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21 July 2017

Director-General (Telecoms & Post)
Assistant Chief Executive (Connectivity & Competition Development)
Info-communications Media Development Authority

Dear Ms Chia

PUBLIC CONSULTATION ON 5G MOBILE SERVICES AND NETWORKS

1. Singapore Telecommunications Limited and Singtel Mobile Singapore Pte Ltd (collectively **Singtel**) refers to the public consultation issued on 23 May 2017 by the Info-communications Media Development Authority (**IMDA**) on 5G Mobile Services and Networks (**Consultation Paper**).

2. Please find our views and comments attached.

Yours sincerely

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SINGAPORE TELECOMMUNICATIONS LIMITED AND SINGTEL MOBILE SINGAPORE PRIVATE LIMITED

RESPONSE TO PUBLIC CONSULTATION ON 5G MOBILE SERVICES AND NETWORKS

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1.1. This submission is structured as follows:

Section 2 – Introduction
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2. INTRODUCTION

2.1. Singapore Telecommunications Limited and Singtel Mobile Singapore Private Limited (collectively **Singtel**) are licensed to provide info-communications services in Singapore. Singtel is committed to the provision of state-of-the-art info-communications technologies and services in Singapore.

2.2. Singtel has a comprehensive portfolio of services that includes voice and data services over fixed, wireless and Internet platforms. Singtel services both corporate and residential customers and is committed to bringing the best of global info-communications to its customers in the Asia Pacific and beyond.

2.3. Singtel welcomes the opportunity to make this submission on the Consultation Paper.

2.4. Singtel would be pleased to clarify any of the views and comments made in this submission, as appropriate.

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3. EXECUTIVE SUMMARY

5G Technology and Use Cases

3.1. To address the IMDA's intent to facilitate the deployment of more innovative and advanced mobile technology, networks and services in Singapore, Singtel submits that the IMDA should assist MNOs' transition to 5G specifically in the areas of licensing and approval frameworks; facilitating inter-agency cooperation and securing deployment permissions and approvals; reasonable resiliency and quality of service (**QOS**) standards; as well as spectrum resource allocation processes.

3.2. The IMDA should monitor licensing and equipment approvals to ensure conflicting, outdated or less conducive standards and equipment are appropriately phased out to facilitate technology evolution. The IMDA should also ensure relevant associated technical standards are updated and equipment registration processes are simplified where feasible to facilitate the availability of 5G hardware for mass deployment.

3.3. It is vital that the IMDA make rapid gains in developing a conducive 5G ecosystem by ensuring whole-of-government support for the IMDA's goals. This entails enhancing inter-agency cooperation and providing assistance for MNOs to secure the necessary approvals and permissions for 5G deployment in a more efficient and expeditious manner. In June 2017, Singtel submitted its response to the IMDA's Public Consultation on the Review of the Code of Practice for Info-Communication Facilities in Buildings (**COPIF**), detailing areas where changes to the COPIF will be essential to facilitating 5G related deployment, such as extending COPIF requirements to non-commercial locations and public facilities such as lampposts, monopoles, bus stops and substations; increasing the allocation of mobile deployment space (**MDS**) with the introduction of a fourth MNO; provide specific access to spaces required for the deployment of small cells and other new technologies on a rent-free basis; in addition to facilitating MNOs in reaching agreements with private building owners/management.

3.4. IMDA should consider exempting 5G technology from QOS obligations for a period of up to 10 years if necessary due to the radical changes in 5G network architecture. In addition, existing QOS and resiliency frameworks and initiatives will need to be revised and re-calibrated to appropriate levels, both to take into consideration the nature of 5G technology, as well as to reduce cost burdens of older mobile networks that will eventually be phased out.

3.5. Numbering requirements would be intensified with the introduction of 5G and it is important that IMDA regularly updates its National Numbering Plan in alignment with the International

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Telecommunications Union (**ITU**)'s recommendations and in view of changes to the numbering landscape.

3.6. The choice of radio access technology for Internet of Things **(IoT)** services is very much dependent on the use case requirements. The requirements can vary due to various factors and a single radio access technology may not be sufficient. Besides Narrowband-IoT (**NB-IoT**), there are several other radio access technologies which can be considered by MNOs, such as proprietary vendor solutions as well as 3GPP-standards-based solutions.

3.7. Singtel considers that the current spectrum bands allocated (both sub-1GHz and 1-3GHz) for mobile services are already bands supported by 3GPP for NB-IoT and MTC services, and will already provide mobile network operators with sufficient resource to enable IoT services.

3.8. Singtel would like to highlight the exorbitant cost of spectrum in developing new mobile network technology It is paramount that the IMDA assists MNOs in reducing costs in deploying new technology, and that sufficient use case justification be present before any existing technologies (which have involved extremely high capital and cost commitments) be rendered obsolete.

3.9. Singtel is of view that the current generations of mobile networks are already capable of supporting various low-cost, mass market IoT use cases. This is in consideration of the existing availability of 3GPP-based solutions like NB-IoT, LTE MTC **(Long Term Evolution Machine Type Communication)** and vendor proprietary solutions.

3.10. The future generations of mobile networks will further support diverse use cases. The current massive IoT network will co-exist with future mobile networks, which will consist of various network slices to fulfil different use case and quality-of-service requirements. The spectrum requirements for each of the network slices are unknown at this juncture.

3.11. Singtel is of the view that the key 5G technologies are likely to include advanced radio techniques such as massive multiple input, multiple output (**MIMO**) and Coordinated Multipoint (**CoMP**); leveraging spectrum for better transmission utilisation; cost effective network densification; flexible networks as well as new service creation.

3.12. Beyond a conducive regulatory framework, IMDA can also consider the facilitation of 5G ecosystem development through the creation of open labs and innovation centres to enable industry players to incubate 5G use cases.

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3.13. To facilitate 5G network development, the underlying transport network infrastructure should be ultra-high capacity and pervasive. The IMDA may review the access of Fibre to the x (**FTTX**) to numerous small cells and also the capacity of transport networks.

Below 1 GHz Frequency Bands

3.14. The 600MHz spectrum, being largely a TV broadcast spectrum, can also be considered for 5G/IMT allocation after Singapore switches-off the analogue TV broadcasting by end 2017. With the ceasing of analogue TV broadcasting, the freed-up spectrum especially in the 600MHz will create more capacity for mobile broadband. The maturity of the ecosystem depends on the market volume and traction – for this case, it is mainly US market driven.

1-6 GHz Frequency Bands

3.15. Singtel is of view that Frequency Division Duplex (**FDD**) or Time Division Duplex (**TDD**) frequency arrangements are more suitable to be adopted in Singapore for the identified L band – based on new 3GPP TDD or FDD bands considerations. The mobile supplemental downlink (**SDL**) arrangement is specifically used in Europe. The two 3GPP Release 15 work items on new FDD and TDD operating bands in L band for LTE are expected to be completed within 2017. The availability of LTE equipment for the new FDD or TDD operating bands in L band will be achieved before 2020, while 5G New Radio Access Technology (**NR**) equipment is expected to be available post-2020.

3.16. Existing 3GPP bands do not fully utilise the 91MHz of the L band and as recognised by the IMDA in its Consultation Paper, while there have been developments in terms of identification and harmonisation at international fora, it is still subject to further studies (e.g. co-existence studies) at the ITU. There also remains "*continuing work from WRC-15 on the harmonisation of the L band for the Asia Pacific region*". Singtel would recommend the entire 91MHz of L band be allocated to the maximum possible extent for enhanced mobile broadband services, owing to the scarcity of contiguous spectrum bands below 6GHz subject to 3GPP standardisation.

3.17. If the entire extended C-band (3.4-3.6GHz) is considered for International Mobile Telecommunications system (**IMT**), the migration of existing satellite users to the other parts of the C-band will pose a major challenge to not only Singtel but also other satellite operators, because changing of the frequency plan in space will cause abrupt disconnection of existing ST2 data services.

3.18. Instead of the entire extended C-band spectrum, Singtel recommends that the lower-half of the extended C-band (3.4-3.5GHz) be allocated for IMT. In this way, Singtel-owned satellite ST2

can still operate within 3.5-3.7GHz keeping its services, while additional 100MHz of spectrum can be set aside for IMT – this minimises disruption and challenges posed not only to Singtel but also other satellite operators in neighbouring countries.

3.19. Singtel would like the IMDA to review and consider the 4.4-4.99GHz frequency bands for IMT/ 5G, in particular given the spectrum has been proposed for 3GPP Release 15 5G NR by Japan and China mobile operators.

Above 6 GHz Frequency Bands

3.20. In locations or at special events where video/data-intensive user density is extremely high, the current generation of mobile technology, operating on spectrum bands below 6GHz, will not be able to deliver a consistent and acceptable user experience to all users. Due to the nature and characteristics of the mmWave bands, system capacity and spectral efficiency can be greatly increased, delivering the desired user experience in dense areas. The amount of spectrum required in the mmWave bands would be at least 1GHz per MNO in Singapore. The minimum size for each mmWave spectrum block should be 100MHz in contiguity.

3.21. Singtel is of the view that, based largely on more favourable radio propagation characteristics, the spectrum bands below 43.5GHz should be prioritised for IMT services in Singapore. Singtel emphasises that the IMDA should not rule out the use of other bands at this stage.

3.22. The 28GHz band should be made available for the deployment of 5G services in Singapore, in consideration of the fact that a number of operators globally have indicated their intention of launching their first 5G deployments in the 28GHz band. In addition, noting the proximity of the 24.5-27.5GHz (26GHz) to 28GHz bands, and that equipment developed for 28GHz might offer a tuning range spanning both bands, both the 26GHz and 28GHz bands should be made available for 5G services in Singapore to provide economies of scale for related consumer devices, which will encourage commercialisation and spur the growth of 5G ecosystem.

3.23. The IMDA may wish to note that Under WRC-15, Agenda Item 1.5, the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) have been considered for use by earth stations in motion communicating with geostationary space stations in the fixed-satellite service.

3.24. Singtel has not come to a decision with regard to deploying Earth Stations in-Motion **(ESIM)** services in Singapore, but partnering other satellite operators for purpose of proving such services remains under consideration. Singtel is of view that 28GHz should be prioritised for IMT services in Singapore.

Future Spectrum Estimation

3.25. The estimated demand is dependent on data consumption and capacity demands on 5G and at this juncture, Singtel is of the view that it may be too premature to derive estimations regarding consumption patterns of 5G applications or use cases, which may alter as the technology further develops. It is estimated in multiple technology standards fora that early 5G market deployments will be targeting the timeframe between 2020 and 2022 and 5G spectrums may be required by 2019/2020. Given the uncertainty of the spectrum amount available within the 1-6GHz bands, mmWave bands should be made available for hotspot type deployments.

Use of License-Exempt Spectrum

3.26. The adoption of listen-before-talk (**LBT**) will facilitate sharing of license-exempt spectrum. This has been standardised in 3GPP and will ensure fair access to the license-exempt spectrum.

3.27. The requirement of adopting LBT would concern operators intending to commercially deploy LTE-U technology. Singtel works closely with mobile terminal vendors in Singapore, and sees that the ecosystem may be geared more towards LAA (**License Assisted Access**) (with LBT) compared to LTE-U.

3.28. Singtel is of view that apart from (i) technical conditions prescribed in the Short Range Device Framework; and (ii) LBT protocol, there is no need to introduce further regulatory measures to ensure the sharing of license-exempt spectrum in an efficient and fair manner at this point

3.29. There are currently no commercial LTE-U network deployments in Singapore. Depending on the operators' business needs and the readiness of LAA and LTE-U[1] ecosystems, the operators will need to decide whether to and when to deploy LAA or LTE-U networks with these commercial availabilities in mind.

[1] As recognised by the IMDA in its Consultation Paper, "*LAA was introduced in 3GPP Release 13 to standardise LTE operations in the 5 GHz Wi-Fi spectrum. LTE-U was developed outside of established standards bodies and it is compatible with Rel. 10/11 3GPP LTE standards. While LTE-U aims to achieve the same objective as LAA, the key difference between both technologies is the measures that can be taken to ensure coexistence with other users in the licence-exempt spectrum (e.g. Wi-Fi users).*"

3.30. With regard to the conducting of LTE-U trials, Singtel does not recommend any further information to be submitted to IMDA for assessment.

3.31. Singtel is of view that limiting the LAA and LTE-U trial to parts of 5GHz license-exempt spectrum may not necessarily minimise the impact to Wi-Fi users. On the other hand, certain Wi-Fi Access Points (**AP**) may have to share license-exempt spectrum resources with LAA and LTE-U more often than Wi-Fi APs which have dynamic allocation.

3.32. Singtel emphasises that LBT ensures fair sharing in license-exempt 5GHz band and is standardised not only in 3GPP Release 13 but also in European Telecommunications Standards Institute, ETSI EN 301 893.

3.33. There are currently no other license-exempt frequency bands besides the 5GHz band for LAA and / or MuLTEfire and Network equipment vendors are still monitoring the uptake of 5GHz-based LAA and / or MuLTEfire.

3.34. Both LAA and LWA complement each other under different deployment scenarios. Trials have shown that LAA does not cause additional interference to existing Wi-Fi Networks in comparison to introducing another Wi-Fi AP. Therefore the IMDA should consider the readiness of the whole ecosystem and terminal support in determining technology readiness.

3.35. Both the LTE and Wi-Fi components of the LWA solution will need to be supplied by the same network equipment vendor.

3.36. LAA and LWA provide better quality-of-service, control and mobility, thanks to the presence of an LTE anchor carrier on a licensed spectrum band. MuLTEfire does not require an anchor LTE carrier in the licensed spectrum and fully operates in the license-exempt spectrum. IMDA should ensure that entities will not be able to bypass regulations and operate networks without an LTE License Anchor.

4. GENERAL COMMENTS

4.1. Singtel welcomes the IMDA's consultation on 5G in recognition of the "*rapid and significant transformations*" of the telecommunications industry. More importantly, the role of the IMDA as a regulator and facilitator of the telecommunications industry will be a key factor in enabling the development of 5G technology and deployment in Singapore. As the IMDA has rightly recognised, the standardisation process is at an early stage and it is anticipated that 5G may be commercialised around 2020 at the earliest.

4.2. Singtel notes that several spectrum frequency bands discussed in this Consultation Paper entail international interests involving neighbouring countries – in all such cases it will be necessary that the IMDA duly facilitates the settlement of these spectrum allocations on a government-to-government level basis.

4.3. Singtel further submits that its comments provided under this consultation are preliminary and reflect the current telecommunications environment only, in view of the early stage of 5G technology development. Subsequent consultations by the IMDA will be necessary to ensure that measures aimed at facilitating 5G technology development, including regulatory and licensing frameworks, programmes and incentives, are constantly updated and remain relevant.

5. SPECIFIC COMMENTS

5G Technology and Use Cases

Question 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?

5.1. Singtel notes Singapore's Smart Nation initiatives in leveraging technology and technology-enabled solutions. As aforementioned, the role of the IMDA as a regulator and facilitator of the telecommunications industry will be a key factor in enabling the development of 5G technology and deployment in Singapore. Singtel submits that the IMDA should assist MNOs specifically in the areas of licensing and approval frameworks; facilitating inter-agency cooperation and securing deployment permissions and approvals; reasonable resiliency and QOS standards; as well as spectrum and resource allocation processes.

5.2. In the area of equipment registration frameworks and telecommunication standards, while the industry is advancing towards 5G technology, there is also a growing trend of non-conventional players providing cellular hardware, largely driven by open-sourced consortium[2] and major architecture change with virtualisation of conventional radio network functions[3], which may see non-conventional off-the-shelf equipment. Although these may not be prevalent as yet, Singtel

[2] Project OpenCellular under the Telecom Infra Project, driven by Facebook and other operators, infrastructure providers, system integrators, and other technology https://telecominfraproject.com/project/access-projects/opencellular-wireless-access-platform-design/

[3] ETSI GS NFV – Network Functions Virutalisation Use Cases #6

is of the view that beyond its attention regarding the availability and allocation of spectrum for purpose of 5G, the IMDA should also monitor licensing and equipment approvals to ensure conflicting, outdated or less conducive standards and equipment are appropriately phased out to facilitate technology evolution. The IMDA should also ensure relevant associated technical standards are updated and equipment registration processes are simplified where feasible to facilitate the availability of 5G hardware for mass deployment.

5.3. The most immediate way for the IMDA to make rapid gains in developing a conducive 5G ecosystem is in the area ensuring whole-of-government support for the IMDA's goals. This entails enhancing inter-agency cooperation and providing assistance for MNOs to secure the necessary approvals and permissions for 5G deployment in a more efficient and expeditious manner. This is given the nature of 5G technology, where IoT and small cell deployments are often numerous in numbers and will need large-scale, nationwide deployment to achieve its purpose.

5.4. In June 2017, Singtel submitted its response to the IMDA's Public Consultation on the Review of the COPIF, highlighting the importance of the COPIF in enabling this goal. Singtel has detailed numerous areas where changes to the COPIF will be essential to facilitating 5G related deployment, such as extending COPIF requirements to non-commercial locations and public facilities such as lampposts, monopoles, bus stops and substations[4]; increasing the allocation of MDS[5] with the introduction of a fourth MNO; providing specific access to spaces required for the deployment of small cells and other new technologies on a rent-free basis; in addition to facilitating MNOs in reaching agreements with private building owners/management. Singtel submits that detailed studies and further discussion should be conducted with MNOs specific to 5G deployment to ensure that better inter-agency alignment. Specifically, the gains achieved should not only in the areas of permissions approval, but also ensuring technical specifications and allowances that affect 5G performance (such as clearance distance to building edges, as well as deployment on a variety of public locations) are fully examined, with a possibility of revisions not only to IMDA's regulations about also amongst the various public agencies.

[4] Necessary for purpose of expanding deployment options available, which will quicken the development and deployment of future technology.

[5] Singtel disagreed with the retention of current MDS space allocation and submitted that an increase in MDS allocation is necessary due to growing end-user demand; tightening IMDA regulations such as QOS standards; newer technology such 5G requiring future-proofing in the form of capacity expansion, infrastructure construction and upgrading.

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5.5. The IMDA should be aware that these needs arise and are compounded as more base stations and potentially new "hub" sites are required in new 5G architecture to support the increased peak throughput and bandwidth (**eMBB**); the deployment of shorter range site using the high frequency mmWave; the growing number of connected devices (**mMTC**) and ultra-reliable mission critical services.

5.6. With the rapidly developing 5G platform, MNOs would also be able to leverage on the new 5G capabilities such as network slicing and enhanced core. This will involve customisation of innovative products and services across different verticals that adopt IoT. As a result, Singtel is seeing an extremely competitive market and where Singtel is now increasingly hampered by Dominant Licensee requirements under the IMDA's Code of Practice for Competition in the Provision of Telecommunication Services. This disadvantage is unnecessary in various markets and has grown, given the competitive landscape has greatly evolved since the liberalisation of the telecommunications market in Singapore and the introduction of the Next Generation Nationwide Broadband Network. Singtel submits that it will be important that the IMDA takes this into serious consideration in evaluating exemption requests by Singtel.

5.7. In the area of resiliency and QOS standards, Singtel emphasises that in addition to measures for facilitating the industry, it is just as important that there are efforts to reduce unnecessarily onerous burdens on MNOs. Some of such past policies, if continued will potentially limit 5G development.[6] Prime Minister Lee Hsien Loong, in his speech at the launch of the EW Barker Centre for Law and Business on 29 May 2017, made clear that "*Singapore's law must change accordingly as globalization and technology are changing how business is done*" and that "*effective, but not onerous regulation has become a new source of economic competitiveness*".[7] In the latest global Speedtest study published on May 24, 2017, Singapore was reported to possess amongst the fastest mobile and broadband speeds in the world, with the fastest average mobile upload speed in the world at 17.46Mbps[8].

5.8. Disproportionate measures and standards frameworks divert considerable, exorbitant resource from developmental efforts and increase the cost commitments for mobile networks. Singtel

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[6] In June 2015, IMDA reduced the rectification period accorded to MNOs from 6 months to 4 months for sites of non-compliance with its stringent QOS standards. This is despite the fact that time required for the various permissions, procurement and actual on-site installation works and testing amounts to at least 6 months on average. In June 2016, IMDA announced new 4G QOS standards for compliance to ensure mobile phone users experience an acceptable level of service quality in Singapore, which runs concurrently with its existing 3G QOS standards. IMDA requires MNOs to cover at least 99% of outdoor areas from 1 July 2017, and implemented standards for tunnels as well as building premises. Since 2015, IMDA has also implemented additional, stringent requirements requiring speedy deployment of mobile coverage at HDB and private housing developments.

[7] https://www.reach.gov.sg/participate/discussion-forum/2017/05/30/law-and-lawyers-must-keep-pace-with-changes

[8] Internet speeds in Singapore among world's fastest: http://www.channelnewsasia.com/news/singapore/internet-speeds-in-singapore-among-world-s-fastest-report-8879516

submits that the IMDA should consider exempting 5G technology from QOS obligations for a period of up to 10 years if necessary. In addition, existing QOS and resiliency frameworks and initiatives will need to be revised and re-calibrated to appropriate levels, both to take into consideration the nature of 5G technology, as well as to reduce cost burdens of older mobile networks that will eventually be phased out.

5.9. Specific to 5G, the IMDA needs to take into consideration the considerable difference between 5G and previous generations of mobile network technology. Due to technological developments under 5G such as network slicing, virtualisation, heterogeneous access networks and standardised interworking with existing LTE networks, the scope of services as well as coverage achieved is projected based on 3GPP to be far superior than existing standards. Such changes in the networks' nature makes it more challenging to be measured via the traditional QOS standards, due to the more area-specific use cases, as well as static deployment of large numbers of equipment, such as sensors for 5G use cases.[9]

5.10. In the area of national numbering and allocation process, Singtel is of the view that with the advent of mass market IoT and mobile data applications which do not require circuit switch technology, there is a need to ensure that we have sufficient number levels to support the numbering requirements. The allocation of such numberings should also be made more affordable and processes simplified, so as to encourage commercialisation and uptake of related devices.

5.11. Numbering use requirements would likewise be intensified with the introduction of 5G, which pivoted upon massive Machine-Type Communications as a key usage scenario. Thus it would be important that IMDA regularly updates its National Numbering Plan in alignment with the ITU's recommendations and changes to both the global and local numbering landscape. As the IMDA would be aware, discussions are already ongoing under ITU-T E.164.1 to review the ITU's recommendation for numbering allocation criteria and procedures for Machine-to-Machine (**M2M**) and IoT technology.

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[9] GSA Executive Report: How 5G changes perceptions of applications, coverage and architecture: https://gsacom.com/paper/gsa-executive-report-5g-changes-perceptions-applications-coverage-architecture/

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Question 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?

5.12. Singtel is of view that the choice of radio access technology for IoT services is very much dependent on the use case requirements. The requirements can vary due to various factors (such as data rate, latency, coverage, mobility, battery life and voice support etc). In order to meet a diversity of requirements, a single radio access technology may not be sufficient. Besides NB-IoT, there are several other radio access technologies which can be considered by MNOs, with various proprietary solutions available from vendors as well as 3GPP-standards-based MTC solutions (e.g. Release 8 LTE Category 1, Release 13 LTE Category M1 and Release 14 Category 1bis.)

5.13. Aforementioned proprietary vendor solutions run on unlicensed spectrum, while 3GPP solutions support operating bands in both sub-1GHz and between 1 and 3GHz. NB-IoT and MTC device categories are designed to operate in the following Evolved Universal Terrestrial Radio Access **(EUTRA)** operating bands[10]:

User Equipment Categories	**Sub-1GHz operating bands (450/700/800/900MHz)**	**Operating bands between 1 and 3GHz**
Category NB1, NB2 (NB-IoT)	5, 8, 12, 13, 17, 18, 19, 20, 26, 28, 31	1, 2, 3, 11, 25, 66, 70
Category M1	5, 8, 12, 13, 18, 19, 20, 26, 27, 28, 31	1, 2, 3, 4, 7, 11, 21, 25, 39, 41
Category 1bis	5, 8, 12, 13, 20, 26	1, 2, 3, 4, 7, 39, 41, 66

[10] Refer to 3GPP TS 36.101 V14.3.0 (2017-03) for the EUTRA operating bands for UE Category M1 and Category NB1.

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5.14. The current sub-1GHz spectrum allocated for mobile services in Singapore includes 700MHz (band 28) and 900MHz (band 8), while spectrum allocated between 1 and 3GHz includes 1800MHz (band 3), 2100MHz (band 1) and 2600MHz (band 7). Singtel considers that the current spectrum bands allocated (both sub-1GHz and 1-3GHz) for mobile services are already bands supported by 3GPP for NB-IoT and MTC services, and will already provide mobile network operators with sufficient spectrum resource to enable IoT services.

5.15. Singtel would like to highlight the exorbitant cost of spectrum in developing new mobile network technology. In the recently concluded 4G spectrum auction, MNOs paid a combined $1.14billion for spectrum necessary for 4G services. In view of the recently concluded auction, it would not be sensible both from a commercial as well as a technological perspective for the MNOs nor the IMDA to rush into 5G commercialisation until at least 2020 and beyond. It is paramount that the IMDA assists MNOs in reducing costs in deploying new technology, and that sufficient use case justification be present before any existing technologies (which have involved extremely high capital and cost commitments) be rendered obsolete.

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?

5.16. Singtel is of view that the current generations of mobile networks are already capable of supporting various low-cost, mass market IoT use cases, also referred to as massive Machine-Type Communications (**mMTC**). This is in consideration of the existing availability of 3GPP-based solutions like NB-IoT, LTE MTC and proprietary vendor solutions.

5.17. The future generations of mobile networks will further support diverse use cases related to mobile broadband access in dense and rural areas; high user mobility environments (in-train, on-aircrafts); smart wearables; sensor networks; mobile video surveillance; tactile Internet; lifeline communication; ultra-reliable, ultra-low latency and ultra-high availability network access, etc. Based on the current developments in 3GPP, the current massive IoT network will be able to co-exist with future mobile networks, which will consist of various network slices to fulfil different use case and quality-of-service requirements. The spectrum requirements for each of the network slices are unknown at this juncture, as it is dependent on the specific use case requirements and the 3GPP standards.

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Question 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.

5.18. Singtel views that the key 5G technologies are likely to include the following:

i. Advanced radio techniques such as massive MIMO and CoMP, which increase spectral efficiency and reduce interference;
ii. Leveraging spectrum – techniques such as control/user plane split that utilises low/high band spectrum properties, full duplex for uplink/downlink **(UL/DL)** simultaneous transmission, unlicensed bands and spectrum sharing techniques, opening up of higher spectrum bands including mmWave;
iii. Cost effective network densification – multi-layer, multi-radio access technology **(multi-RAT)** access with self- configuration, optimisation, load balancing;
iv. Flexible network – Network function virtualisation / software defined network **(NFV/SDN)** and network/service management and orchestration to enable flexible and programmable networks and enable network slicing to support diverse use cases; and
v. New service creation – Data analytics, context awareness to create new value for verticals and open APIs to support anything-as-a-service **(XaaS)**.

5.19. Beyond ensuring a conducive regulatory framework, IMDA can also consider the facilitation of 5G ecosystem development through the creation of open labs and innovation centres to enable industry players including network operators, network vendors, industry players, chipset/device manufacturers, application developers as well as research bodies to come together and incubate 5G use cases.

5.20. To facilitate 5G network development, the underlying transport network infrastructure should be ultra-high capacity and pervasive. The IMDA may review the access of FTTX to numerous small cells and also the capacity of transport networks, so as to support sites capable of beyond 10Gbps in user speeds.

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Below 1 GHz Frequency Bands

Question 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?

5.21. The 600MHz spectrum, being largely a TV broadcast spectrum, can also be considered for 5G/IMT allocation after Singapore switches-off the analogue TV broadcasting by end 2017[11]. With the ceasing of analogue TV broadcasting, the freed-up spectrum especially in the 600MHz will create more capacity for mobile broadband. In the recent FCC Broadcast Incentive Auction in the US, 70MHz of 600MHz spectrum has been freed-up from 175 TV stations for mobile broadband services[12]. It is also worth noting that in the recent 3GPP TSG RAN Plenary Meeting #75 held at Croatia in March 17, a work item to standardise a new FDD operating band to be called band 71, based on the FCC 84MHz band plan ((UL: 663-698 MHz; DL: 617-652 MHz) has been included and is expected to be ratified within this year[13]. The maturity of the ecosystem depends on the market volume and traction – for this case, it is mainly US market driven.

1 – 6 GHz Frequency Bands

Question 5

IMDA would like to seek views and comments on the 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;

5.22. 3GPP is currently working on specifying two new operating bands for FDD and TDD in L band respectively in 3GPP Release 15[14]. The new operating bands will utilise the entire identified L band (1427-1518MHz) to the maximum extent possible, taking into account the ongoing ITU-R study on sharing and compatibility with other services within this band or in the surrounding

[11] Refer to the Straits Times publication at the website: http://www.straitstimes.com/singapore/no-analogue-broadcasting-by-end-2017-digital-tvs-or-set-top-boxes-needed-to-watch-free-to

[12] Refer to the FCC public notice and news release at: https://apps.fcc.gov/edocs_public/attachmatch/DA-17-314A1.pdf and https://apps.fcc.gov/edocs_public/attachmatch/DOC-344397A1.pdf.

[13] Refer to http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_75/Docs/RP-170051.zip and http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_76/Docs/RP-171142.zip

[14] Refer to 3GPP Release 15 work items FDD operating band in the L band for LTE (Unique ID 740075) and TDD operating band in the L band for LTE (Unique ID 740080), at the links: http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_74/Docs/RP-162536.zip, http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_74/Docs/RP-162557.zip

bands (e.g. Earth Exploration-Satellite Service or "EESS" below 1427MHz, and Mobile Satellite Services or "MSS" above 1518MHz). The two 3GPP work items mentioned are expected to be completed within this year.

5.23. Singtel is of view that FDD or TDD frequency arrangements are more suitable to be adopted in Singapore for the identified L band – based on new 3GPP TDD or FDD bands considerations. SDL arrangement is specifically used in Europe and there is currently no 3GPP work plan to further extend the bandwidth to maximise 1427-1518MHz utilisation. On the other hand, IMDA should also take into consideration if the NR[15] on L band will be eventually based on TDD or FDD technology. This can help the IMDA in its consideration as to whether the L band frequency arrangement can support 5G NR or can be easily re-farmed to support 5G NR.

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).

5.24. The two 3GPP Release 15 work items on new FDD and TDD operating bands in L band for LTE are expected to be completed within 2017. Singtel is of the view that the availability of LTE equipment for the new FDD or TDD operating bands in L band will be achieved before 2020, while NR equipment is expected to be available post-2020.

Question 6

i.	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.

5.25. Existing 3GPP bands do not fully utilise the 91MHz of the L band and as recognised by the IMDA in its Consultation Paper, while there have been developments in terms of identification and harmonisation at international fora, it is still subject to further studies (e.g. co-existence studies) at the ITU. There also remains "*continuing work from WRC-15 on the harmonisation of the L band for the Asia Pacific region*". IMDA has further recognised that for "*deployment in the upper and lower parts of the L band and the use of it outside Europe, it may take more than 5 years*". Singtel would recommend the entire 91MHz of L band be allocated to the maximum

[15] In the 3GPP Release 15 work item New Radio Access Technology (Unique ID 750067), the 1427-1518MHz portion of L band has been included as one of the NR operating bands. Refer to http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_75/Docs/RP-170855.zip

possible extent for enhanced mobile broadband services, owing to the scarcity of contiguous spectrum bands below 6GHz. However, this is subjected to 3GPP standardisation of the LTE and NR operating bands within the L band, which takes into consideration the co-existence with EESS and MSS systems in the adjacent bands.

Question 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?

5.26. The Singtel-owned satellite, ST2, operates its transponders within the frequency range of 3.5-3.7GHz. If the entire extended C-band (3.4-3.6GHz) is considered for IMT, the migration of existing satellite users to the other parts of the C-band will pose a major challenge to not only Singtel but also other satellite operators, because changing of the frequency plan in space will cause abrupt disconnection of existing ST2 data services. To mitigate impact to the customers, Singtel is of view that the only way to migrate the customers to the new frequency would be to launch a new satellite, which requires provisions from ITU as well as coordination with satellite operators in neighbouring countries. Hence, Singtel would not recommend that the full extended C-band to be allocated for IMT.

Question 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.

5.27. Instead of the entire extended C-band spectrum, Singtel recommends that the lower-half of the extended C-band (3.4-3.5GHz) be allocated for IMT. In this way, Singtel-owned satellite ST2 can still operate within 3.5-3.7GHz keeping its services, while additional 100MHz of spectrum can be set aside for IMT – this minimises disruption and challenges posed not only to Singtel but also other satellite operators in neighbouring countries. For co-existence with cross-border operations, techniques such as beamforming to increase directivity to Singtel users and regulating the physical antenna tilts and radio power can be applied. Singtel will work closely with IMDA to ensure harmonisation of the 3.4-3.5GHz for IMT, while not causing interference to cross-border satellite operations.

Singtel

Question 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.

5.28. Singtel would like the IMDA to review and consider the 4.4-4.99GHz frequency bands for IMT/ 5G, in particular given the spectrum has been proposed for 3GPP Release 15 5G NR by Japan and China mobile operators[16].

Above 6 GHz Frequency Bands

Question 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;

5.29. Singtel would like to clarify that millimetre wave-length bands should be frequencies between 30 and 300GHz. For purpose of this Consultation Paper, Singtel shall refer to mmWave bands as frequencies between 24 and 86GHz. The mmWave bands play a vital role in delivering data-intensive broadband access (e.g. pervasive high-definition video, augmented reality and virtual reality specifically in dense areas and in special events). In locations or at special events where video/data-intensive user density is extremely high, the current generation of mobile technology, operating on spectrum bands below 6GHz, will not be able to deliver a consistent and acceptable user experience to all users. Due to the nature and characteristics of the mmWave bands, hundreds to thousands of MHz of spectrum bandwidth can be made available, and where new techniques like beam-forming/tracking and multi-user MIMO can form pencil-sharp beams to users, while will greatly increase the system capacity and spectral efficiency, delivering the desired user experience in dense areas.

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

5.30. Singtel is of the view that the amount of spectrum required in the mmWave bands would need to be at least 1GHz per MNO in Singapore. In addition, the minimum size for each mmWave

[16] In the 3GPP Release 15 work item New Radio Access Technology (Unique ID 750067), the 4.4-4.99GHz portion of L band has been included as one of the NR operating bands. Refer to http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_75/Docs/RP-170855.zip

spectrum block should be 100MHz in contiguity. IMDA may wish to note that during Singtel's 5G demonstration in August 2016, Singtel and Ericsson demonstrated 27.5Gbps of peak speed achieved with 800MHz of 15GHz spectrum.

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

5.31. Singtel is of the view that, based largely on more favourable radio propagation characteristics, the spectrum bands below 43.5GHz should be prioritised for IMT services in Singapore. Singtel emphasises that the IMDA should not rule out the use of other bands at this stage.

5.32. The specific priority spectrum bands that should be considered for IMT in Singapore are as follows:

- 24.5-27.5GHz,
- 27.5-29.5GHz,
- 31.8-33.4GHz,
- 37.0-40.5GHz,
- 40.5-42.5GHz,
- 42.5-43.5GHz.

Question 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)?

5.33. The 28GHz band should be made available for the deployment of 5G services in Singapore, in consideration of the fact that a number of operators globally have indicated their intention of launching their first 5G deployments in the 28GHz band. These include the USA, where its use for 5G was confirmed by the FCC in 2016, as well as in the Republic of Korea where the government has announced the allocation of 5G frequencies for commercial services including 28GHz by 2018. In addition, noting the proximity of the 24.5-27.5GHz (26GHz) to 28GHz bands, and that equipment developed for 28GHz might offer a tuning range spanning both bands[17], both the 26GHz and 28GHz bands should be made available for 5G services in Singapore. This approach will encourage commercialisation and spur the growth of 5G ecosystem due to the likely availability and the economies of scale for related consumer devices.

[17] This is in reference to the NGMN 5G Spectrum Whitepapers found at this link: https://www.ngmn.org/uploads/media/1701031_NGMN_5G_SPECTRUM_WHITE_PAPER_V1.0.pdf

Singtel

Question 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?

5.34. The IMDA may wish to note that under ITU World Radio-communications Conferences in 2015 **(WRC-15)**, Agenda Item 1.5, the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) have been considered for use by earth stations in motion communicating with geostationary space stations in the fixed-satellite service. This agenda item entails the actions taken at WRC-15, under which new regulations for the operation of earth stations in motion **(ESIM)** in the bands 19.7-20.2 GHz and 29.5-30 GHz were agreed upon.

5.35. Singtel has not come to a decision with regard to deploying ESIM services in Singapore, but partnering other satellite operators for purpose of proving such services remains under consideration. Singtel is of view that since ESIM services can be made available on the bands 19.7-20.2 GHz and 29.5-30 GHz, 28GHz should be prioritised for IMT services in Singapore so as to make available more mmWave bands and to provide economies of scale to the 5G consumer devices.

Future Spectrum Estimation

Question 13

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

5.36. The estimated demand is dependent on data consumption and capacity demands on 5G. This is highly dependent on the applications or use cases implemented and at this juncture, Singtel is of the view that it may be too premature to derive estimations regarding consumption patterns of 5G applications or use cases, which may evolve as the technology further develops.

Singtel

Question 14

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?

5.37. Singtel expects that 4G data usage will continue to experience healthy growth and to sustain he rate of mobile traffic and LTE growth, current bands including the recently released TDD as well as sub-GHz bands will be required for both serving as a coverage layer for 4G, as well as for IoT services[18].

5.38. It is estimated that early 5G market deployments will be targeting the timeframe between 2020 and 2022 and to enable such deployments and facilitate Singapore's Smart Nation initiatives, 5G spectrums may be required by 2019/2020, so as to enable early deployment. Given the uncertainty of the spectrum amount[19] available within the 1-6GHz bands, mmWave bands should be made available for hotspot type deployments especially for 5G eMBB use cases by 2019/2020.

Use of Licence-Exempt Spectrum

Question 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;

5.39. The adoption of LBT will facilitate sharing of license-exempt spectrum. This has been standardised in 3GPP and will ensure fair access to the license-exempt spectrum.

5.40. The requirement of adopting LBT would concern operators intending to commercially deploy LTE-U technology. Singtel works closely with mobile terminal vendors in Singapore, and sees that the ecosystem may be geared more towards LAA (with LBT) compared to LTE-U. Before the 3GPP specifications for LAA were defined, LTE-U technology has been available for early

[18] 5G Americas reported in June 2017 that "*worldwide, LTE is forecast to continue its momentum, reaching close to 2.5 billion connections by the end of 2017, 3 billion in 2018 and 4.2 billion connections in 2020.*"
[19] Singtel is of view that < 91MHz will be available from L band for co-existence with EESS and MSS, while only the lower 100MHz of extended C-band will be made available for IMT to co-exist with FSS services.

adopters in countries such as the US, even before the eventual approval of devices by FCC in February 2017. In view of 3GPP having already ratified LAA specifications in its Release 13, operators will likely choose LAA implementation over LTE-U, considering in addition the fact that LAA has an evolution path to e-LAA to support uplink carrier aggregation.

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

5.41. There are already extensive test cases done on LTE-U by suppliers such as Ericsson and FCC has approved LTE-U as of 22nd Feb 2017. Similarly, T-Mobile is launching LTE-U following FCC certification. Singtel is of view that apart from (i) technical conditions prescribed in the Short Range Device Framework; and (ii) LBT protocol, there is no need to introduce further regulatory measures to ensure the sharing of license-exempt spectrum in an efficient and fair manner at this point

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

5.42. There are currently no commercial LTE-U network deployments in Singapore. Depending on the operators' business needs and the readiness of LAA and LTE-U ecosystems, the operators will need to decide whether to and when to deploy LAA or LTE-U networks with these commercial availabilities in mind.

Question 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

5.43. Singtel does not recommend any further information to be submitted to IMDA for assessment.

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

5.44. Singtel is of view that limiting the LAA.LTE-U trials to parts of 5GHz license-exempt spectrum may not necessarily minimise the impact to Wi-Fi users, as it may constrain the range of

frequency channels for LAA/LTE-U to switch to opportunistically – reducing the average speeds on the LAA/LTE-U. Due to the reduced speed on the LAA/LTE-U, users would have to occupy the radio resources longer to complete the data transactions or transfers. On the other hand, Wi-Fi APS which have static frequency channel allocation within the regulated range may have to share the license-exempt spectrum resources with the LAA/LTE-U more often than Wi-Fi APs which have dynamic allocation – this may not be fair-sharing.

5.45. Singtel would also like to re-emphasise that LBT ensures fair sharing in license-exempt 5GHz band and is standardised not only in 3GPP Release 13 but also in European Telecommunications Standards Institute, ETSI EN 301 893[20]. Several parameters i.e. Energy Detection Threshold (**ED**), Clear Channel Assessment (**CCA**) and extended CCA are included in the standards and should be reviewed and considered in the LAA trials.

- ED introduces a more sensitive threshold that is common for all technologies when sensing each other.
- CCA: If no signal is sensed based on ED threshold, then go ahead with transmission right away.
- eCCA: If channel is busy (CCA), then wait for it to become clear. Once it is clear, wait for a random number of additional CCAs indicating that the channel has remained clear before starting transmission.

Question 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

5.46. There are currently no other license-exempt frequency bands besides the 5GHz band for LAA and / or MuLTEfire. Network equipment vendors are still monitoring the uptake of 5GHz-based LAA and / or MuLTEfire before a decision can be made regarding whether additional license-exempt bands should be included in their developmental roadmap.

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

5.47. Singtel agrees with IMDA that similar regulations adopted for LAA should be applied to MuLTEfire operations to ensure existing and new occupants of the license-exempt spectrum are not compromised.

[20] http://www.etsi.org/deliver/etsi_en/301800_301899/301893/02.00.07_20/en_301893v020007a.pdf

Singtel

Question 18

IMDA would like to seek views and comments on the following: iii. The possibility of deploying LAA and / or MuLTEfire in other frequency bands besides the licence-exempt 5 GHz band; and

5.48. Both LAA and LWA complement each other under different deployment scenarios and can be useful in alleviating congestion during high traffic situations. Trials have shown that LAA does not cause additional interference to existing Wi-Fi Networks in comparison to introducing another Wi-Fi AP. Therefore the IMDA should not see a need to choose between LAA and LWA as a technology that is applicable for Singapore. Instead, the IMDA should consider the readiness of the whole ecosystem and terminal support in determining technology readiness.

5.49. Notwithstanding the aforementioned, Singtel would like to clarify the difference between LWA and Multi Path Transmission Control Protocol (**MPTCP**).

- LWA or LTE-Wi-Fi Link Aggregation leverages on the Dual-Connectivity defined in 3GPP Release 12 where, at the LTE base station interface, the user data on the Packet Data Convergence Protocol (**PDCP**) layer is being split from the LTE base station into the Wi-Fi link (which behaves as a second access for data), while the control is managed by the LTE base station. This solution requires close integration and inter-operability between the LTE base station and Wi-Fi AP.

- MCTCP does not require additional functionality on the LTE node, as MPTCP leverages on multiple TCP connections where LTE and Wi-Fi each takes a TCP connection. With this solution, users can enjoy faster speeds with the LTE aggregated with any Wi-Fi connection on the Internet Protocol (**IP**) level, as long as the device and network infrastructure supports MPTCP.

5.50. What the aforementioned means is that in practical sense, both the LTE and Wi-Fi components of the LWA solution will need to be supplied by the same network equipment vendor. In other words, when deploying LWA, the operator will need to leverage on their existing non co-located Wi-Fi APs (of the same vendor, if any) or decide to deploy additional Wi-Fi APs co-located with LTE. In the latter case where new APs are added, introducing LWA may create interference to the surrounding Wi-Fi APs from other service providers – LAA may be a fit for this scenario.

Singtel

Question 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.

5.51. LAA and LWA provide better quality-of-service, control and mobility, thanks to the presence of an LTE anchor carrier on a licensed spectrum band.

i. Quality-of-service: LAA can support carrier aggregation up to five carrier components, opportunistically boosting speeds up to a theoretical 1Gbps, anchoring on one carrier component on licensed spectrum band. Similarly, LWA anchors on an LTE component on licensed band, and is able to achieve speed boosts. In contrast to Wi-Fi offloading, when users are offloaded to Wi-Fi, user speeds can often be limited by the Wi-Fi coverage and capacity.

ii. Control and mobility: With LAA and LWA, the control signalling is still managed by the LTE anchor component, which includes handover, link adaptation, interference management and any other feature that maintains the robustness of the LTE anchor component. In contrast to Wi-Fi offloading, users on Wi-Fi will often experience abrupt transitions between different Wi-Fi APs, and this is often described as "break-before-make" phenomenon.

5.52. MuLTEfire does not require an anchor LTE carrier in the licensed spectrum and fully operates in the license-exempt spectrum. Therefore, the use case for MuLTEfire may not be strong for MNOs, since MuLTEfire may be more suitable for other companies (e.g. fixed-line service providers, Internet Service Providers, venue owners, etc) which do not own spectrum assets (licensed). Singtel further submits its concerns over the use of MuLTEfire over unlicensed spectrum and is of the view that IMDA should ensure that entities will not be able to bypass regulations and operate networks without an LTE License Anchor.