C-band can be observed today on policy, regulation, technology and ecosystem aspects, including migration of existing satellite users on extended C-band 3.4-3.7GHz to other parts of C-band.

The Global mobile Supplier Association (GSA) developed a white paper[2] on future IMT development over the 3300 to 4200 MHz band. The mobile manufacturers expect that 5G NR ecosystem for 3.3-3.8 GHz will be commercially ready in 2018.

Huawei strongly supports IMDA to make available the 3.4-3.6 GHz band in Singapore for 5G deployment as early as possible. This will allow Singapore to be in the first wave of 5G development of the world, with capability to support eMBB, URLLC as well as some mMTC applications, while taking benefits of the established ecosystem mainly driven by the leading markets.

For coexistence between IMT systems and FSS in adjacent band, those measures that work for co-channel coexistence can also be used, e.g. separation distance, sector disabling and multi antenna techniques. In addition, the suitable guard bands between IMT and FSS or suitable IMT spectrum emission mask can release the adjacent band interference. For the cross border coexistence between IMT and FSS ES, bilaterally negotiation and PFD limitation are relatively simple and effective ways to protect FSS earth stations.

We encourage IMDA to take actions to address the cross boarder co-existence concern and to pave the way for Singapore MNOs to use of the extended C-band for 5G.

9) IMDA would like to seek views and comments on whether there are other frequency bands in the 1-6 GHz frequency band that IMDA should consider for IMT / 5G.

Huawei's comments:

[2] https://gsacom.com/paper/future-imt-3300-4200-mhz-frequency-range

Other portion of C-band, e.g. the 4.8-4.99 GHz band, could be another potential band for 5G development. The frequency band 4800-4990 MHz was identified for IMT at WRC-15 for a number of countries in Region 2 and Region 3. ITU-R WP 5D is working on the technical and regulatory conditions for the use of IMT in this frequency band. China and Japan are planning 5G deployment on this band (in China it is 4400-4500 MHz and 4800-5000 MHz; in Japan it is 4400-4900 MHz). 3GPP is working on 4400-4990MHz band for 5G NR in Rel-15. We recommend IMDA to consider this band as a potential 5G band.

Above 6 GHz Frequency Bands

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

i) The role mmWave bands will play in delivering the vision of 5G, in particular, what services could not be delivered by alternative frequency bands and / or technologies;

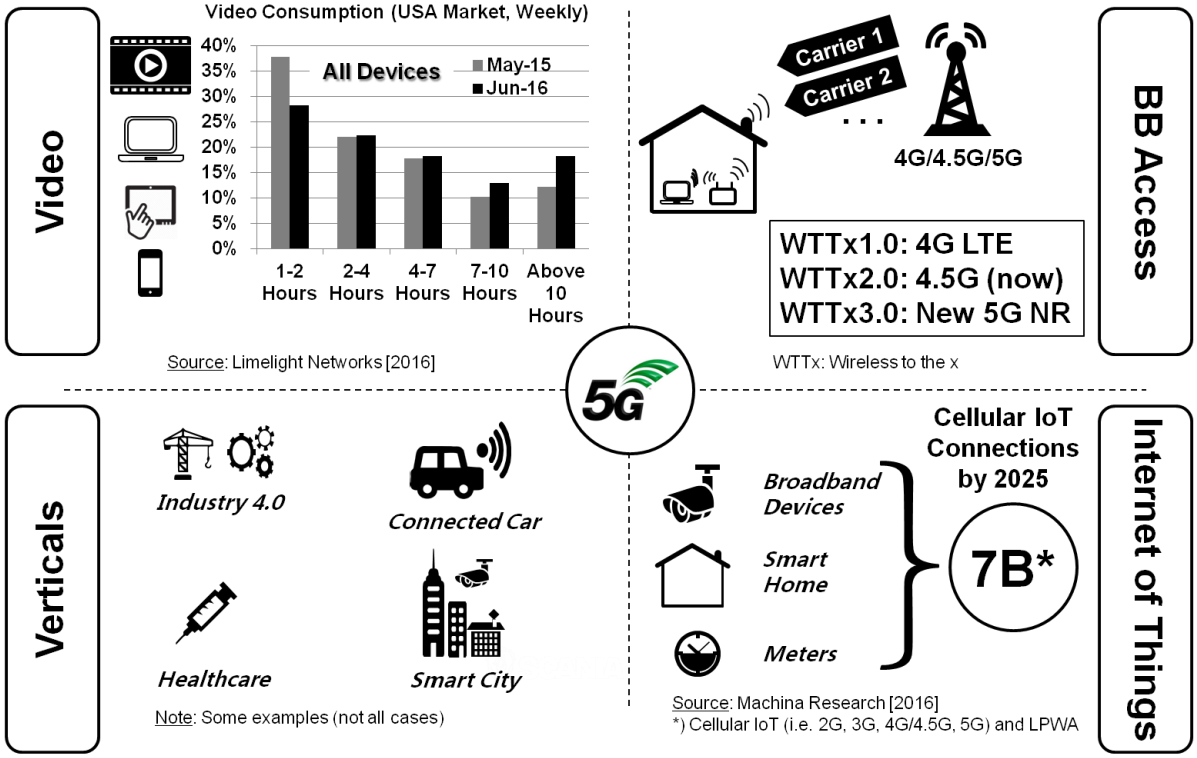
ii) The amount of spectrum required in the mmWave spectrum bands to meet 5G applications that will require higher bandwidths; and

iii) The specific mmWave bands that you consider should be a priority in Singapore for IMT services and why?

Huawei's comments:

i) ITU-R identified three usage scenarios for IMT-2020/5G (see Fig. 2 of the consultation document). The frequency bands below 6 GHz are of high value and recognized as "key" bands for 5G because of its capability to support all three usage scenarios and most applications of 5G. The mmWave bands are considered as important complement to the IMT bands below 6 GHz because of the very wide bandwidth that can support extremely high data rates required for some eMBB applications e.g. 10-20 Gbps peak data rate and 1 Gbps user experienced data rate.

Given the propagation characteristics of mmWave band, 5G systems working on mmWave band will be mainly deployed in hotspot and indoor scenarios. The Hetnet architecture is required in which radio system working on bands below 6 GHz provide coverage, service continuity and capacity while system working on mmWave bands provide extremely high data rate and capacity offloading. The mmWave bands will also be used for provision of wireless broadband (fixed wireless access) service. The wide bandwidth can support a "fibre-like" broadband access to homes, offices and other places, including those that are not connected by fibre. It is identified as one of four major 5G business pillars (see Figure below).



ii) Based on the ITU-R studies, the spectrum needs for mmWave could be up to 20 GHz[3] in order to meet the 5G ultra-high capacity requirement, and Huawei is of the view that contiguous bandwidth of 800-1000 MHz per MNO is necessary for the initial mmWave deployment. Large bandwidth is the unique merit of mmWave bands comparing with bands below 6 GHz; it would compensate its weakness of propagation characteristics. The 5G NR being developed by 3GPP will support a maximum carrier bandwidth of 400 MHz for mmWave bands, and but such carrier can be aggregated together to provide even larger contiguous bandwidths. The average throughput of 400 MHz bandwidth at 26 GHz is comparable with 100 MHz bandwidth at the 3.5 GHz band, but the coverage of mmWave deployment is challenging especially for the outdoor to indoor coverage, not to mention the transmission reliability given that mmWave is easily blocked by leaves, human bodies and etc. From this perspective, 800-1000 MHz bandwidth per operator, which could provide better performance than the extended C-band in the context of capacity, is the minimum bandwidth that will demonstrate the value of mmWave bands and incentivize MNOs to invest. Mobile communications over mmWave band is new; a successful initial phase of mmWave network operation including business aspect is very important to incentivise further investment. Moreover, a 5G NR system working on 800-1000 MHz contiguous mmWave band will have less complexity thus with less cost in comparison with working on two separate blocks of 400-500 MHz bands. Therefore, we recommend IMDA to make available at least 800-1000 MHz contiguous spectrum per MNO for the initial deployment of mmWave 5G system.

iii) 24.25-27.5 GHz and 37-43.5 GHz should be considered by IMDA as high priority mmWave bands for

[3] Spectrum needs and characteristics for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz, see an ITU-R TG5/1 document (R15-TG5.1-C-0036!!MSW-E)

Singapore. Because the eco-system for these two bands are being developed, and early deployment will be before year 2020. These two bands are within WRC-19 AI 1.13, and global harmonization can be expected.

28 GHz is another mmWave band for 5G. The ecosystem is driven by the USA, Republic of Korea and Japan targeting early deployment by 2020. An uncertainty of this band is that it is not included in the WRC-19 AI1.13, which may limit its potential to be a global or regional harmonized band for 5G.

The 31.8-33.4 GHz band is comparable with 26 GHz from the propagation perspective, but it faces certain issues as a candidate band for 5G due to limited amount of usable bandwidth given the requirement for compatibility with passive service on immediately adjacent band.

11) *Considering that there are 11 candidate bands under consideration at WRC-19, how would making available the 28 GHz band help in the deployment of 5G services in Singapore? Would this band play a significant role in achieving the targets set out for 5G (i.e. higher throughput, ultra-low latency)?*

Huawei's comments:

The development of 28GHz is pilot for the mmWave business. 28GHz will be the earliest commercialized band, and the eco-system is being developed now to provide the early deployments from year 2018 as driven by the USA, Republic of Korea and Japan markets. The eco-system, use cases and business models developed for 28GHz will accelerate the development of the other mmWave bands, especially the adjacent 26GHz. Along Europe and China's potential trial and commercialization on 26GHz before year 2020, the 5G ecosystem over 26 GHz would soon catch up. Given that Singapore considers to start mmWave deployment after year 2020 when the eco-systems of 26GHz and 28GHz are mature, so the best case is Singapore to consider 24.25-29.5 GHz in a whole to provide around 5GHz bandwidth below 30GHz to support the higher throughput.

However, as indicated by the consultation document, 28.5-29.5GHz is allocated to Fixed Satellite Service, while the mobile satellite user terminals are allowed in 28.6-29.1GHz but will mostly be confined to air platforms or vessels, it is highly related with WRC-19 AI 1.5 for ESIM development over 27.5-29.5 GHz.

When making a decision for the 28 GHz band, the above factors should be taken into account, in particular on the available bandwidth, the eco-system development, potentiality of global or regional harmonization, and Singapore's time line for introducing mmWave system and services.

Huawei launched a 5G field trial for the 28 GHz band in Shanghai with the purpose of technology verification. The test result is as following:

- 40+ Gbps user data rate at 1 GHz spectrum bandwidth
- 8 users with 16 layers

12) *If the 28 GHz band is opened for IMT services in Singapore, would there be any future competing services that may be deployed in this band which may cause interference issues?*

Huawei has no comment.

Future Spectrum Estimation

13) IMDA seeks views and comments on the estimated spectrum demand of 3360 MHz by 2025 and whether this estimate is realistic?

Huawei's comments:

The spectrum demand of 3360 MHz for year 2022 seems realistic; however, the value might be conservative for year 2025. It's expected that 5G deployment will gain considerable scale in developed markets at around 2022 in particular on bands below 6 GHz. The mobile data traffic by year 2025 is expected to increase a lot from previous years, also because the availability of 5G network will trigger further usages – both for human and for machines, and will also enable new applications that will consume additional traffic. The mobile data traffic will increase a lot in 2025, which is probably under estimated.

The projected supply of frequency bands 24.25-24.45, 25.05-25.25 and 42-42.5 GHz are fragmented and not sufficient for 5G, Huawei recommends IMDA to provide large continuous spectrum within 24.25-29.5 GHz and 37-43.5 GHz to meet the potential demands for year 2022 and beyond.

14) Noting that several regulators have made available mmWave bands for IMT services, IMDA would like your views and comments on whether access to the mmWave spectrum should be provided earlier than 2022 for commercial network deployment?

Huawei's comments:

Huawei is of the view that access to mmWave spectrum for commercialization from year 2022 is appropriate. Around year 2020, the target spectrum to be used for initial mmWave deployment will be clear, as WRC-19 (Oct. 2019) will make regulatory decisions on the exact mmWave bands to be identified to IMT and the relevant regulatory conditions for global/regional/cross boarder coordination. By year 2020, there will be some early deployments in the leading markets on 26GHz, 28GHz, and 40GHz, but still in small scale, so the eco-system and business are not mature enough. So it's wise for Singapore to start access to mmWave for commercialization around year 2022, which will benefit to the most extent from the WRC-19 decisions for global/regional/cross boarder coordination, experience of leading markets for national regulation and business model and much more mature mmWave eco-system. And the exact timing depends on the operators requirements.

Use of Licence-Exempt Spectrum

15) Considering the current regulations/policies for licence-exempt use and the possibility of LTE-U interfering with Wi-Fi users, IMDA would like to seek views and comments on the following:

i) The adoption of LBT to facilitate sharing of licence-exempt spectrum and whether there would be any implication arising from such a requirement;

ii) The need for further technical requirements and regulatory measures to facilitate the sharing of licence-exempt spectrum in an efficient and fair manner; and

iii) The need for companies with commercial LTE-U networks to upgrade to LAA once the software/hardware products are commercially available.

Huawei's comments:

i) The LBT is a well-established approach and an important mechanism to ensure fair access to the license-exempt spectrum; therefore, it shall be adopted. All the LTE-U network deployment should be upgraded to support the LBT protocol.

ii) The LBT protocol is an important mechanism to ensure fair access to the license-exempt spectrum. In addition to that, we don't see any other technical or regulatory measure that should be required.

iii) Companies with commercial LTE-U networks need to upgrade the LTE-U networks to LAA when software or hardware products are available in market. It is not only to meet the regulatory requirement for fair access to the license-exempt spectrum, but also to enable more user devices to connect to the upgraded network.

16) During the interim period before regulations are finalised, IMDA plans to facilitate industry trials for LAA/LTE-U technologies. As such IMDA would like to seek views and comments on the following:

i) Besides the information listed in Para 80, should MNOs/MVNOs interested in conducting LTE-U trials submit any further information for IMDA's assessment; and

ii) To minimise impact to Wi-Fi users, should IMDA limit LAA/LTE-U trials to parts of the 5 GHz licence-exempt spectrum?

Huawei's comments:

i) Considering the potential interference of LTE-U trial networks to Wi-Fi users, buildings and sites with public Wi-Fi coverage or considerable Wi-Fi usages should not be allowed for LTE-U trial.

ii) Yes, IMDA should limit LTE-U trials to parts of 5 GHz licence-exempt spectrum, in order to minimize the impact to Wi-Fi users.

17) IMDA would like to seek views and comments on the following:

i) The possibility of deploying LAA and / or MuLTEfire in other frequency bands besides the licence-exempt 5 GHz band; and

ii) The regulatory and coexistence measures that should be adopted for MuLTEfire.

Huawei's comments:

i) The designs of LAA and MuLTEfire are frequency band agnostic. It can support other frequency bands if

respective new RF specification is defined. The 3GPP Release 13 and Release 14 of LAA specifications only support the 5 GHz licence-exempt spectrum. The MuLTEfire 1.0, which is based on 3GPP standards (Release 13 for downlink / Release 14 for uplink), can be deployed in the 5 GHz license-exempt spectrum globally, and in the USA in 3.5 GHz CBRS band. Support of narrow band IoT applications in lower frequency band (licence-exempt) for better coverage and lower power consumption is being considered in the development of next version of MuLTEfire specifications.

ii) MuLTEfire is operating on LBT protocol to enable spectrum sharing with Wi-Fi users. We don't see the necessity of other regulatory measures for MuLTEfire.

18) Considering that the LWA approach would not create coexistence issue with Wi-Fi users, would this approach be better suited for countries with extensive Wi-Fi usage?

Huawei's comments:

The LBT protocol ensures LAA to access the licence-exempt spectrum in a fair manner and removes the coexistence concern for existing Wi-Fi users. In comparison with LWA, which requires coordination of two different radio access technologies, the LAA approach can provide additional value to end users, including robustness, better coverage and efficient multi-user scheduling.

19) IMDA would like to seek views on how the above approaches (i.e. LAA, MuLTEfire and LWA) would enhance the capacity of the mobile network in ways that Wi-Fi offloading is not able to achieve.

Huawei's comments:

In comparison with Wi-Fi offloading and some other technology, the LAA approach has the following advantages:

- Seamless coordination with LTE working on licensed spectrum; increase system robustness
- Better coverage
- Efficient multi-user scheduling

We recommend LAA, for the better utilization of licence-exempt spectrum and for its complementary role to existing mobile broadband communications.

Part II

About Huawei:

Huawei is a leading global information and communications technology (ICT) solutions provider. Driven by a commitment to sound operations, ongoing innovation, and open collaboration, we have established a competitive ICT portfolio of end-to-end solutions in telecom and enterprise networks, devices, and cloud technology and services. Our ICT solutions, products, and services are used in more than 170 countries and regions, serving over one-third of the world's population. With 180,000 employees, Huawei is committed to enabling the future information society, and building a Better Connected World.

Huawei 5G industry contribution

Huawei has continued to innovate and invest 5G in the past few years. Huawei has invested at least US $ 600 million before 2018 for research and innovation of 5G technology. At present, Huawei has invested more than 2,000 expert engineers in 5G research and development, and has established 11 5G R&D centers on a global scale.

Huawei has established a partnership with a number of partners in the global ecosystem, and as of March 2016, Huawei has established partnerships with more than 30 partners in the world, including leading global operators, industry alliances and organizations, vertical industry leaders and so on.

Cooperation with Global Leading Carriers:

Huawei and China Mobile, NTT DOCOMO, Vodafone, LGU +, KT, Deutsche Telekom, Singtel, MegaFon, Etisalat, Telefonica, TeliaSonera, SoftBank and other global leading operators to carry out 5G joint innovation research.

Huawei established deep cooperation in 5G with NGMN (Next Generation Mobile Network) operators.

Huawei has signed MoU of 5G with world’s top operators including China Mobile, KT, Vodafone, NTT DOCOMO, LGU+, Deutsche Telecom, Singtel, MegaFon and Etisalat, etc.

Participation in Industry Alliance:

Huawei actively participates in EU METIS / METIS II, 5GPPP, China IMT-2020 5G Promotion Group and Japan 5GMF, Korea 5G Forum and other industry organizations and alliances, and with more than 20 universities around the world to establish cooperation relations.

- Participated in the first and second phase of the METIS (Mobile and wireless communications Enablers for the Twenty-Information Society) in the European Union FP7 (Framework Program7) to build the key technologies in the field of wireless mobile communications for the information society in 2020.

- Participated in 5GPPP (5G Public-Private Partnership Association, 5G public-private partnership)

and become members of the board of directors of the European Union and the industry. 5GPPP is the flagship research project for the network infrastructure under the H2020 (Horizon 2020, Alternative EU Framework FP8) program.

- As one of the founding members of the UK 5G Innovation Center (5GIC), Huawei is one of the initiators of the 5G National Project, and Huawei is actively involved in the formulation, planning and implementation of the project.

- Huawei has become Japan 5GMF (Japan's Fifth Generation Mobile Communications Promotion Forum) and China IMT-2020 5G promotion group of important members.

Joint Research with Vertical industry:

- Huawei and vertical industry equipment manufacturers, such as automotive equipment manufacturers (well-known automotive equipment manufacturers), industrial control (KUKA) and test equipment manufacturers (RS) to carry out 5G joint research, is currently being carried out 5G innovation project covers a high Speed, large connectivity, ultra-reliability and low latency and other needs of different industries such as intelligent driving, robot control and so on.

- In September 2016, Huawei announced the establishment of the "5G Auto Alliance (5GAA)" with Audi Inc., BMW Group, Daimler AG, Ericsson, Intel, Nokia and Qualcomm. The Alliance will focus on developing, testing and driving communications solutions for autopilot, business pan-access, smart city integration and intelligent transportation applications, boosting commercialization of products and penetrating global markets to meet People demand for social mobile interconnection and road safety.

- In March 2017, at the World Mobile Congress in 2017, the 5G Automobile Alliance ("5GAA") and the European Automotive Telecommunication Union (hereinafter referred to as "EATA") jointly announced the signing of the MU. The cooperation is to promote the automatic driving in the program standardization, spectrum strategy, the typical use case deployment and other aspects of the process.

Cooperation with Academies

Huawei has cooperated with world’s top universities and research institutes including Stanford University, Harvard University, New York University, Oxford University, Munich University and Tsinghua University, etc., for joint study and researches for 5G.

Summit and Forum

Huawei has conducted extensive dialogue with the industry in promoting the global 5G industry process, and organized 5G @ Europe, 5G @ Europe, 5G @ Asia Summit and Roundtable Forum, and from the communications equipment manufacturers, operators and vertical industry Partners to discuss the future trend of 5G and industrial development.

Huawei will actively invest in the use of the communications industry, the accumulation of technical reserves and continuous innovation efforts to jointly promote this process.