

**Submission to
the Info-communications Media
Development Authority (IMDA):**

**Comments on
Consultation Paper
on 5G Mobile Services and Networks**

JULY 21ST, 2017

SAMSUNG



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1. Executive Summary

Samsung Electronics Co., Ltd (hereinafter Samsung) is pleased to take this opportunity to submit these comments to the IMDA in response to the public consultation paper on 5G mobile services and networks¹. Samsung is grateful for the opportunity to work with the IMDA and the industry on 5G spectrum matters and to help Singapore be a global wireless leader and realize the economic and social benefits of 5G.

In section 2, Samsung provides views and comments on the issue for questions on 5G. Samsung fully supports the IMDA taking into account both bands below 6 GHz and mmWave bands for 5G. In order to drive an early 5G market and to realize the full potential of 5G, Samsung would especially encourage the IMDA to introduce both bands below 6 GHz and mmWave bands at the same time. In order to realize the goal of being a wireless leader then commercial networks would need to commence deployment in 2019/2020 which means that the licensing of both bands below 6 GHz and mmWave bands needs to happen in 2018. This would then provide sufficient time for trials, commercial negotiations, network planning, equipment development etc. to take place. Potential international harmonization, radio propagation characteristics and readiness of the technology and commercialization are factors which need to be taken into account.

Finally Samsung thanks the IMDA for the opportunity to comment on the public consultation, and looks forward to working closely with the IMDA in order to realize commercial 5G in Singapore by 2019/2020.

2. Views and Comments

In this section, Samsung provides views and comments for each question.

In part // “Technology and Use Cases”

Q1. 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?

Recently, many countries and regions such as USA, Korea, Japan, China and Europe have announced their 5G spectrum strategy and roadmap judging that the year 2018-2020 is the right time to deploy 5G commercial systems.

The US FCC R&O (FCC 16-89²) and the European 5G Action plan³ provide representative cases.

The US FCC decided to provide 28 GHz, 37-38.6 GHz (hereinafter 38 GHz) and 38.6-40 GHz (hereinafter 39 GHz) as licensed bands as well as 64-71 GHz (hereinafter 66 GHz) as unlicensed band for early 5G market as announced in their policy and technical regulation on July 14th, 2016. It is

¹ Available at <https://www.imda.gov.sg/regulations-licensing-and-consultations/consultations/consultation%20papers/2017/public-consultation-on-5g-mobile-services-and-networks>

² Available at https://apps.fcc.gov/edocs_public/Query.do?numberFld=&numberFld2=&docket=14-177&dateFld=&docTitleDesc=

³ Available at <https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document>

expected that the first pre-standard 5G commercial services will be provided by operators in USA from early 2018 using the 28 GHz band for Fixed Wireless Access (FWA) service as the first band for 5G among the mmWave bands. Currently 5G FWA deployment has been led by US operators including AT&T and Verizon supported by number of multiple mobile equipment industry leaders. With a combination of operators' and equipment vendors' efforts, the commercialization of 5G FWA using 28 GHz band will begin in early 2018. And it is expected that 5G mobile service using 28 GHz band would begin in 2019 onward.

The European Commission (EC) invites the Member States to deploy early 5G networks by the end of 2018, followed by fully commercial 5G services by the end of 2020 by publishing the 5G Action Plan. In November 2016, the European Commission and the 48 CEPT⁴ countries agreed that the 24.25-27.5 GHz (hereinafter 26 GHz) band should be one of the "pioneer bands" for 5G in Europe. And the 3.4-3.8 GHz band would be a strategic band for 5G in Europe.

On January 21st, 2017, Korea MSIP announced⁵ the K-ICT Spectrum Plan in order to use the 28 GHz (26.5-29.5 GHz) band and 3.4-3.7 GHz for 5G commercial service. In particular, the Republic of Korea is planning to use the 28 GHz band for not only 5G trial services during the 2018 Winter Olympic Games but also 5G commercial services before 2020.

Japan MIC published the final report⁶ on the 2020 Japan Radio Policy on July 15th, 2016 with regard to their 5G candidate spectrum bands including the 3-4 GHz bands and the 28 GHz band, in order to realize 5G in 2020.

On June 2017, China MIIT opened their public consultation to hear views and comments from industry on the 3 – 4 GHz bands, the 26 GHz band and the 40 GHz band for 5G usage in China.

The ITU-R has proved the technical feasibility for mobile services in the bands above 6 GHz in the Report ITU-R M.2376⁷, and the ITU resolves to emphasize the new generation 5G from 2020 by approving Resolution ITU-R 56⁸ on naming and introducing "IMT-2020" to the IMT technology family. Recommendation ITU-R M.2038⁹ for IMT-2020 deployed by ITU members expected from 2020 onwards stresses a need of mmWave bands to support the different usage scenarios (eMBB, mMTC and URLLC) requiring from several hundred MHz up to at least 1 GHz of contiguous bandwidth. In addition, Report ITU-R M.2370¹⁰ anticipates that global IMT traffic will grow in the range 10-100 times during the years 2020 to 2030. This means that IMT traffic growth via 5G deployment will be explosive and the availability of mmWave bands will be a critical factor to relieve the traffic explosion.

4 <http://apps.ero.dk/eccnews/dec-2016/index.html>

5 Available at

[http://msip.go.kr/cms/www/mdFile32.jsp?path=/cms/www/news/news/report/_icsFiles/afieldfile/2017/01/19/170118%2520%25EC%2584%259D%25EA%25B0%2584%2520\(%25EB%25B3%25B4%25EB%258F%2584\)%2520K-](http://msip.go.kr/cms/www/mdFile32.jsp?path=/cms/www/news/news/report/_icsFiles/afieldfile/2017/01/19/170118%2520%25EC%2584%259D%25EA%25B0%2584%2520(%25EB%25B3%25B4%25EB%258F%2584)%2520K-)

[ICT%2520%25EC%258A%25A4%25ED%258E%2599%25ED%258A%25B8%25EB%259F%25BC%2520%25ED%2594%258C%25EB%259E%259C%2520%25EC%2588%2598%25EB%25A6%25BD.pdf](http://msip.go.kr/cms/www/mdFile32.jsp?path=/cms/www/news/news/report/_icsFiles/afieldfile/2017/01/19/170118%2520%25EC%2584%259D%25EA%25B0%2584%2520(%25EB%25B3%25B4%25EB%258F%2584)%2520K-) (only provided in Korean). Especially, the band 27.5-28.5 GHz will be provided by 2018, and both 26.5-27.5 GHz and 28.5-29.5 GHz bands will also be provided by 2021. However, both 26.5-27.5 GHz and 28.5-29.5 GHz bands will also be provided by 2018 together with the band 27.5-28.5 GHz when user and network equipment for those bands would be available early.

6 Available at http://www.soumu.go.jp/main_sosiki/kenkyu/denpa_2020/02kiban09_03000328.html

7 Report ITU-R M.2376 "Technical feasibility of IMT in bands above 6 GHz", July 2015

8 Resolution ITU-R 56-2 "Naming for International Mobile Telecommunications", RA-15, October 2015

9 Recommendation ITU-R M.2083 "IMT-Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond, September 2015

10 Report ITU-R M.2370 "IMT traffic estimates for the years 2020 to 2030", July 2015

Moreover, WRC-15 established Agenda Item 1.13 for WRC-19 to identify frequency ranges from 24.25 GHz to 86 GHz for IMT-2020 systems to satisfy the requirements of high data traffic such as in dense urban areas and/or in peak times.

Therefore, Samsung recognizes that 5G using bands below 6 GHz and mmWave bands will support services that will penetrate into our practical life starting before 2020. Accordingly, Samsung recommends that IMDA takes into account 5G commercialization no later than the year 2020. In particular Samsung believes the frequency bands in the ranges below 40 GHz especially 3.5 GHz, 26 GHz, 28 GHz and 38/39 GHz will be the focus for early equipment eco-system development before 2020. The ability for the mmWave bands, especially the 28 GHz band, to provide high performance and capacity in dense urban areas and in peak times will be a significant and essential driver for 5G services both for mobile access and fixed wireless access, based on a liberalized regulatory and licensing approach.

Q2. To facilitate and understand potential spectrum requirements for IoT deployments in Singapore, IMDA would like to seek views on the following:

i) Based on the current spectrum allocated for mobile services in the sub-1 GHz frequency bands, are there further suitable spectrum resources that could be released to support both IoT and LTE services?

ii) How will future generations of mobile networks (e.g. high capacity, low latency) support the growth of IoT and what would be the spectrum requirements?

In order to facilitate innovation and growth for IoT deployments, a broad range of spectrum with a technology neutral, flexible-use approach is suggested. A flexible spectrum regulatory approach will allow operators to manage their spectrum resources matching the capacity need of its IoT services, which is efficient and scalable to support a large number of IoT users in a given area. The operator can manage and employ the spectrum based on license and unlicensed manner without the need for regulators to allocate dedicated spectrum for IoT. The harmonization of the usage for IMT systems, including those used to support NB/BB-IoT applications is also encouraged with the consideration of economies of scale.

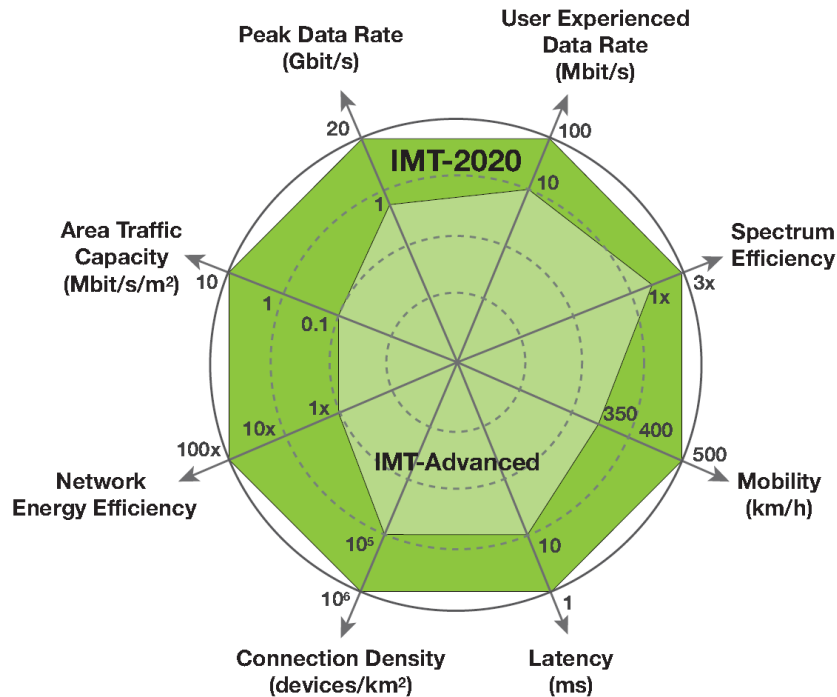
Q3. IMDA would like to seek views and comments from industry on what they consider will be the key technologies for 5G and whether current regulatory frameworks sufficiently facilitate the deployment of such technologies.

Technology using mmWave bands is in the spotlight for 5G taking into account global trend and status.

The vision in the ITU-R for 5G in the form of IMT-2020¹¹ emphasizes usage scenarios such as eMBB, URLLC and mMTC as key for 5G. In order for 5G to fulfil these usage scenarios, various technologies will be needed. For the eMBB usage scenario, the target peak data rate for IMT-2020 as defined by ITU-R is 20 Gbit/s, requiring frequency bands not only below 6 GHz but also wide bandwidth contiguous mmWave bands. These would be necessary to fulfil minimum technical performance requirement for 5G. To realize technology using mmWave bands, advanced antenna

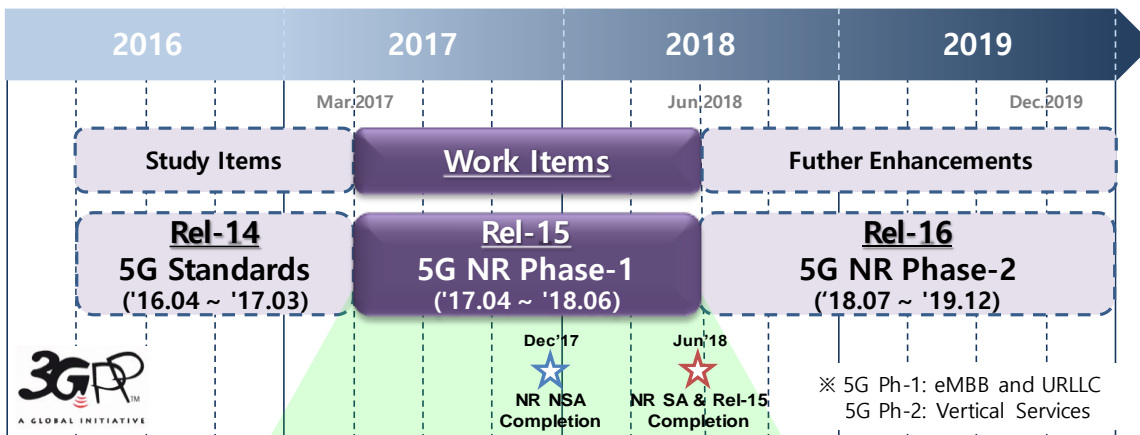
¹¹ Recommendation ITU-R M.2083

technology using massive MIMO and beamforming techniques as well as advanced channel coding scheme will be the important technical elements for 5G.



[Figure 1. Enhancement of key capabilities of 5G]

Moreover, in order to fulfil URLLC and mMTC usage scenario, varied technologies such as an innovative new solution to shorten TTI, new waveform solution supporting varied vertical services in one 5G network, advanced air interface solution for advanced multiple access scheme and advanced network solutions like SDN/NFV/network slicing/MEC would be one of the key technical enhancements. These advanced technologies are being developed within 3GPP. The following figure shows 3GPP timeline for 5G NR standardization.



[Figure 2. 3GPP 5G NR timeline]

In part III “Spectrum requirements”

Q4. 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 releases for mobile services?

Samsung notes that in some regions and countries around the world there are discussions regarding spectrum below 1 GHz for 5G to provide wide area, particularly in suburban and rural area, as well deep indoor penetration coverage. It is anticipated that these discussions will continue.

Q5. 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; and**
- ii) The timeline for access to the L band and the availability of the equipment (specifically whether it will be available earlier or later than 2020).**

Q6. 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.

L-band (1427-1518 MHz) was identified to IMT at WRC-15¹². This band is used for IMT service in Japan based on FDD frequency arrangement. Meanwhile some regions and countries are considering this band based on TDD, FDD or SDL, and this discussion on frequency arrangement is under progress within ITU-R WP 5D by updating Recommendation ITU-R M.1036. Regionally Europe has adopted a SDL arrangement in ECC Decision (13)03 for 1452-1492 MHz and is finalizing a draft ECC Decision for SDL in the ranges 1429-1452 MHz and 1492-1518 MHz.

If 40 MHz bandwidth from 1452 MHz to 1492 MHz would only be available in Singapore, SDL or TDD frequency arrangement would be better rather than FDD requiring more spectrum compared to SDL or TDD.

Using entire 91 MHz bandwidth in L-band would be supportive for eMBB as one of the usage scenario of 5G. But only about up to 25 MHz to 30 MHz would be available per each mobile operator when the bandwidth would be allocated to three mobile operators. In this case, eMBB usage scenario requiring wide spectrum bandwidth for 5G may not be fulfilled sufficiently. Therefore it is more recommended to use 3.5 GHz band supporting wider bandwidth rather than use of L-band to support the deployment of eMBB services.

¹² See RR 5.341C and 5.346A for Region 3

- Q7. 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?**
- Q8. 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.**
- Q9. 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.**

The extended C-band from 3.4-3.6 GHz is normally used for satellite communications (space to Earth) in many countries within Asia-Pacific region. As noted in the consultation paper, co-channel operations of both IMT and FSS (space to Earth) services may not be possible, taking into account the geographical size of Singapore. However, Many administrations and industries in the world have recognized the potential for early availability of the frequency band 3.4-3.6 GHz (hereinafter 3.5 GHz band) for 5G service¹³. The 3.5 GHz band as promising band for 5G can offer advantages from coverage and higher performance.

Meanwhile, Samsung recognizes that the extended C-band is not heavily used for FSS, which the majority of users in the extended C-band are for the purpose of satellite signals reception for TV receive-only stations to the limited sites. These existing services would be migrated to upper C-band from 3.7 GHz to 4.2 GHz which there is extensive use for mainly satellite teleport for terrestrial networks. In this regard, Samsung believes that Singapore regulator could consider the way forward of clearing the extended C-band from FSS usages to IMT usages in near future.

In 3GPP, especially, C-band (3.3-4.2 GHz) including the 3.5 GHz band was decided as one of the spectrum for 5G NR technology. And the band had been identified to IMT by WRC-07 and WRC-15. Although currently only 3.4-3.5 GHz band is identified to IMT in Singapore in accordance with RR. 5.432B, many countries would use the band for IMT usage in near future. As emphasized in answer 1 above, especially, Korea, Japan, China, USA and European countries strongly support the extended C-band by announcing their plan and policy to use the band for IMT/5G.

Therefore, Samsung strongly recommends that Singapore takes into account the extended C-band (3.5 GHz) in the light of these global status and standardization activities as well as global harmonization.

¹³ Relevant information and materials are available at <http://www.cept.org/ecc/news/successful-outcome-of-5g-workshop/> and <https://5g-ppp.eu/event/second-global-5g-event-on-9-10-november-2016-in-rome-italy/>

Q10. IMDA would like to seek your views and comments on the following:

- i) The role mmWave bands will play in delivering the vision of 5G, in particular, what services could not be delivered by alternative frequency bands and/or technologies;**
- ii) The amount of spectrum required in the mmWave spectrum bands to meet 5G applications that will require higher bandwidths; and**
- iii) The specific mmWave bands that you consider should be a priority in Singapore for IMT services and why?**

There are several reasons why mmWave bands are essential for 5G:

(1) wide contiguous bandwidth would be available in the mmWave bands to support the different usage scenarios such as eMBB, URLLC and mMTC described in Recommendation ITU-R M.2083.

(2) mmWave bands could resolve mobile traffic explosion issue in dense urban areas and/or in peak times.

(3) mmWave bands is an essential to fulfil 5G requirements targeting peak data rate as 20 Gbit/s defined by ITU-R.

Recently ITU-R WP 5D as responsible group for IMT matters in ITU completed to define minimum technical performance requirements¹⁴ such as peak data rate, peak spectral efficiency, and so on. To fulfil the minimum technical performance requirement, especially peak data rate, more than 670 MHz bandwidth would be required assuming peak spectral efficiency 30 bps/Hz for downlink. It is expected that mmWave bands should be accompanied because bands below 6 GHz would not be supportive to provide wide bandwidth.

From the Recommendation ITU-R M.2083, a variety of services such as AR/VR transmitting real time high definition multimedia is one of the 5G key usages. In addition, FWA services, as one of the 5G services, ensuring QoS in last one mile would also require mmWave bands, so that mmWave bands is worth to realize 5G era. Therefore, if the mmWave bands are not considered to support 5G services, then 5G vision will not be realized and new differentiated services would not be possible.

There is a diversity of views on how much spectrum would be needed for 5G in mmWave bands. Taking into account Doc 5-1/36¹⁵, it is an undeniable fact that mmWave bands providing a large chunk of bandwidth are an essential requirement. As studied by ITU-R WP 5D, around a bandwidth of 20 GHz would be required at mmWave bands for 5G. In particular, approximately 2-3 GHz bandwidth would be needed in frequency range from 24.25 GHz to 33.4 GHz expecting high usage among mmWave bands. Moreover, recently 3GPP decided the bands 24.25-27.5 GHz and 26.5-29.5 GHz for 5G NR, and 400 MHz bandwidth as a component carrier bandwidth was adopted.

Considering carrier aggregation technology for 5G NR, bandwidth of at least several hundred MHz and up to several GHz would be required. And technical specifications for these bands would be completed by December 2017 for Non-Standalone mode and by June 2018 for Standalone mode, respectively.

¹⁴ Available at <https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-SG05-C-0040>

¹⁵ Available at <https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-TG5.1-C-0036>, Spectrum needs and characteristics for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz

Recently, an initiative has started to promote the 28 GHz band for 5G use globally. For this initiative in the name of “28 GHz Initiative Workshop”, key 5G leading countries such as USA, Korea, Japan and Singapore together with global 5G leading industries are participating. Especially, the 28 GHz band from 26.5 GHz to 29.5 GHz was named as “5G Frontier band” at the 2nd workshop in June 2017.

Samsung recognizes that the Singapore administration proposed the 28 GHz band for 5G at APG15-5 meeting¹⁶ and WRC-15¹⁷. Samsung also recognizes that Singapore IMDA has waived the frequency fees associated with 5G trials from May 2017 to December 2019 in the band 26.5-29.5 GHz. Samsung as 5G leading company is very welcome for this kind action by Singapore IMDA. Given the desire to deploy commercial 5G services in a timely manner and the early development work that is maturing the 28 GHz band technology first, Samsung recommends that the IMDA adopts the band 28 GHz for 5G in Singapore¹⁸.

Additionally, Samsung emphasizes that in addition to bands below 6 GHz (e.g. 3.5 GHz) the mmWave bands focusing the 28 GHz band should be provided for 5G services, in order to fully satisfy the 5G requirements and vision.

Samsung notes that within the industry that seems to be a general view that between 400 MHz to 1 GHz of unpaired spectrum per network operator is needed in the mmWave 26 GHz and 28 GHz bands.

Furthermore, Samsung also recommends IMDA to consider 38 GHz and 39 GHz bands for 5G, taking into account other countries’ movements toward commercialization and regional groups for WRC-19.

Q11. 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)?

Yes. Some administrations believe that the 28 GHz band was not properly discussed at WRC-15 leading to its exclusion from WRC-19 Agenda Item 1.13, however these key administrations strongly support to adoption of the 28 GHz band for their 5G service. These key administrations also announced plans to use the 28 GHz band for 5G commercialization in near future like the year 2018. Despite interest in the 26 GHz band in some countries, the necessary studies on whether the band would be possible and available for 5G in ITU-R TG 5/1 have only just started. As noted, there is a lot of existing services like EESS as passive service in the frequency bands in the Radio Regulations. At the present time, the band has uncertainties over its use for 5G. In addition, there are existing services such as short-range devices and low power applications in 26 GHz band in Singapore. The most important point is that the 28 GHz band is allocated to mobile service on a co-primary basis in the Radio Regulations. This means that Singapore can use the 28 GHz band for 5G without any constraints.

¹⁶ APG15-5/INP-35, “Proposal on WRC-15 Agenda Item 10: A WRC-19 New Agenda Item for Identification of IMT in the Frequency Bands above 6GHz”

¹⁷ Document 117, “Proposals for the work of the Conference - Agenda item 10”

¹⁸ But, Samsung also supports to consider lower 28 GHz band from 24.25 GHz to 27.5 GHz as one of the listed in Resolution 238 (WRC-15) in conjunction with WRC-19 Agenda Item 1.13 when the band 28 GHz would not be available in Singapore. In addition, the bands 38GHz/39GHz (37-40.5 GHz) might also be considered when mmWave bands for 5G would be more required in the future.

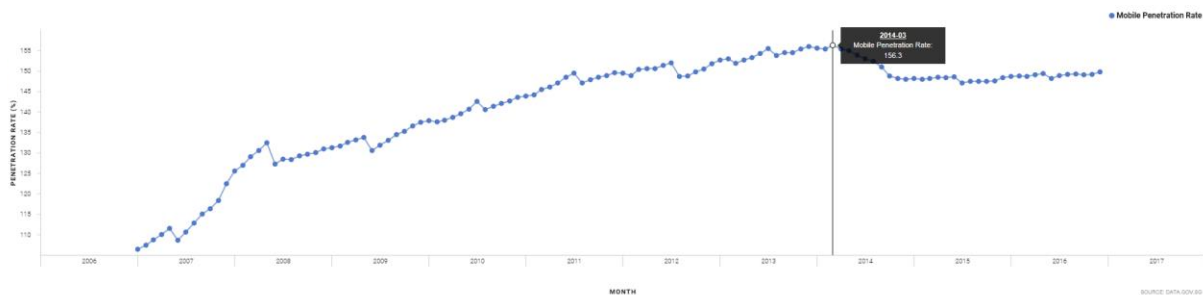
Therefore, Samsung can say clearly that the 28 GHz band is the strongest band for 5G aiming for higher throughput eMBB support, for early 5G market.

Q12. 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?

No. Even though the 28 GHz band has overlap with WRC-19 Agenda Item 1.5 for ESIM, Samsung recognizes that Singapore has no plan to use the 28 GHz band for other services, in accordance with AWG-21/OUT-11(Rev.2)¹⁹. Therefore, if Singapore provides the 28 GHz band for terrestrial 5G usage in very near future, it would have strong a differentiated service providing higher throughput, compared to the other services.

Q13. IMDA seeks views and comments on the estimated spectrum demand of 3360 MHz by 2025 and whether this estimate is realistic?

According to the IMDA POI analysis, mobile data traffic reached to 13.3 PB as of the 1st quarter of 2017. Assuming the population of the Singapore is about 5.7 million, mobile data usage per person would be about 2.3 GB/month. Recently mobile penetration ratio in Singapore is more than 150%²⁰ and mobile traffic usage increases more and more continuously.

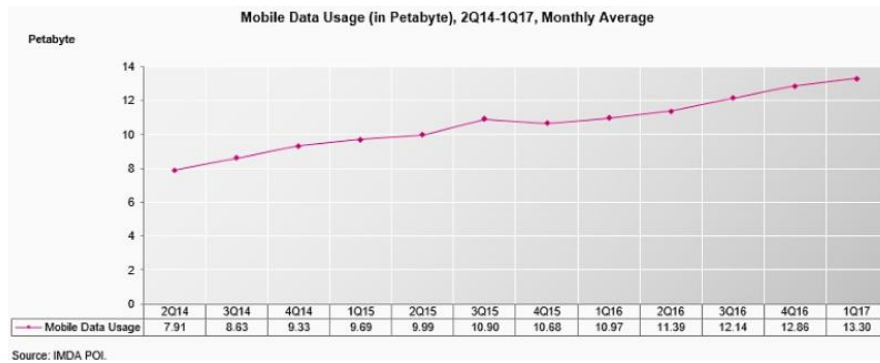


[Figure 3. Mobile penetration in Singapore]

If the 5G service would be rolled out in Singapore from 2020, the phenomenon to increase mobile data traffic would be deepened. In this regard, a figure 5 in the consultation paper may be a possible estimation which sees the required bandwidth up to 3360 MHz for the year 2025. Meanwhile it should also be considered that bandwidth more than 3360 MHz would be required when 5G penetration ratio would be increased 2020 onward.

¹⁹ APT Report on Survey Study on the Usage and Future Plans of the Bands 17.7-20.2 GHz and 27.5-30 GHz in the Asia-Pacific Region (http://www.apr.int/sites/default/files/2017/04/AWG-21-OUT-11Rev.2_Ka-band_Usage_rev2.docx)

²⁰ Available at <https://data.gov.sg/dataset/mobile-penetration-rate>



[Figure 4. Mobile data usage (in Petabyte), 2014 2Q – 2017 1Q, Monthly average²¹]

Q14. Noting that several regulators have made available mmWave bands for IMT services, IMDA would like to your views and comments on whether access to the mmWave spectrum should be provided earlier than 2022 for commercial network deployment?

From the Report ITU-R M.[IMT-2020.EVAL], as shown table 1, 3.5 GHz band representing 4 GHz as well as 26 GHz/28 GHz band representing 30 GHz are adopted as a carrier frequency bands for evaluation, which bands are supportive of the use at macro and micro cell. In addition, 3GPP agreed that 3.5 GHz band and 28 GHz band is the frequency bands for 5G NR in Release 15 which will support 5G commercialization in 2020.

[Table 1. Evaluation configurations for Dense Urban-eMBB test environment]

Parameters	Dense Urban-eMBB		
	Spectral Efficiency and Mobility Evaluations		User Experienced Data Rate Evaluation
	Configuration A	Configuration B	Configuration C
Baseline evaluation configuration parameters			
Carrier frequency for evaluation	1 layer (Macro) with 4 GHz	1 layer (Macro) with 30 GHz	✓ 1 or 2 layers (Macro + Micro). ✓ 4 GHz & 30 GHz available in Macro & Micro layers

It should be recognized that key administrations have announced to use mmWave bands focusing on 28 GHz band for their 5G. When taking into account urgent global movements on 5G, it is very important that the matured 28 GHz band is appropriate for an early 5G market in Singapore.

Therefore, Samsung strongly recommends that Singapore takes into account the deployment of 5G by 2020 rather than 2022. In order to realize the goal of being a wireless leader then if commercial networks commence deployment in 2020 then this would imply that the licensing of the 28 GHz band needs to happen in 2018. This would then provide sufficient time for trials, commercial negotiations, network planning, equipment development etc. to take place.

²¹ Available at <https://www.imda.gov.sg/industry-development/facts-and-figures/telecommunications>

3. Acronyms and Abbreviation

3GPP	3 rd Generation Partnership Project
CEPT	Conference of European Postal and Telecommunications administrations
EC	European Commission
eMBB	Enhanced Mobile Broadband
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
IMT	International Mobile Telecommunications
ITU	International Telecommunications Union
MEC	Mobile Edge Computing
MIC	Ministry of Internal Affairs and Communications
MIIT	Ministry of Industry and Information Technology
MIMO	Multiple Input Multiple Output
mMTC	Massive Machine Type Communications
MSIP	Ministry of Science, ICT and Future Planning
NB-IOT	NarrowBand-Internet Of Things
NFV	Network Functions Virtualization
NR	New Radio
NSA	Non-Standalone
R&O	Report and Order
SA	Standalone
SDL	Supplementary Downlink
SDN	Software Defined Networking
TDD	Time Division Duplex
TTI	Transmit Time Interval
URLLC	Ultra-reliable and Low Latency Communications
WRC	World Radiocommunication Conferences