SINGAPORE TELECOMMUNICATIONS LIMITED

RESPONSE TO SECOND CONSULTATION ON
5G MOBILE SERVICES AND NETWORKS

1. CONTENTS

1.1. This submission is structured as follows:

2. SUMMARY OF MAJOR POINTS

2.1. Singapore Telecommunications Limited (**Singtel**) notes the IMDA's intention to facilitate the commencement of 5G rollout from 2020 after the standalone (**SA**) network standards have been finalised. This will place Singapore amongst the early wave of countries deploying 5G networks capable of supporting fully-fledged 5G functionality and services. However, based on our discussions with chipset and network equipment providers, currently there is no confirmed roadmap for chipset and network equipment for mmWave devices on a SA 5G network architecture. To date, Mobile Network Operators (**MNOs**) around the world have launched 5G services on non-standalone (**NSA**) 5G network architectures. Further, the 5G applications eco-system is also currently being developed using NSA technology. In light of this, Singtel submits that the IMDA must take NSA into consideration and facilitate a roadmap to transition from NSA to SA network architecture.

2.2. A two-network framework with the proposed spectrum allocation would result in two sub-optimal 5G networks that are not considerably superior to 4G. A lack of sufficient difference in 5G user experience will significantly temper market demand. Singtel suggests that the IMDA consider phasing the two-network deployment by allocating more spectrum to the first network and staggering the deployment of the second network, which can commence when more 3.5 GHz spectrum becomes available. The IMDA may also wish to consider allocating contiguous 100 MHz of 3.5 GHz spectrum on an unrestricted basis to enable superior 5G throughput performance.

2.3. Singtel suggests that the IMDA consider making 5G mmWave spectrum available from 2020 in a technology neutral manner (i.e. spectrum can be used for an NSA or SA architecture, and let market forces and consumer demand drive adoption). Due to the abundance of mmWave spectrum lots, Singtel is of the view that 28 GHz spectrum need not be shared and proposes that the IMDA debundle the mmWave band from the 3.5 GHz band packages and allocate dedicated 28 GHz spectrum lots of 800 MHz to each MNO. This will serve to drive greater competition and service innovation in 5G mmWave.

2.4. Singtel submits that a spectrum right of 12 to 15 years is insufficient and does not provide the required investment certainty for the MNOs, especially considering the denser deployment needed for 5G base stations (in comparison to 4G) to cover the same area. Given the nascent stage of 5G technology development and ecosystem readiness, the high cost of deployment, as well as the IMDA's emphasis on MNOs' network rollout, network design and resiliency, Singtel submits that a spectrum right of 20 to 25 years is appropriate.

2.5. Singtel submits that the IMDA should not impose a 5G network coverage obligation (50% coverage within 24 months from the commencement of the 3.5 GHz spectrum right) at this stage. Singtel is of the view that greater visibility of the ecosystem readiness is required along with consideration of the practical feasibility of deploying significantly more base stations that are necessary for 5G.

2.6. Singtel supports the IMDA's emphasis on 5G network design and resiliency, as Singtel sees network design and resiliency as key to future services, especially for critical communication services. Notwithstanding this, there is a need to have a balanced view of the network design and resiliency requirements versus the costs of implementation for any new technology rollout, and costs must be commercially justifiable. Thorough consultation with the industry should be held before any requirements are imposed. In addition, there are certain technical constraints, especially in the last mile to the base station, which are likely to make the proposed end-to-end resiliency impractical to implement. Singtel requests that the IMDA consider funding support for any requirements that may not be commercially justifiable.

2.7. In relation to the base prices for the allocation of the 3.5 GHz spectrum packages, Singtel submits that the base price should be set at the lower end of the benchmarks, to encourage investment and to reflect the higher risk associated with early 5G investment in terms of higher equipment cost and the uncertainty of market demand.

3. STATEMENT OF INTEREST

3.1. Singtel and its subsidiaries 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.

3.2. 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 Asia Pacific and beyond.

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

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

4. SPECIFIC COMMENTS

Vision and Recommended Playbook

Question 1

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

4.1. Singtel agrees with the IMDA that new skillsets will be necessary to handle new 5G technologies and spectrum characteristics, as well as network design and resiliency issues. As the IMDA has rightly recognised, 5G is still in a nascent stage of development. As use-cases emerge, the workforce transformation and skillsets required evolve and adapt. At this juncture, Singtel would broadly characterise the skill requirements into two categories, namely engineering-centric and digital-centric skillsets.

Question 2

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

4.2. The innovative use-cases for 5G rely on the high speed enhanced Mobile Broadband (**eMBB**) and low latency advantages of the 5G network. As such, the use-cases that are likely to attract demand include virtual reality (**VR**)/augmented reality (**AR**)/mixed reality (**MR**); cloud services and gaming; education; healthcare; security and communications. The more relevant and interesting use cases are typically content heavy and require high volumes of bandwidth, high downlink/uplink speeds and low latency.

4.3. In the area of VR/AR/MR, as consumer expectations and behaviour change from a fixed location of consumption of services (e.g. home) to on-the-go consumption via mobile devices and smartphones, the need for on-the-go technology will likely support demand for 5G. This will also require the relevant technology and devices to become cheaper and more mobile. On a broader level, gaming and entertainment will also increasingly require high bandwidth, high downlink/uplink speeds and low latency, as the services place a premium on streaming and content quality. This will include online multi-player gaming, live concerts and sporting events.

4.4. Singapore is recognised as the location-of-choice in the region for many Cloud service providers such as Amazon, Microsoft and Google siting their data centres in Singapore. The government may continue to support this environment, as the siting of content within Singapore will reduce both latency and cost. Singapore's high fibre connectivity also contributes to good backbone connectivity. Cloud services will become a key driver for 5G technology as cloud storage and high speed connectivity will be required to support 5G use-cases. With 5G enhanced mobile broadband and reduced latency, it is possible for heavy computing tasks to be shifted from devices to the network edge or Cloud, thus enabling future consumer devices to be lower in cost, smaller and light weight. One such example is the emergence of Cloud gaming, where projects such as Microsoft ProjectX Cloud, Google Stadia and Sony Playstation Now are showing signs of thinner client consoles emerging in the market.

4.5. In the education sector, immersive classroom experiences and remote learning opportunities will likely be the key use-cases, both in public and private education, as well as training settings. These include simulation training for military, security and professional services-based industries (such as pilots and drivers). Other industry sectors that may drive innovative use cases include security surveillance, emergency services and communications; factory monitoring and automation; real-time remote control; Cellular Vehicle-to-Everything (**C-V2X**) and autonomous driving technology; as well as healthcare services such as remote consultation and surgery.

4.6. Singtel wishes to highlight that while innovative use-cases may capitalise on Singapore's efforts to accelerate and scale 5G innovation, the direction and pace of 5G development is also heavily dependent on use-case emergence. This means that 5G specifications (such as the choice of radio access technology for Internet of Things (**IoT**) services for example) will be awaiting use case requirements. The requirements can vary due to factors such as data rate, latency, coverage, mobility, battery life and voice support, etc. In order to meet the diverse requirements, a single radio access technology may not be sufficient. Apart from NarrowBand-Internet of Things (**NB-IoT**), there are several other radio access technologies which can be considered. These include both proprietary vendor solutions, as well as 3GPP-standards-based Machine-Type Communication (**MTC**) solutions (e.g. Release 8 LTE Category 1, Release 13 LTE Category M1 and Release 14 Category 1bis).

4.7. Singtel is of the 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 due to the existing availability of 3GPP-based solutions like NB-IoT, LTE MTC and proprietary vendor solutions.

4.8. 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.

4.9. Therefore, the government will need to be as nimble and flexible as possible in responding to the needs of the industry. This means providing support for test-beds and trial opportunities (with relevant fee waivers, financial and tax incentives); expediting permissions and approvals processes; as well as coordinating inter-agency support and approvals for deployment and technology implementation proposals submitted by the industry.

Question 3

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

4.10. Singtel notes the IMDA's plan to make available 100 MHz of spectrum for outdoor, indoor and underground (unrestricted) use within the 3.5 GHz – 3.6 GHz band for 5G telecommunication systems and services, and up to 100 MHz of spectrum within 3.4 GHz – 3.5 GHz band on a "restricted" use basis, where deployments may have to be limited to indoors and underground.

4.11. In relation to suitable technical parameters (including the reasonable amount of guard band needed to reduce potential interference between International Mobile Telecommunications (**IMT**) and Fixed-satellite service (**FSS**) use in the 3.5 GHz band), Singtel would refer to the statement issued by the Hong Kong Office of Communication Authority (**OFCA**)[1] for Change in the Allocation of the 3.4 GHz – 3.7 GHz Band from Fixed Satellite Service to Mobile Service.

4.12. In the aforementioned statement, the OFCA has emphasised that protection of satellite downlink signal, which is very weak, would require suppression of unwanted mobile signals (which are typically very strong) receivable at the satellite dish. Additional filters would be needed to suppress the unwanted signal, and a frequency separation of 100 MHz is needed to ensure that the filtering effect is up to industry suppression requirements. OFCA has also issued its assessment on the impact of using 50 MHz or 100 MHz as guard bands, based on an official study with consultants, as follows:

> *"Laboratory measurements demonstrated that with a 100 MHz guard band, an appropriate band pass filter retrofitted into a SMATV system can suppress the receivable unwanted mobile signals by a magnitude of up to 60 dB. If the bandwidth of the guard band is reduced to 50 MHz, the achievable suppression is 27 dB only. To offer the same level of protection to SMATV systems when a 50 MHz guard band is used, the transmitting powers of mobile base stations need to be reduced proportionately by 33 dB, thereby leading to a significant decrease in the coverage area of a mobile base*

[1] Statement of Communication Authority, Change in the Allocation of the 3.4 – 3.7 GHz Band from Fixed Satellite Service to Mobile Service is available at https://www.coms-auth.hk/filemanager/statement/en/upload/441/ca_statements20180328_en.pdf

station and hence a corresponding increase in the number of mobile base stations required for attaining ubiquitous coverage. With these findings, the consultant has re-affirmed that a 100 MHz guard band is optimal in striking a balance between protecting SMATV systems on the one hand and not impeding the roll out of public mobile services on the other."

4.13. Singtel submits that with regard to the suitable technical parameters and the amount of guard band within the 3.6 GHz – 3.7 GHz spectrum range, IMDA will need to consider both the impact to the Telemetry, Tracking & Control (**TT&C**) services within 3.6 GHz – 3.7 GHz, as well as the impact to the coverage of 5G base stations. Providing a lesser amount of guard band (< 100 MHz) within 3.6 GHz – 3.7 GHz, as well as lowering transmitting powers of mobile base stations, would effectively place a cap on the full potential of 5G technology (i.e. beamforming). This will pose significant challenges to MNOs in building a 5G network, especially on a cost-efficient basis.

4.14. Singtel would emphasise that the IMDA needs to especially consider safety, liability and indemnity concerns, regarding out-of-band spurious emissions from 5G to FSS and the importance of the 100MHz guard band between 5G and FSS. It is challenging for the Singtel satellite (**ST-2**) TT&C & FSS antenna system to co-exist with all 5G base stations due to the high out-of-band spurious emission power. This is based on the 100 MHz guard band in 3.695 GHz ~ 4.2 GHz (Standard C) if no exclusion zone and/or 5G 3GPP filtering is incorporated for outdoor usage (given the current deployment status of all MNOs base station sites across Singapore).

4.15. To further evaluate 5G and its associated trials beyond 3.4 GHz - 3.6 GHz band, the IMDA must ensure that detailed modelling studies be conducted. These studies have to address feasibility of defined exclusion zones and/or 5G 3GPP filtering, as well as power and bandwidth specifications to be implemented (for indoor use together with the 5G spectrum for outdoor use). These studies will need take into consideration all 5G base station locations, be a pre-requisite, and involve all MNOs. Singtel does not recommend that the IMDA approve a trial without such studies, because no bandpass filter can eliminate the out-of-band spurious emission from 5G, which overlaps with the in-band frequency of FSS and ST-2 TT&C. Such an occurrence will greatly increase the risk profile of ST-2 and Singtel customers' (IPTV and FSS) operations.

Question 4

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

i. Whether the industry agrees with the timelines on the expected availability of the next wave of 5G spectrum; and

ii. Whether current deployments in the 2.5GHz FDD spectrum band (based on 3GPP Band 7) and in the 2.5GHz TDD spectrum band (based on 3GPP Band 38), should be refarmed to 3GPP Band 41 for future 5G services in Singapore, and the views on the associated costs and challenges.

4.16. Singtel agrees and maintains its position that the 700 MHz commencement date is dependent on the neighbouring countries' completion of analogue switch-off (**ASO**) at the border areas. L-band deployment will require further monitoring in terms of regional and international harmonisation of the channelling arrangements, as well sufficient ecosystem development. Similarly, the 4.5 GHz spectrum ecosystem development should also be further monitored before deciding to allocate this band for 5G in Singapore.

4.17. In relation to the 2.5 GHz FDD and 2.5 GHz Time division duplex (**TDD**) bands, this hinges on whether the MNOs decide to re-farm these spectrum bands from LTE to 5G before 2030 and 2033 respectively in accordance with the end of the associated spectrum rights. Regardless, Singtel submits that the IMDA consider the cost implications and recommends that further reviews should be conducted before any decisions are made.

Initial Market Structure and 3.5 GHz and mmWave Band Plan Options

Question 5

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

i. Whether Singapore should have two nationwide networks as a start given the considerations and trade-offs;

ii. The proposed 3.5 GHz lot sizes and spectrum packages;

iii. Whether 5G equipment would be able to support 3.5 GHz bandwidths in multiples of 50 MHz;

iv. The value, if any, in assigning the remaining 50 MHz restricted 3.5 GHz spectrum in the same assignment exercise as the unrestricted lots;

v. The proposed mmWave lot sizes and preferred band plan option; and

vi. The rank order preference of the 3.5 GHz spectrum package and mmWave lot combinations.

4.18. In relation to point i), Singtel notes the IMDA's intention to facilitate the commencement of 5G rollout from 2020 after the standalone SA network standards have been finalised. This will place Singapore amongst the early wave of countries deploying 5G networks capable of supporting fully-fledged 5G functionality and services. However, based on our discussions with chipset and network equipment providers, currently there is no confirmed roadmap for chipset and network equipment for mmWave devices on a SA 5G network architecture and any industry plans are on an indicative basis. [2] To date, MNOs around the world have launched 5G services on NSA 5G network architectures. Further, the 5G applications eco-system is also currently being developed using NSA technology. In light of this, Singtel submits that the IMDA must take NSA into consideration and facilitate a roadmap to transition from NSA to SA network architecture.

4.19. In its Consultation, the IMDA has cited a 5G peak downlink throughput of 1750 Mbps with 100 MHz of 3.5 GHz, which is above the 4G peak throughput of 1200 Mbps to 1500 Mbps in Singapore. A two-network framework with the proposed spectrum allocation would result in two sub-optimal 5G networks that are not considerably superior to 4G. A lack of sufficient difference in 5G user experience will significantly temper market demand. Singtel suggests that the IMDA consider phasing the two-network deployment by allocating more spectrum to the first network and staggering the deployment of the second network, which can commence when more 3.5 GHz spectrum becomes available.

4.20. With regard to point ii), to enable superior 5G throughput performance, Singtel suggests that the IMDA consider allocating contiguous 100 MHz of 3.5 GHz spectrum on an unrestricted basis.

4.21. Singtel notes that the IMDA would like to review the exact allocation of 3.5 GHz spectrum in the future, when more spectrum becomes available. In the case of mmWave, sufficient spectrum is available immediately, therefore there is no need for future spectrum reallocation of mmWave.

4.22. In respect to point iii), both 5G base station and user equipment will support 3.5 GHz bandwidths in multiples of 50 MHz, as defined under the 3GPP Release 15 technical specifications[3], specifically for New Radio operating band n78 (3300 MHz - 3800 MHz). Singtel obtains regular product roadmap updates from the mobile network equipment vendors, as well as from mobile device and chipset vendors. Singtel understands that 3.5 GHz bandwidths in multiples of 50 MHz will be supported in their products.

[2] Industry indicative roadmap is based on 3GPP Release 15 specifications from 2020 onwards, and Release 16 specifications from 2021 onwards.
[3] Refer to 3GPP TS 38.104 V15.5.0 (2019-03): http://www.3gpp.org/ftp//Specs/archive/38_series/38.104/38104-f50.zip and TS 38.101-1 V15.5.0 (2019-03): http://www.3gpp.org/ftp//Specs/archive/38_series/38.101-1/38101-1-f50.zip

4.23. In relation to point iv), Singtel is of the view that there may be little benefit in assigning the remaining non-contiguous 50 MHz restricted 3.5 GHz spectrum in the same assignment exercise as the unrestricted lots. This is in view of the fact that, without intra-band carrier aggregation between non-contiguous spectrum initially, and with only 50 MHz of 3.5 GHz indoors, the 5G peak downlink throughput per user indoors is expected to be between 550 Mbps and 875 Mbps. This is lower than the 4G peak downlink throughput of more than 1 Gbps under Singtel's network today. Singtel suggests that the IMDA consider allocating this non-contiguous 50 MHz restricted 3.5 GHz spectrum in the next phase.

4.24. With regard to point v) and vi), Singtel suggests that the IMDA consider making 5G mmWave spectrum available from 2020 in a technology neutral manner (i.e. spectrum can be used for an NSA or SA architecture, and let market forces and consumer demand drive adoption). Due to the abundance of mmWave spectrum lots, Singtel is of the view that 28 GHz spectrum need not be shared and proposes that the IMDA debundle the mmWave band from the 3.5GHz band packages and allocate dedicated 28 GHz spectrum lots of 800 MHz to each MNO. This will serve to drive greater competition and service innovation in 5G mmWave.

Key Obligations and Requirements

Question 6

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

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

4.25. In relation to point i), Singtel submits that the IMDA should not impose a 5G network coverage obligation (50% coverage within 24 months from the commencement of the 3.5 GHz spectrum right) at this stage. Singtel is of the view that greater visibility of the ecosystem readiness is required along with consideration of the practical feasibility of deploying significantly more base stations that are necessary for 5G.

4.26. With regard to the obligation of putting mmWave band to use within 12 months from the commencement of the spectrum right, Singtel proposes that the IMDA consider accepting deployment of 5G NSA on mmWave band. Currently, Singtel's understanding of the network equipment and device chipset vendor positions is that the industry has yet to include a roadmap to support 5G SA on mmWave band. The IMDA may wish to confirm the availability of 5G SA on mmWave band with the network equipment and device chipset vendors.

4.27. With regard to point ii), Singtel is of view that MNOs should be given the discretion to decide which geographical areas they would like to serve and cover, so as to fulfil the coverage requirement (if any) as well as meet MNOs' business objectives. The methodology to measure the 5G SA coverage should be similar to that of 4G, while the measurement criteria should be decided at a later stage in a closed discussion with the 3.5 GHz spectrum right holders.

4.28. Singtel notes that IMDA plans to impose regulatory requirements to ensure 5G networks remain resilient and trusted. Singtel supports the IMDA's emphasis on 5G network design and resiliency, as Singtel sees network design and resiliency as key to future services, especially for critical communication services. Singtel also sees reasonable resiliency as part of the required and acceptable service level for 5G services.

4.29. In respect to point iii), Singtel notes that there are significant challenges in achieving 100% resiliency in the last mile to the base station. To meet such resiliency requirements, MNOs will have to invest in 100% duplicated base station components (e.g. baseband units, cell site routers, etc.) as well as mobile backhaul. Such an approach will require a complete redesign and overhaul of the existing radio access networks and it would involve substantial cost and take considerable time. In addition, the existing provision of space and power for mobile infrastructure is likely to be insufficient, so the surrounding passive infrastructure is also likely to be upgraded. In order to overcome the challenge, Singtel would suggest that the IMDA consider resiliency based on overlapping coverage, including coverage from other technologies (such as LTE).

4.30. Singtel would like to emphasise the need to have a balanced view of the network design and resiliency requirements versus the cost of implementation for any new technology rollout, and costs must be commercially justifiable. This is to ensure that the business model remains viable and sustainable for the consumers, enterprises, government and the MNOs. In addition, there are certain technical constraints, especially in the last mile to the base station, which are likely to make the proposed end to end resiliency impractical to implement. Thorough consultation with the industry should be held before any requirements are imposed. Singtel requests that the IMDA consider funding support for any requirements that may not be commercially justifiable.

4.31. Singtel notes that spectrum right holders shall provide 5G wholesale services to other mobile service providers, specifically to any MNOs and MVNOs, upon request. Singtel will support a continuation of existing frameworks in this area.

Spectrum Assignment Mode

Question 7

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

4.32. Singtel agrees with the IMDA proposal that an auction approach will not bring about the desired policy outcomes in this first wave of spectrum assignment and supports the IMDA's proposal to assign the spectrum via a call for proposal (**CFP**) approach.

4.33. Singtel notes that IMDA is proposing around 12 - 15 years for the duration of the spectrum rights. A spectrum right of 12 - 15 years is insufficient and does not provide the required investment certainty for the MNOs, especially considering the denser deployment needed for 5G base stations (in comparison to 4G) to cover the same area. Given the nascent stage of 5G technology development and ecosystem readiness, the high cost of deployment, as well as the IMDA's emphasis on MNOs' network rollout, network design and resiliency, Singtel submits that a spectrum right of 20 to 25 years is appropriate. Reference from other countries such as UK[4] and Germany[5] suggests that a more adequate duration for spectrum rights is important.

[4] Refer to OFCOM website for UK 3.5 GHz license term.
https://www.ofcom.org.uk/__data/assets/pdf_file/0030/81579/info-memorandum.pdf

[5] Refer to Bundesnetzagentur website for Germany 3.5 GHz license term.
https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/201070704_KeyElementsDemandIdentification.pdf?__blob=publicationFile&v=1

4.34. In relation to the base prices for the allocation of the 3.5 GHz spectrum packages, Singtel submits that the base price should be set at the lower end of the benchmarks, to encourage investment and to reflect the higher risk associated with early 5G investment in terms of higher equipment cost and the uncertainty of market demand.

4.35. While we welcome the IMDA's proposal not to impose any spectrum premium for the mmWave spectrum due to the excess supply of mmWave spectrum available, we request that the IMDA also consider waiving the applicable annual charge for the mmWave, similar to the approach undertaken by the OFCA of Hong Kong[6], which highlighted its "abundant supply" and how such a move would "shorten the time involved" for 5G roll-out. At least, the IMDA should consider waiving the applicable annual charge for the mmWave spectrum for the initial years (e.g. 5 years).

Question 8

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

4.36. The IMDA has already pointed out that site colocation and backhaul models are the most basic form of network sharing, where operators share either their sites or transmission, while deploying other passive and active elements on their own. If the partner networks are deployed in different regions within Singapore especially in the initial years of >50% coverage, site colocation may not apply and there may not be overlapping coverage between the sharing network operators in the same region. Backhaul sharing between partner networks is possible, but in case of a fibre cut at the shared portion of the backhaul, services on all networks will be impacted at the same time.

4.37. The IMDA has also highlighted that passive infrastructure sharing has already been deployed by the MNOs, largely limited to in-building and in-tunnel antenna system. For 5G, as a majority of the existing passive components do not support the 3.5 GHz and mmWave spectrum, the industry is looking at deploying small cell type solutions in-building, which can allow active sharing – these can be either Multi Operator Radio Access Network (**MORAN**) or Multi Operator Core Network **(MOCN**). For in-tunnel, passive infrastructure sharing may still apply, provided that the leaky cable system can be modernized to support 3.5 GHz spectrum.

[6] Hong Kong aims for cheaper, faster 5G roll-out with proposal to not charge telcos for spectrum Retrieved from: https://www.scmp.com/news/hong-kong/hong-kong-economy/article/2157078/hong-kong-aims-cheaper-faster-5g-roll-out-proposal

4.38. MORAN is technically feasible if operators decide to share the same base station active elements (baseband and radio) and passive elements (antenna feeder system) from the same network equipment vendor, while keeping spectrum and core networks separate. The base station would be the single-point-of-failure impacting both network operators in case of faulty radio/antenna system. As there is an abundance of mmWave spectrum, MORAN would be more feasible for mmWave deployment if sharing operators have the same coverage objective, especially where it is a common access area with common customers. Operators can decide not to share (with MORAN) when the operators need to serve different customers. This may not be applicable to the 3.5 GHz spectrum since it is a scarce resource.

4.39. MOCN is similar to MORAN in terms of sharing the base station active and passive elements, except that MOCN includes sharing of the spectrum. MOCN is recommended for 3.5 GHz spectrum sharing, and when the sharing operators still want to have individual network slicing capabilities. The MOCN model will only be possible if the potential sharing operators are agreeable to the same deployment and coverage objectives.

4.40. Hosted (wholesale) model is technically feasible as well, but both the shared core network and shared RAN would be the single-point-failure. The sharing partners would need to discuss and agree on an arrangement to manage and operate the network.

Question 9

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

i. The synchronisation approach for 5G TDD networks in a multi-operator environment for the 3.5 GHz and mmWave bands, specifically for the following:

a. Synchronised networks: the required frame alignment, compatible frame structures and BEM specifications for AAS and non-AAS base stations; and

b. Unsynchronised networks: the amount of guard band, geographical separation and BEM specifications for AAS and non-AAS base stations;

ii. The adoption of other suitable mitigation measures to mitigate interference between unsynchronised networks; and

iii. The need for IMDA to mandate a regulatory requirement for synchronisation across the 5G TDD networks or leave it to operators to co-ordinate their network deployment and parameters in order to reduce interference between networks.

4.41. Singtel shares the IMDA's view with regard to fully synchronising the TDD networks on the 3.5 GHz band. This means that there will not be a need for any of the available spectrum to be used

for guard bands for the purpose of interference prevention, leading to more efficient use of the spectrum. Given that the 3.5 GHz spectrum is a scarce resource in Singapore, it is reasonable for IMDA to propose synchronised networks for 3.5 GHz band. The frame structures and BEM specifications for AAS and non-AAS base stations should be compliant with what has been defined in 3GPP Release 15 specifications[7]. For full synchronisation of TDD networks, the following network parameters need to be aligned, namely:

- Numerology (subcarrier spacing and slot/symbol length)
- Downlink-uplink transmission pattern periodicity
- Number of consecutive full DL slots at the beginning of each DL-UL pattern
- Number of consecutive full UL slots at the end of each DL-UL pattern
- Number of consecutive DL symbols in the beginning of the slot which follows the last full DL slot
- Number of consecutive UL symbols in the end of the slot which precedes the first full UL slot
- Optional pattern-2

4.42. Singtel submits that MNOs should consider aligning the frame structure with best practices and mainstream deployments globally. Singtel is still monitoring global trends on this matter and has yet to decide on which frame structure to adopt. Further, with regard to mmWave TDD networks, Singtel welcomes the IMDA's proposal of allowing MNOs to have the flexibility of customising network parameters used for serving different requirements from different specific use-cases within a localised area. Each localised mmWave deployment may require a different uplink/downlink transmission ratio, spectral efficiency and latency. Hence, there is no one-size-fits-all for mmWave scenario. Due to the propagation characteristics of this frequency band, deployments in this frequency band are unlikely to result in mutual interference with sufficient geographic separation.

4.43. With regard to suitable measures to mitigate interference between unsynchronised networks, MNOs can consider adjusting engineering parameters such as base station antenna azimuth, tilt angle, horizontal and vertical beam-width, as well as the radio transmit power. This is in addition to geographical separation, guard band separation and adoption of external customized filters for non-AAS base stations.

[7] Refer to TS 38.211 V15.5.0 for NR numerology (subcarrier spacing and slot length), TS 38.213 V15.5.0 for slot configuration and format, and TS 38.104 V15.5.0 for AAS and non-AAS BEM.
http://www.3gpp.org/ftp//Specs/archive/38_series/38.211/38211-f50.zip
http://www.3gpp.org/ftp//Specs/archive/38_series/38.213/38213-f50.zip
http://www.3gpp.org/ftp//Specs/archive/38_series/38.104/38104-f50.zip

4.44. Singtel submits that there is no need for the IMDA to mandate a regulatory requirement for synchronisation across the 5G TDD networks. The IMDA may leave it to MNOs to co-ordinate their network deployment and parameters in order to reduce interference between networks. However, to facilitate the coordination on mmWave unsynchronised networks deployment, Singtel proposes that the IMDA provide a geolocation database for MNOs to register localised mmWave deployments and prompt for coordination if the location registered is adjacent to an existing deployment by another MNO. In this manner, both the IMDA and MNOs can play a more pro-active role in mitigating interference on the mmWave band.

Other Facilitation/Reviews Required

Question 10

IMDA would like to seek views and comments on the following: *i. The interest from industry players to leverage 5G spectrum or other mobile spectrum bands for fixed-wireless services that support mobile connectivity; and* *ii. The policies (e.g., spectrum allocation, numbering) that should be considered to facilitate such use-cases.*

4.45. Singtel is open to evaluating using 5G for the provision of fixed-wireless access (**FWA**) service as a high-speed internet access alternative to current Fibre NBN. The key consideration is the relatively high costs of deployment of 5G NR in comparison to fibre broadband. These costs may impact the cost per connection, which may impact the commercial feasibility of such a proposal. It will be a commercial decision whether to deploy 5G or to lay fibre to locations requiring high-speed internet access.

4.46. We note that the 3G and 4G spectrum are currently capable of supporting data-enabled voice/video services. Many application-based voice/video services are already using mobile data to deliver their voice/video services, e.g. WhatsApp, WeChat, etc. Such services are very prevalent as compared to fixed line voice services. Singtel supports the use of mobile spectrum (3G, 4G or 5G) for fixed-wireless services that support mobile connectivity. We are of the view that there are benefits to allowing operators to use mobile spectrum for fixed-wireless services, e.g. customers do not need to install internal wiring or be constrained by the location of the internal wiring within their premises.

5. OTHER COMMENTS

5.1. Singtel notes that the 2019 World Radio Communication Conference (**WRC-19**) will take place in October/November 2019. Therefore, 5G mmWave deployment from 2020 would benefit from mmWave spectrum harmonisation and allow Singapore to reap the economies of scale from commercially available 5G equipment. Singtel is pleased that given global developments related to the use of 26 GHz and 28 GHz bands for 5G services, IMDA has decided to allocate these bands on a primary basis to mobile service, in addition to existing allocations, if any. Singtel notes that under this arrangement, mobile service, fixed service and fixed satellite service operating in the frequency band 28.5 GHz – 29.5 GHz will be on a co-primary basis, while mobile service and fixed service operating in the frequency band 27.5 GHz – 28 GHz will also be on a co-primary basis. Singtel proposes that the IMDA provide a geolocation database for MNOs, FS and FSS operators/users to register the use of mmWave and prompt for coordination if the location registered is adjacent to an existing deployment. In this manner, both the IMDA and MNOs can play a more pro-active role in mitigating interference on the mmWave band.

5.2. Concerning infrastructure access, Singtel shares the view that a coordinated whole-of-government approach is required to facilitate access to commercial and non-commercial locations for the deployment of small cells and other new telecommunication infrastructure. The Code of Practice for Info-communications Facilities in Buildings (**COPIF**) will need to be further amended to include space, power and facilities needed for 5G infrastructure. It will be essential to extend COPIF requirements to non-commercial locations and public facilities/ infrastructures such as lampposts, bus stops, substations and monopoles, and equipped with pre-laid power and fibre cables. It is important to increase the allocation of mobile installation space (**MIS**) to cater for 5G equipment and to provide specific access to spaces required for the deployment of small cells and other new technologies on a rent-free basis.

5.3. Singtel agrees with the IMDA that there are geographical clusters in Singapore with dense deployment of FSS services such as the Seletar Earth Station, which houses the TT&C operations of an operational satellite, including manoeuvring the satellite in orbit and monitoring the operational status of the satellite. As a satellite operator, Singtel submits that technical studies to assess the feasibility of 5G deployment within 3.4 GHz – 3.7 GHz bands (to determine the final amount of guard band) must be carried out with extreme caution and without putting at risk any existing operations.

6. CONCLUSION

6.1. The IMDA should continue to actively engage industry post-consultation, due to the constantly developing and nascent nature of 5G technology. Singtel would be pleased to clarify any of the views and comments made in this submission, as appropriate.