



## **Second Consultation on 5G Mobile Services and Networks**

**Submission by TPG Telecom Pte Ltd to the  
Infocomm Media Development Authority**

**8<sup>th</sup> July 2019**

## Introduction:

TPG Telecom Pte Ltd (TPG) thanks IMDA for the opportunity to respond on the Second Consultation on 5G Mobile Services and Networks dated 7th May 2019 (Consultation).

IMDA has articulated well the important and fundamental aspects of 5G technology in paragraphs 6 to 11 of the Consultation. TPG shares IMDA's 5G vision and its undeniable impact on the nation and economy. If executed well, Singapore will undoubtedly take the lead as the premier regional 5G innovation centre to drive new and transformational use-cases.

Given the economic and foundational nature of 5G, a supportive regulatory environment to speed up the rollout of the new 5G network is essential. From a build perspective where massive network densification is needed and taking into consideration of importance of security and resiliency in today's connected world, support and cooperation from all related Government agencies will be required. This strategic 5G national rollout will effectively be the ideal case study for public-private partnership. After all, 5G is a convergence play and poised to change the industry landscape. Monetizing 5G requires new business model innovation and cross-sector partnership in the more machine-centric environment.

TPG welcomes the introduction of 3.5GHz and 26-28GHz (mmWave) for the first wave of spectrum allocation given similar deployments globally which results in quicker on-boarding of 5G devices which support these bands. However, given IMDA's deemphasis on eMBB and the preference to launch with a 5G Standalone (SA) network, TPG agrees with IMDA's more relaxed coverage obligations for both these bands as there will be several initial deployment challenges including technology maturity to overcome. Thus, TPG advocates a market driven approach for the introduction of 5G to the public. The initial wave of commercially available devices are eMBB-focused and primarily NSA only. MNOs have already invested in NSA-capable mobile core architectures. Thus, MNOs are in a position to rollout NSA initially with a smooth migration to SA with dual NSA/SA co-existence.

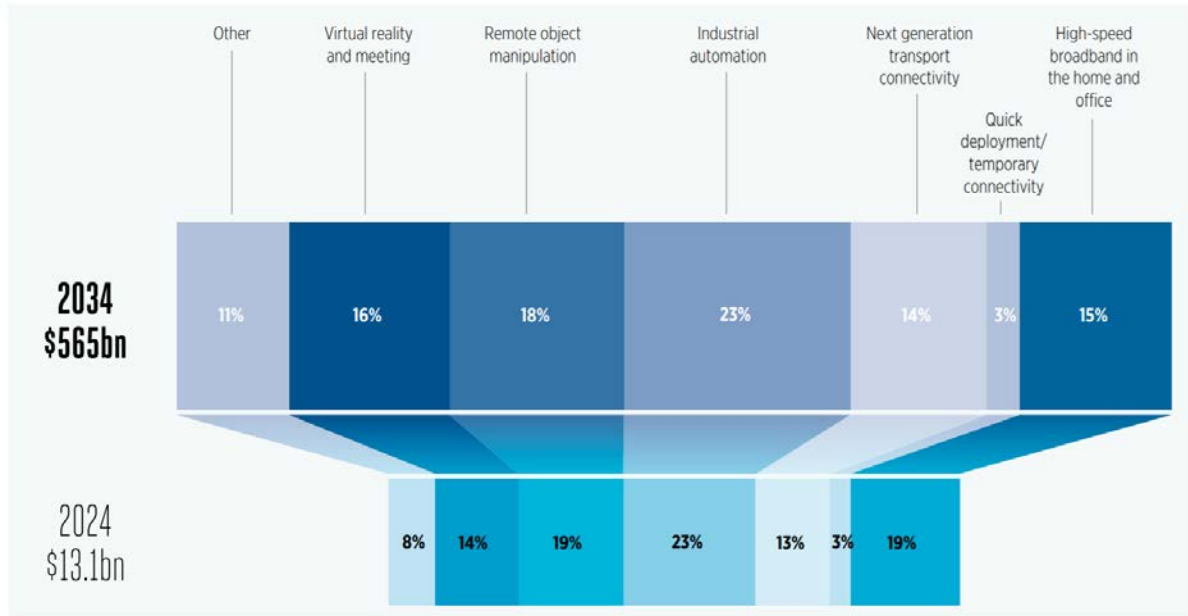
5G chipset development is moving rapidly with support for 3GPP Bands 1, 7, 38, 40, 41, 79 and other bands coming into the market by 1H 2020. For a successful and effective 5G deployment, an MNO will need to deploy 5G across a mix of low-band, mid-band and high-band spectrum to provide coverage, capacity and resiliency. As such, it would be essential for IMDA to make all existing spectrum assigned to MNOs technology neutral to facilitate the deployment of state-of-the-art technology in a timely and flexible manner to best meet the market demand. In support of our nation's ICT objectives, allowing technology neutral spectrum licences is best practice. GSMA studies have shown that countries that were among the first to implement them have been rewarded with better coverage and higher mobile broadband speeds.

In a report published June 2019 titled ***"The Benefits of Technology Neutral Spectrum Licences"***, GSMA further concluded that *"Regulators who prevent operators from using the latest technology in any frequency band are very likely to be in conflict with their own mandate to ensure efficient use of spectrum as well as the Constitution of the ITU. Not only is this bad practice from a purely regulatory view point but more importantly MNOs paying again for licences they have already purchased is damaging for the economies of these countries. Charging for making spectrum technology neutral is effectively a barrier to investment because it introduces a disincentive to invest in new technology. This runs contrary to the fundamentals of economic management. Investment should be actively encouraged and not disincentivised through what becomes effectively a re-farming tax."*

TPG believes that it is important to allow MNOs the flexibility to 5G NR enable their existing spectrum so that they can optimize the characteristics of the various frequency to build a

more cost effective and resilient 5G network with best outdoor and indoor coverage from the onset.

It has been projected by GSMA that 5G mmWave deployment will enable new use cases which in turn will contribute significantly to global GDP as shown in the diagram below:



Given the strategic importance of 5G mmWave, TPG recommends that all four MNOs in Singapore be given as much allocation as possible (in equal shares) to drive competition and innovation. This is similar to the recommendation in the GSMA Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands (Dec 2018). MNOs have various vendor alignments and by introducing a good mix of mmWave equipment with their respective capabilities will ensure the best technological outcome for users be it consumers, enterprises and industrial users. Allocation of mmWave should be decoupled from the 3.5GHz spectrum should IMDA determine that the allotment will be decided by the proposed “call of proposal” approach. Based on TPG’s analysis, up to 240MHz of 3.5GHz spectrum can be made available for 5G and thus 60MHz can potentially be assigned to each MNO. TPG also proposes that mmWave spectrum should be completely license fee and utilization fee free so that MNOs can maximize their financial resources for a wider and deeper deployment of mmWave coverage similar to OFCA’s recent decision

Given the extensive nature of 5G deployment, associated investments by MNOs and ongoing 5G technical standards evolution, TPG strongly recommends the duration of the spectrum rights to be considered for 20 years. It will take time for many of the 5G use-cases to gain momentum and become profitable as well.

TPG agrees with the view that network synchronization alignment amongst MNOs, and with the neighboring countries is crucial for maintaining interference free network and maximizing available scarce 3.5GHz spectrum resources. TPG suggest that IMDA mandate a regulatory requirement for synchronization across 5G TDD networks.

We address the questions raised in the Consultation by restating them and responding as follows:

**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.*

**TPG response:**

As 5G is based on a flexible service-based architecture with support for network slicing for a wide variety of use cases, it is expected to be a revolutionary business-driven technology infrastructure enabler. 5G will provide fibre-like and resilient network capabilities to enable the Digital Transformation across a range of industries including but not limited to manufacturing, transport, aviation, agriculture, education, construction, health-care, public utility, multimedia, and entertainment industries. Therefore, the new skills requirements with the advent of 5G are not limited to ICT industry only but across all related industries.

ICT professionals have to learn new skills to match the requirements to operate and manage a 5G network especially with its extensive use of virtual/cloud technologies. Deep appreciation and understanding on how to secure the network on an end-to-end basis will be important given the pervasive nature of 5G deployment for both businesses and consumers. The substantial technology changes in the underlying infrastructure paves the way for several new job roles which will have an influence not only on the telecom industry but the other industries as well.

The diagram (Figure 1) below depicts the 5G and Digital Transformation which introduces new skillsets for the whole ecosystem. Two key skill change drivers are 5G Infrastructure Operations and Ecosystem Digital Transformation that drive skill domain changes. The skillsets may include but are not limited to:

- Industrial Digital Service Design
- Big Data and Data Analytics
- Artificial Intelligence
- Applications of NFV and SDN Technology
- Software and Application Development
- Cloud Computation
- Network Security/ Cyber Security
- IoT
- 5G New Radio (NR)
- Industrial Business Process Digitalization

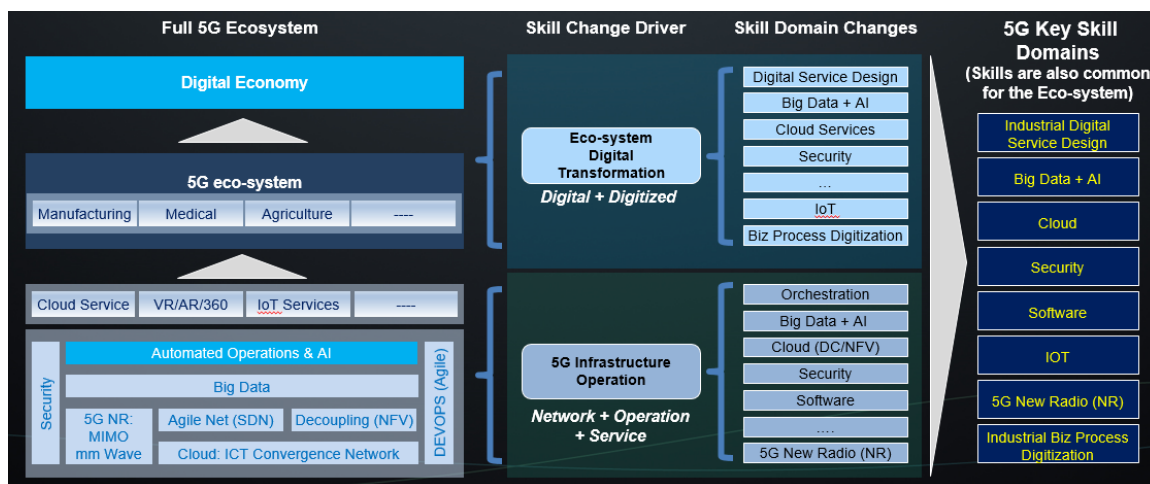


Figure 1 : 5G & Digital Transformation brings new skills for whole ecosystem

**Question 2:** IMDA would like to seek views on:

- (i) The types of innovative use-cases that could capitalize 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.

**TPG response:**

(i) Innovative 5G Use Cases

As outlined in the introductory remarks above, 5G (especially with the introduction of mmWave specific use-cases) will undoubtedly enhance Singapore's competitive advantages. Three-dimensional capabilities of 5G i.e. ultra-low latency, massive machine connectivity and deployment, and enhanced mobile broadband makes the 5G technology different than the current 4G & 3G technologies. Key to rapid and pervasive 5G deployment will be of strategic importance and hence IMDA's decision on mmWave allotment decoupling from the 3.5GHz spectrum lots and allocation of mmWave spectrum to all MNOs will help foster and build a vibrant 5G industry.

By way of an example, 5G technology will benefit Singapore's shipping industry through the introduction and use of autonomous delivery vehicles and support for remote operations of heavy machines with precision and accuracy.

Other 5G use cases range from immersive entertainment and gaming to robotics including industrial controls in critical national infrastructure. Given Singapore's recognition of having the best healthcare system in the region, remote robotic surgery is another excellent 5G use case which can enhance Singapore's premier healthcare status even further. It is evident that such use cases will involve cross-industry collaboration, joint investment and support from related government agencies.

Additional potential use-cases of 5G include:

- elderly health care and remote diagnosis of a medical condition in support of the nation's ageing population. 5G will enable a much larger number of active sensors

to be connected (always-on) and large amounts of data to be carried efficiently and processed in realtime.

- smart grid, smart parking and smart metering in addition to autonomous cars, autonomous delivery vehicles, and remote driving.
- use of machine learning and artificial intelligence with 5G will enable smart operation and automation of processes in the service industry as well as the manufacturing industry.
- adoption of 5G to elevate live-stream broadcasting, cloud gaming, cloud-based AR/VR (augmented reality/virtual reality) which will transform legacy electronic-gaming. Widespread use of AR/VR will help the education and travel sectors in particular when they apply these technologies.
- Cloud X services which allows cloud-based interactive computing applications with the real-time transmission on smart devices. Interactive applications streamed from the cloud will increasingly serve enhanced mobile and fixed wireless access (FWA) services based on 5G technology.

5G connectivity and augmented with edge-based computing where applicable will certainly enable digital transformation, resulting in exponential improvements in service delivery and productivity for enterprises, government departments, small business and consumers. It will also support a broad range of new interconnected network traffic evolving from IoT sensors and thereby enable highly customized and personalized experiences for connected consumers.

(ii) Government Support:

In order to enable innovation and drive rapid development of 5G, it requires strong and holistic support of the government in the following areas:

1. **5G Spectrum** – making 3.5GHz spectrum affordable, mmWave spectrum licence fee free and existing low-band/mid-band spectrum technology neutral. The proposed reserve price for 3.5GHz spectrum is very high when benchmarked internationally. High spectrum prices will affect the initial investment and rollout for the initial wave of 5G implementations in Singapore. On the other hand, there is ample spectrum in the 26-28GHz band with no competing applications and thus it is imperative to release as much spectrum as possible to all MNOs to build a more vibrant and innovative 5G industry.
2. **5G Technical Lab** - subsidiary and research fund support to drive and validate 5G new use-cases and to independently audit the 5G network deliverables committed by MNOs as part of their obligations.
3. **Support from Government agencies** - HDB, LTA, SCDF & URA, etc. in particular to speed up mmWave deployment and allow for optimal placing of 5G AAS antennas.
4. **Policies** - Friendly policies for 5G ecosystem development such as incentives for MNOs to speed up 5G deployment and innovative industrial use-case development.
5. **Revision of COPIF** - to include the needs unique to 5G infrastructure, especially availability of street furniture to support dense network deployment.

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

**TPG Response:**

Two primary impairments can affect the coexistence of the C-band FSS and IMT in the 3.5GHz band:

1. LNB saturation:
  - a. 5G in-band transmissions will be received by the Earth stations and may drive the LNB into saturation.
  - b. TPG recommends that Earth stations must be fitted with band-pass filters to prevent 5G signals from over-driving LNBs.
  - c. Have consultation with filter manufacturers to design a filter that achieves desired attenuation in the smallest bandwidth possible.
2. 5G OOB emission:
  - a. 5G out-of-band transmissions will be received in band by the Earth station. Filtering doesn't help.
  - b. Trade-off assessment of the BS transmission OOB is ongoing to determine the required OOB requirements to meet the C/N+I performance.
  - c. Close coordination with 5G equipment manufacturers to further understand the actual transmission characteristics will be required. For 5G equipment typically operating from 3.4 to 3.6 GHz, there is usually a hard filter installed to ensure minimal OOB emissions beyond 3.6GHz.

Taking into consideration the above points and to maximize the availability of C-Band unrestricted-use spectrum for 5G, TPG recommends technical trials with FSS operators, filter manufacturers and 5G equipment vendors to determine the appropriate guard band. IMDA may wish to consider allocating C-Band spectrum for IMT services up to 3.65 GHz with a 50 MHz guard band. This would require steep filters to be installed at the antenna or within the AAU for unrestricted use to reduce the impact of potential interference with FSS. 3.60-3.65GHz for restricted use can be assigned safely based on desktop analysis due to inherent indoor-to-outdoor signal degradation.

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

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

**TPG Response:**

(i) As outlined above, 5G deployment across a wide number of existing 3GPP bands will see rapid progress even faster than that of 4G. It is thus imperative that all MNO's spectrum be made technology neutral and refarming will be carried out based on individual MNO's existing traffic profile and projected 5G traffic take-up. 5G eco-system support for various bands will be even quicker than that of 4G given the rapid development of 5G chipsets and the sophistication and flexibility of RF front-ends of end-user equipment.

(ii) Refarming of 2.5GHz FDD spectrum band will be near impossible without close coordination with our geographic neighbours. Nevertheless, TPG notes that 2.5GHz TDD is well suited for 5G deployment and it is widely used in both US and China. Given the importance and significant global support of 2.5GHz TDD for 5G services, IMDA may wish to take the opportunity to optimize the utilization of the existing spectrum assigned from 2570MHz to 2615MHz. This is a valuable spectrum that should be put to use in the interest of the industry and the public. TPG is willing to consider options to relocate its assigned 10MHz from 2570MHz to 2580MHz to ensure the best utilization of this available 2.5GHz TDD block for 5G services.

**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.

**TPG Response:**

- (i) With 5G, Singapore must leverage its unique position to a leading innovator in this region. Innovation is best driven by market competition and having only two 5G nationwide networks based on the artificial scarcity of 3.5GHz spectrum runs contrary to fundamental economic principles. Allowing all MNOs to embrace 5G will drive the expansion of “super-connected era” and the fusion of new technology and real economy. After the assignment of the 3.5GHz spectrum, MNOs will undoubtedly explore RAN sharing if it is in their best economic and financial interest.
- (ii) Based on TPG’s assessment to Question 3, TPG urges IMDA to consider allocation more 3.5GHz spectrum for unrestricted use. By making 250MHz available, it is possible to allocate at least 50MHz or more to each MNO.
- (iii) There are no known limitations for currently available 5G equipment to support 3.5 GHz bandwidths in multiples of 50 MHz. Current market available 5G RRUs operating from 3.4GHz to 3.6GHz has steep filters at the 3.6GHz edge which will limit the interference with FSS.
- (iv) Based on the 250MHz which TPG believes is assignable to MNOs, TPG does not see the need for any restricted-use classification if FSS bandpass filters are implemented along with a steep filter for the operator assigned with the 3.60-3.65GHz block. There should not be any restrictions on the use of 3.40-3.50GHz as it would be wasteful and several regulators globally including OFCA have assigned this range without restrictions and without any guard bands.
- (v) Similar to our position for 3.5GHz, TPG strongly believes that all four MNOs should get the opportunity to have 5G mmWave spectrum in the first wave. Given the vast amounts of mmWave spectrum available from 24.3GHz to 29.5GHz, the ability for 5G equipment to carrier aggregate more than 800MHz of spectrum from 3GPP R16 onwards and to have ample bandwidth to support Integrated Access and Backhaul and to realise the full potential of 5G, TPG proposes that MNOs submits via the Call-For-Proposal the number of 400MHz blocks they wish to be assigned with the following consideration: a minimum rollout of 2 mmWave AAUs per MHz assigned



within 5 years. It is suggested that MNOs be subjected to a 1,200MHz cap per MNO. Given the limited availability of 3.5GHz spectrum, the true benefits of 5G can only be delivered with mmWave and TPG encourages that IMDA takes the forward-looking approach of OFCA for mmWave assignment.

- (vi) Based on TPG's proposal above, there is no ranking of preference but assignment of blocks below 3.6GHz is preferred in C-Band due to existing NR equipment limitations.

**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.*

**TPG Response:**

- (i) TPG welcomes IMDAs' views that the deployment of mmWave would be localized and that it would not be realistic to deploy mmWave for continuous nationwide coverage given the signal propagation challenges. The requirement to achieve 50% 3.5GHz outdoor coverage within 24 months from the date of the spectrum rights will be challenging as there is a need to mitigate interference issues and more optimal antenna placement for AAS antennas will need to be planned, permitted and executed. 3.5GHz rollout will require the coordination of FSS operators to install the required band-pass filters. To address 5G initial coverage challenges, TPG proposes the use of MNOs' existing spectrum will help fill 3.5GHz coverage gaps for outdoor, indoor and tunnels and this is essential for good user experience and to avoid any disappointments arising from the high expectations of 5G capabilities.
- (ii) Based on vendor feedback, TPG is of the view that current threshold of -109dBm for CSI RSRP continues to be relevant for 5G. In support of uRLLC applications, latency and reliability thresholds for various scenarios may be considered and set through future industry consultations.
- (iii) Network design and resilience challenges of 5G can be addressed with the basic engineering principles such as path diversity and the right system and network architecture. Complexity has to be managed and at the same time, advances in hardware and software technologies adopted rapidly to embrace new features and improve automation based on data analytics.
- (iv) If awarded the 5G spectrum, TPG is open to 5G RAN sharing with any MNO who is not assigned 3.5GHz spectrum on an equitable basis and will provide 5G wholesale services to any MVNO upon request. TPG will adhere to the negotiation principles for wholesale access by IMDA. In particular, TPG will ensure that its wholesale prices should be no higher than its retail prices and ensure that the 5G wholesale services are provided in a timely-manner, on non-discriminatory basis, for both price and non-price elements.

**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.*

**TPG Response:**

- (i) From TPG's perspective, there is sufficient 3.5GHz spectrum to be allocated to all existing MNOs with the spectrum price set at globally comparable \$/Mhz/Pop/Yr benchmarks. Operators can then collaboratively discuss on a commercial basis the possibility of RAN sharing to optimize their respective cost structures.

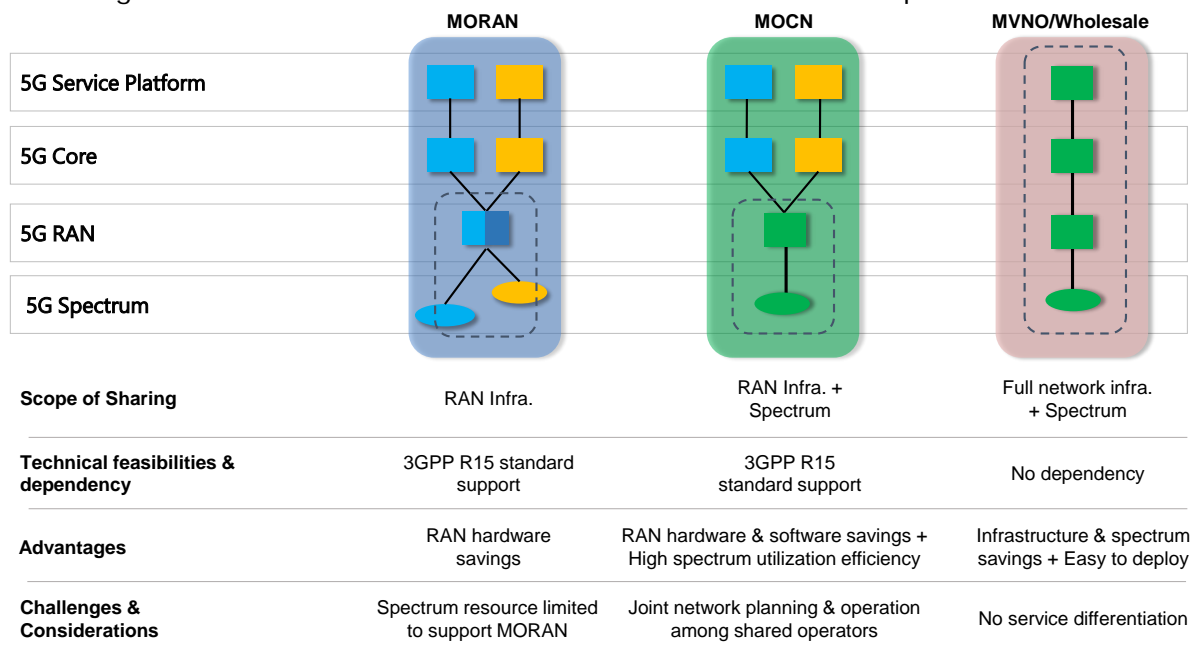
TPG appreciates IMDAs approach in maintaining that the mmWave spectrum allocation has no upfront license cost. It should be decoupled from 3.5GHz spectrum licenses and assigned on a standalone basis to provide MNOs the flexibility to rollout 5G NSA and SA mmWave services to augment low-band and mid-band 5G services and to support the development of mmWave specific applications.

- (ii) 5G requires the implementation of completely new high frequency radio layers which are denser in deployment and thus the CAPEX considerations are substantial. As such, TPG proposes a minimum term of 20 years for the new 5G spectrum rights to support the substantial new network investment.
- (iii) MNOs realizes the importance of 5G and will undoubtedly rollout quickly to introduce new features and services to gain market share, build new revenue streams through new use cases. Nevertheless, IMDA should set out minimal rollout criteria to ensure industry alignment and structured responses from MNOs in their submissions. This includes the proposal to rollout at least 2 outdoor mmWave AAUs per MHz mmWave spectrum assigned.
- (iv) The assessment for the award of the 5G spectrum for both 3.5GHz and mmWave spectrum should be based on meeting the minimum forward looking set of criteria to be strictly defined by IMDA with 3GPP R16 baseline used as the reference. The criteria will also need to address the minimum standards required for security and resiliency. Major categories of use-cases will need to be defined and MNOs compliance to support all defined use-cases will be required as this effectively defines the capabilities of the 5G network slices offered by each MNO.
- (v) As mentioned above, TPG proposes the setup of a 5G Technical Lab under the auspicious of IMDA which can independently audit MNOs' compliance to the 5G network performance obligations and set of criteria define by IMDA.

**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.

**TPG Response:**

Following are the common modes of infrastructure for 5G and comparisons:



**Resiliency for different 5G infrastructure sharing modes:**

There is very minimal difference in term of resiliency between the different 5G infrastructure sharing modes. With a higher degree of network O&M independence, MORAN sharing would be less prone to network reliability and performance incidents resulted from human error. Therefore, there is no impact in term of resiliency for the 5G networks with or without infrastructure sharing. MORAN is the most practical approach and is supported by existing 5G equipment.

Spectrum is shared in the cases of MOCN and MVNO. Hence, end users of the sharing operators can fully utilize the spectrum to achieve higher user speed (and better user experience) as compared to MORAN if the capacity is not limited.

**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.*

**TPG Response:**

- (i) Based on TPG's experience in operating TDD networks in both Singapore and Australia, we strongly recommend IMDA to regulate the synchronization across 5G TDD networks. Singapore has limited C-band 5G spectrum and synchronization is mandatory to the allow maximum utilisation the spectrum by eliminating the need for guard bands.

On top of the regulation proposed above, TPG recommends that IMDA achieves a similar agreement with the regulator and carriers from neighbouring countries on:

- a. Agreement for 5G TDD synchronization  
b. Agreement and scheme to achieve 5G and LTE network co-existence like LTE. Due to the introduction of new numerology in 5G, 4G TDD LTE may force Singapore to fall back to 15KHz subcarrier space which is sub-optimal.
- (ii) For synchronised networks, TPG supports the recommendations in the ECC CEPT Report 67 "to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union" which covers the required frame alignment, compatible frame structures and BEM specifications for AAS and non-AAS base stations. The report also recommends a power limit of -52 dBm/MHz for AAS base stations which implies, under current technology, about 20 MHz frequency separation between the block edge and 3.4GHz to protect radiolocation systems.
- (iii) Given the scarcity of 3.5GHz spectrum, TPG does not recommend the operation of 5G TDD unsynchronized networks.

**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.*

**TPG Response:**

- (i) Considering the high fibre broadband service penetration and nationwide availability of fibre infrastructure in Singapore, TPG agrees that 5G fixed wireless access would not be the main use case for the last mile fixed broadband access.

However, TPG believes that fixed wireless access is the most cost-effective and efficient alternative to providing broadband in areas with limited access to fixed broadband services, cable or fibre. TPG welcomes IMDA's proposal in allowing MNOs to use 5G spectrum rights to provide other value-added services including fixed-wireless service. CMCC's published technical demonstration of 28GHz 5G speeds of 14.3Gbps with 4x4 MIMO clearly demonstrates the potential of 5G mmWave for fixed wireless access.

- (ii) TPG believes that existing framework and policy would be adequate to support fixed wireless service considering this is only a niche 5G use-case in the Singapore market. Nevertheless, for services where there is number allocation to support voice services, the voice should be IP-based and interconnection should also be IP-based.

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Thank you once again for the opportunity to respond to the Consultation and we appreciate the Authority's consideration of our responses.