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INTELSAT SUBMISSION to IMDA Second Consultation on 5G Mobile Services and Networks

i. INTRODUCTION

Intelsat is pleased to make a submission to the second consultation on 5G mobile services and networks. We hope that our inputs will help IMDA in developing the necessary balanced policies for the deployment of advanced mobile services and networks in Singapore while protecting current and planned satellite services in C-band and Ka-band.

ii. SPECTRUM ALLOCATION for 5G in SINGAPORE

Intelsat has concerns about the plans of IMDA to make the 3.5 GHz, 26 GHz, and 28 GHz band spectrum available for the deployment of terrestrial 5G services in Singapore by 2020, despite the heavy investments of the satellite industry in C-band and Ka-band. Particularly, C-band – including extended C-band – is heavily used for satellite communications in Asia Pacific region for several type of services. C-band is the major frequency band for satellite services in Asia Pacific region, since it provides high availability and superior propagation characteristics to overcome high rain attenuation. Therefore, it is important to minimize the impact of the terrestrial 5G deployment to the current satellite operations in Singapore. Satellite services and investments in the C band should not be jeopardized to meet any realistic 5G spectrum requirements in Singapore.

IMDA plans to make available 5450 MHz of new spectrum for the deployment of terrestrial 5G services which consists of 200 MHz spectrum for 3.5 GHz band, 3450 MHz spectrum for 26 GHz band, and 2000 MHz band for 28 GHz band. Meanwhile, in its first consultation on "5G Mobile Services and Networks", IMDA have estimated that terrestrial 5G services would require 3360 MHz of spectrum by 2022. Therefore, allocating 26 GHz band for the deployment of terrestrial 5G services in Singapore should meet and even exceed the estimated need for spectrum. In addition, allocating 26 GHz for the deployment of terrestrial 5G services in Singapore would be

consistent with agenda item 1.13 (WRC-19) which identifies 26 GHz band as one of the candidate bands for IMT. 26 GHz band is also considered as one of the core spectrum resources for 5G by several administrations and regions worldwide. Should there be a need on additional spectrum for the deployment of terrestrial 5G services in Singapore, IMDA should consider first bands with high probability for global harmonization.

iii. EXTENDED C-BAND (3400 – 3700 MHz)

Should there be any final decision on allocating 3.5 GHz band for the deployment of terrestrial 5G services, we understand that the IMDA is planning to implement approximately 100 MHz of guard band between FSS (Fixed Satellite Services) and mobile service. The 100 MHz guard band between FSS and mobile services in 3.5 GHz band would have to be complemented with additional mitigation measures on FSS side (e.g. retrofitting an appropriate band pass filter are being applied by Hongkong administration (Office of the Communications Authority (OFCA)) to protect FSS operations from the terrestrial 5G deployment. OFCA concluded on such mitigation measures after an extensive field test measurement in January 2018.

The protection of satellite services above 3.7 GHz both in Singapore and in neighbouring countries must be addressed by a combination of 5G out-of-band emission masks, guard bands and/or separation distances as the C-band above 3.6 GHz is extensively used throughout the region. The practicability and logistics of migrating existing satellites services in Singapore out of the 3.5 GHz into the band above 3.7 GHz will also require further assessments.

In relation to IMDA's plan to do technical trials to determine the technical feasibility of the recommended parameters (e.g. guard band, emission power limits, etc.), such technical trials should involve experts from the satellite industry and the outcome should be made available for further review by interested stakeholders. In addition, such technical trials should be done prior to making final decision on allocating 3.5 GHz band for the deployment of terrestrial 5G services.

The deployment of terrestrial 5G services in Singapore will force FSS users to migrate part of their services currently provided in the 3.5 GHz band to the band above 3.7 GHz. IMDA should consider incentive reimbursement to the affected FSS users to cover for the extra effort/cost due to migration. Such incentive reimbursement could be taken from the 3.5 GHz spectrum packages being offered to the MNO that plan to deploy 5G services.

Intelsat is pleased to note that regarding the TT&C operations of an operational satellite, IMDA is still considering to determine exclusion zone(s) in Singapore similarly to what has been decided in Hongkong. This could allow satellite operators to establish their TT&C operations in Singapore also in the future.

In relation to cross border coordination, IMDA needs to consider that there are almost 22,000 VSAT terminals occupying the band between 3400 – 4200 MHz in Indonesia territory that need to be protected from harmful interference of terrestrial 5G services. In addition, there are some possible active C-band teleports located in Batam Island which is only 20-30 km away from Singapore. The above information are referring to the link https://www.postel.go.id/downloads/60/20150324042701-Buletin_edisi_7_final.pdf in page 23 (i.e. picture 6 & picture 7) in Indonesian language.

A decision by Singapore to allow terrestrial 5G in the 3.4-3.7 GHz band will have to take into account the use of the band by the FSS in neighbouring countries, such as Malaysia and Indonesia. Unlike Singapore, these countries are not among those that have indicated that they intend to use the band for IMT under ITU Radio Regulation No. 5.432B, nor are they countries listed under No. 5.433A.

iv. 26 GHz and 28 GHz band

In relation to 28 GHz band allocation for 5G services, it is stated that mobile service and FSS operating in the frequency band 28.5 – 29.5 GHz will be on co-primary basis. However, it also stations in the FSS are expected to take measures to ensure protection of and not impose undue constraints on 5G services operating in the band, which could be interpreted that FSS has only a secondary status. Further clarification is needed to have more clarity on 28 GHz band allocation for 5G services.

While spectrum band 24.65/24.75-25.25 GHz has raised a lot of interest for potential 5G deployment in ITU Region 3, it should only be considered for IMT if reasonable regulatory measures to ensure protection of and sustainable viable access for the FSS are implemented. There is a real potential for interference from IMT transmitters in the mmWave bands into satellite receivers at 26 GHz band, therefore adequate and enforceable regulatory measures, such as an EIRP mask and IMT BS tilt angle below the horizon must be adopted and the location of IMT base stations must be available.

Meanwhile, last statements of footnote 16 in page 26 need to be clarified since agenda item 1.5 (WRC-19) on ESIMs issue is not handling the coexistence issues between IMT and ESIMs in the 28 GHz band since there is no IMT identification in the 28 GHz band. Coexistence issues are studied between mobile service and ESIMs and further clarifications will be needed on whether these parameters could be used for IMT/5G as well. In addition, this agenda item is discussing additional satellite deployments in the 28 GHz band not only for aircraft platforms, but also for maritime and land platforms.

The 28 GHz band is one of the key uplink bands for current and future commercial Ka-band satellites, including the HTS-type of satellites. Nearly thirty satellites using the 28 GHz band have

been launched in the last five years. Every effort should be made to avoid disrupting such investments, especially when there are other spectrum bands under consideration in ITU-R which are more likely to be globally harmonized through IMT identification.

v. OTHER CONSIDERATIONS

Utilization of the spectrum allocated for 5G services in Singapore is an important aspect to be considered. Audit mechanism on yearly basis to the applicants would ensure proper spectrum utilization and the delivery of the applicants' proposal.

Furthermore, Intelsat considers that the fact that wireless broadband data is increasingly being consumed through unlicensed devices (e.g. RLAN/Wi-Fi) substantially reduces the spectrum need for terrestrial 5G. This trend combined with the technology advances of 5G, such as carrier aggregation, will make the current Singapore allocation target more than adequate to respond to the future spectrum needs of terrestrial 5G.

The ITU-R is exploring IMT identification on 33+ GHz of spectrum as a part of the WRC-19 (AI 1.13) process therefore there is seems to be little merit to consider other frequency bands, especially those critical to other radiocommunication sectors.

Furthermore, Intelsat would highlight the importance of making sure the spectrum already made available to the terrestrial 5G is fully utilized. The latest findings concerning the countries of the region, not only evidence the progress that has been made in the last few years to this end, but also show that there is even more harmonized IMT spectrum that could be utilized for 5G.

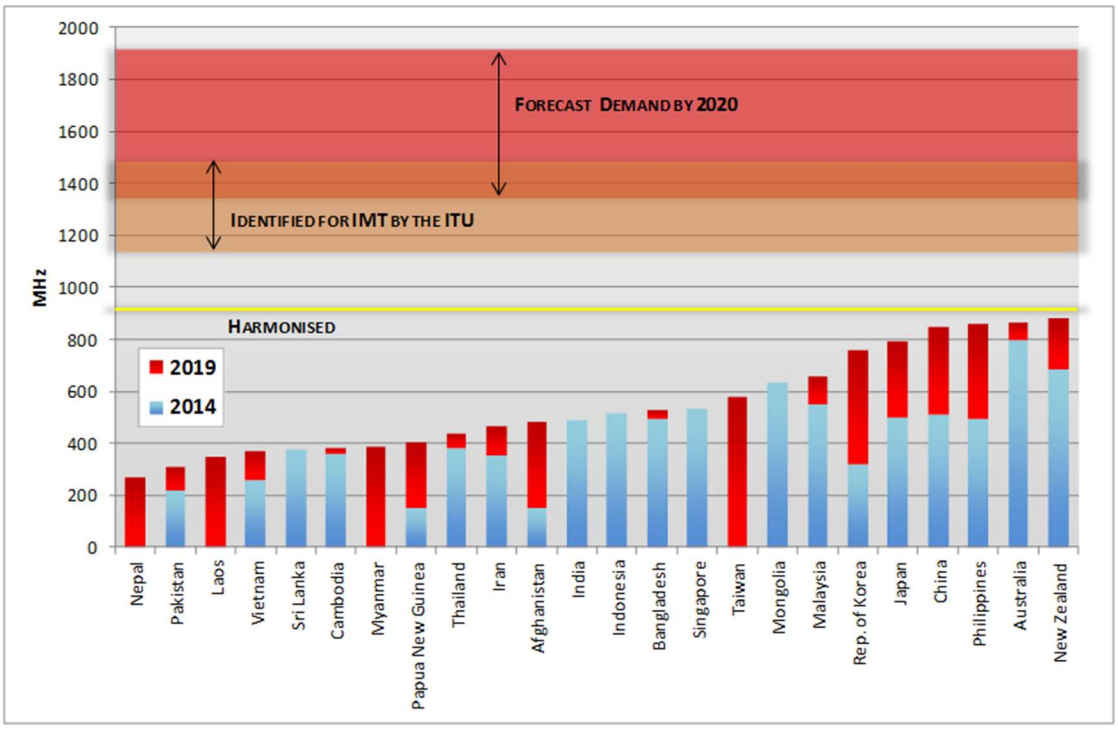

Figure 1: spectrum licensed for IMT services in Region 3

Figure 1 above shows the spectrum licensed for IMT services in Region 3 – LS telkom, 2019. For those countries where data was available in 2014 and again in 2019, it is clear that significant progress has been made in licensing additional spectrum with many countries now having licensed double that which they had five years ago. Despite this progress, the current harmonized spectrum should be more extensively used before seeking additional spectrum. In accordance to Figure 1, there are about 350 MHz of spectrum identified for IMT in Singapore that have not yet being licensed and utilized.

The C-band earth stations have been extensively used in Asia Pacific region delivering US$ billions of values through multiple service sectors. Many C-band dishes are seen on commercial, educational, government, and residential rooftops. Every city, town, and village have C-band dishes whose performance would be impacted by sharing with mobile technologies. Using C-band frequencies for the terrestrial 5G in Asia Pacific region, threatens the domestic television reception and a wide range of business critical and safety related applications including emergency communications. The large numbers of administrations and satellite operators in Asia Pacific region have utilized satellite services with greater satellite service diversity. Therefore, the C-band alliance proposal being adopted in US will not be applicable in Asia Pacific region considering those factors. The US proposed solution is completely unworkable in the Asia Pacific region, including Singapore.

vi. ISSUES FOR COMMENT

IMDA have itemised a list of specific questions for comment. Intelsat responses are largely dealt with in the preceding text and are summarised in brief below 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.

Intelsat Answer: No comment.

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 require in order to enable innovation and development in 5G.

Intelsat Answer:

IMDA need to explore the possibilities of satellite industry to play role in the deployment and development in 5G and such possibilities could be set out in a policy that could drive the development of satellite industry, not only the development of mobile 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 3.5 GHz band.

Intelsat Answer:

Intelsat very much supports the guard band of 100 MHz, between the IMT and FSS and notes that this is consistent with the technical studies conducted by the communications authority of Hong Kong this is because 100 MHz guard band provides 35 dB additional unwanted signal suppression than 50 MHz guard band (i.e.55 dB vs 20 dB) as shown in Figure 2 below showing that 100 MHz guard band is optimal to warrant sufficient unwanted signal suppression in the band-pass filter. However, in accordance to these studies additional restriction zones are required to the TT&C stations. As C-band is based on TDD technology and no duplexing gap is required, there is no cross-border frequency co-ordination issue with neighbouring countries with regards to the envisaged guard band. However, the protection of sensitive FSS earth stations receivers in Singapore from the potential interference arising from IMT deployment in neighbouring countries will need to be carefully studied.

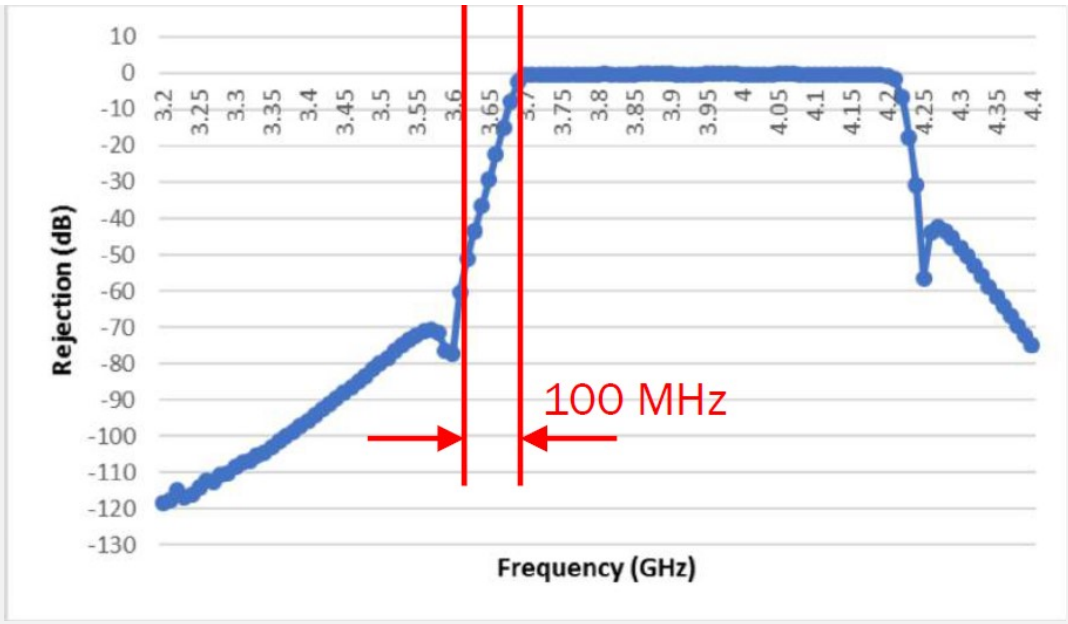

Figure 2: Roll Off Curve. 100 MHz guard band

This is because spectrum sharing with IMT already raises challenges today, given IMT high power and ubiquity, as confirmed by ITU studies. Numerous ITU studies showed that co-frequency sharing between IMT mobile and FSS is not feasible. Even when IMT and FSS operate in adjacent bands, interference into FSS will occur, unless carefully managed. This is because Mobile signals are considerably more powerful than satellite signals, which complicates coexistence between both services.

Finally sharing with (much) more powerful IMT-2020 / 5G will become even more difficult and definitely impose geographical separation between spectrum users and exclusion zones for IMT. This is because as outline above satellite earth stations are very sensitive to terrestrial interference from IMT Mobile signals which can interfere with FSS receive earth stations in two ways:

1. **Saturate the LNB of the earth station, even if the Mobile 5G signal is adjacent to the satellite signal;**
2. **Out-of-Band-Emissions (OOBE) of the Mobile 5G signal can cause in-band interference to FSS signals;**

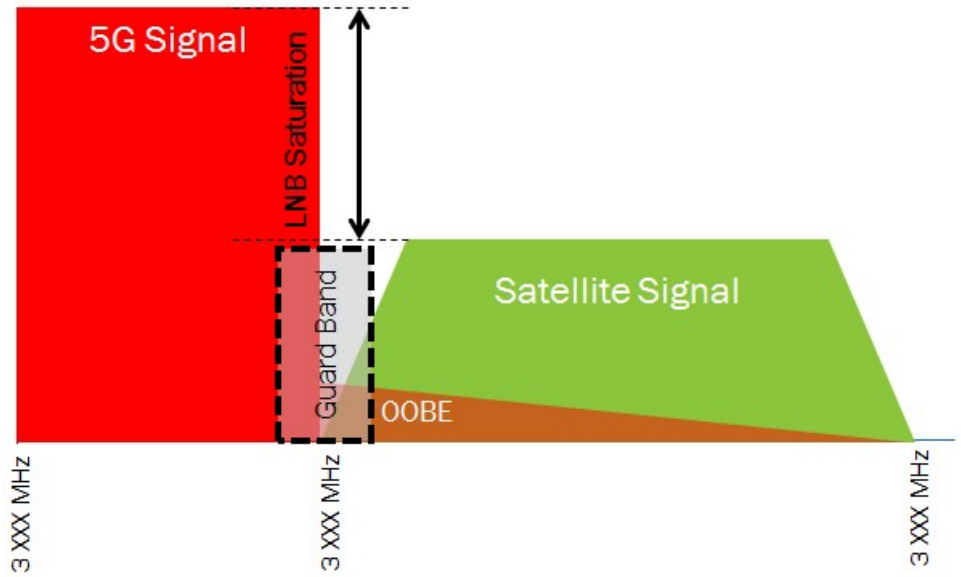

Figure 3: 5G signals must be carefully managed

Therefore, imposing spectrum sharing can pave the way to dismissing existing FSS services which are very much needed in Singapore. This is because current OOBE levels specified in 3GPP standards do not protect FSS signals in adjacent bands. Therefore, using a guard band and imposing strict OOBE conditions on Mobile 5G are required to ensure protection of FSS earth stations.

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.

Intelsat Answer:

5G NR technology supports bandwidths 10, 15, 20, 30, 40, 50, 60,70, 80, 90 and 100 MHz and carrier aggregation can be used for combining spectrum in different frequency bands, therefore there is no imminent need for wide contiguous spectrum blocks.

Another example is what China is doing which in the band below 3GHz, which has been planned frequency amount of 689MHz for IMT systems. At present, it mainly deploys 2G, 3G and 4G networks of China Telecom, China Mobile and China Unicomm. In December 2018, China Mobile has authorized 5G trial in 2515-2675 MHz band and in the future, according to the needs of MNO operators, the corresponding frequency band can be refarmed for 5G.

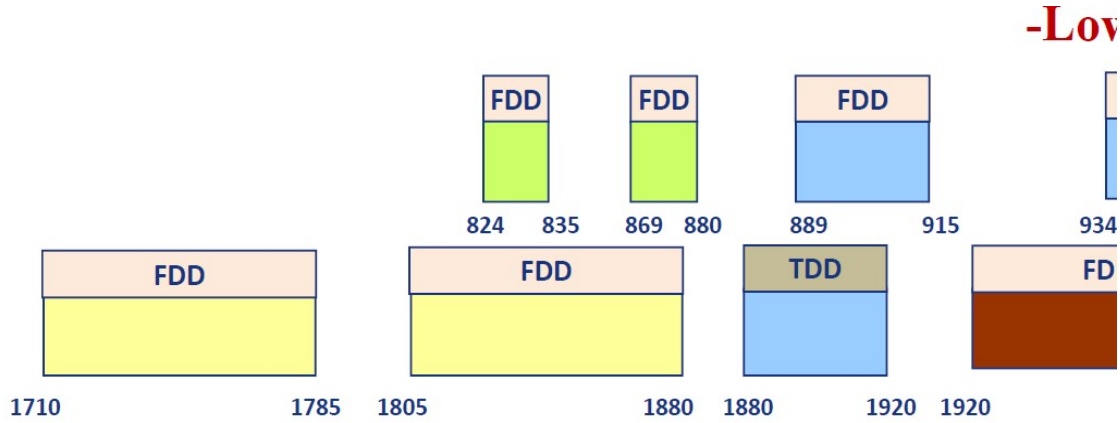

Figure 1:Latest development of 5G in China

China also stipulated the protection of the existing fixed satellite services, fixed services, radio astronomy and other services within any band identified for IMT. In December 2018, China released the "Regulations of Interference Coordination between 5G Base Station and Other Radio Stations in the 3000-5000MHz band", stipulating the coordination procedures and protection standards for fixed satellite, fixed and radio astronomy services. In this document, different coordinated distances of the cochannel and adjacent channel interference are established for the protection of satellite earth station and the technical specifications of LNB for satellite earth station are required.[1]

[1] published on the MIIT website

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;
Intelsat Answer:
IMT2020 technology supports bandwidths from 5 MHz upwards in the C-band, and auctions in Europe are commonly done in multiples of 5 MHz. The outcome in several European auctions of C-band spectrum has been significantly more narrow bandwidths than 100 MHz. Some examples from Europe:

Country	BW licensed per operator
United Kingdom	20 MHz, 2*40 MHz, 50 MHz
Italy	2*20 MHz, 2*80 MHz,
Spain	50 MHz, 60 MHz, 90 MHz,
Czech Republic	3*40 MHz, 80 MHz
Hungary	20 MHz, 60 MHz,
Ireland	25/60 MHz, 60/- MHz, 80/85 MHz, 85/105 MHz (rural/cities), 100 MHz nationwide

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;

Intelsat Answer:
An overview of the prices paid by the European mobile operators per MHz per head of population in all European C-band auctions shown in the figure below reveals that there is no significant difference in price paid by operators gaining 40 MHz of spectrum to those gaining 100 MHz or more.

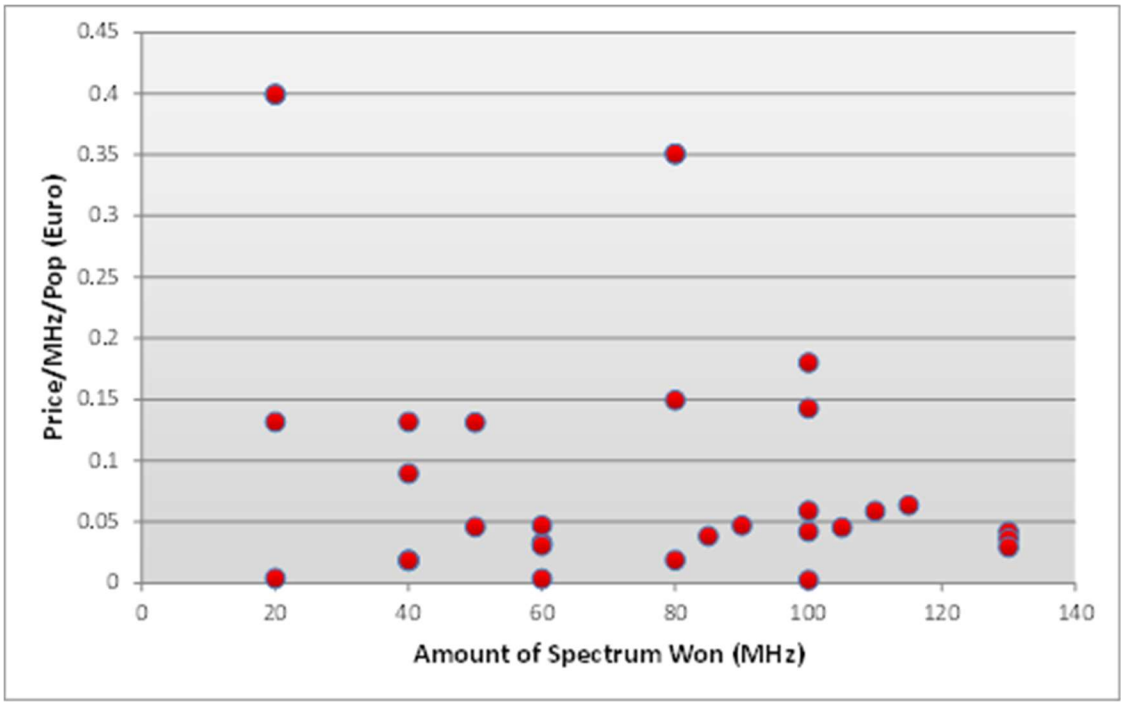

Figure 5: Value of Spectrum won via Auctions

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.
Intelsat Answer: No comment.

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.
Intelsat Answer: As mentioned in section iii above, IMDA need to provide incentive reimbursement to C-band licensees that need to migrate to the other suitable frequency band with the consideration that there will be extra effort/cost to perform the "Migration Exercise". Such incentive reimbursement could be included in the 3.5 GHz spectrum packages being offered.

As explained above, C-band will remain important, given the number of satellites and the unique characteristics (robustness, size of beams) that suit specific needs. In the event that IMDA would want to identify on a national level additional bands for IMT, it would need to undertake a certain number of steps and perform careful technical studies to ensure service compatibility and protection to existing services. Most importantly, in order not to impact any incumbent services it would be necessary for IMDA to set up a workable spectrum sharing framework.

If IMDA carry out a national deployment without proper mitigation techniques for bands used for 5G mobile, then a large amount of spectrum directly adjacent will be unusable by incumbent services (e.g. satellite receivers). In fact, several administrations (e.g. Germany, China, Honk Kong, Australia, etc.) around the world have conducted studies on mitigation techniques required to protect incumbent services from both adjacent and in-band interference caused by IMT Mobile stations.

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.

Intelsat Answer:

IMDA needs to implement an audit mechanism on a yearly basis to ensure the applicants can deliver their proposals and to ensure the spectrum are well utilized.

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.

Intelsat Answer: No comment.

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.

Intelsat Answer:

TDD technology provides increased flexibility in comparison to the use of FDD, and several European administrations have used this flexibility to introduce regional licenses. It is up to each national administration to carefully evaluate the trade-off between introducing IMT2020 in accordance to the connectivity needs, existing usage in the band, and national policy objectives.

Furthermore, A TDD band plan provides flexibility so countries can examine the C-band and pick the parts which best fits their situation and meets their national needs. Thus, using 5G NR B77 will equally accommodate the use of the 3400-3600 MHz band since a country and an operator in the country is assigned only to a part of the band. Without duplexing gap as in FDD, so IMDA should not assume they need to adhere to the exact bands from 3GPP as there is no difference between the equipment in case if a country identifies 3300-3600 or 3300-4200 MHz.

In accordance to GSMA, with the use of TDD technology a single device will be able to operate in the entire range (3300-3700 MHz) and adjust to portions of the band released in any given country. That enables not only regional flexibility, but seamless roaming and the economies of scale necessary to drive down the cost of equipment.[2]

Comparing the cost to the other IMT bands, higher frequency bands will lead to reduced cell sizes, increasing the cost of mobile infrastructure. In addition, the TDD system required 31% more base stations than FDD when using a 1:1 TDD system, and 65% more base stations when

[2] GSMA "Considerations for the 3.5 GHz IMT range: getting ready for use," May 2017, Available at https://www.gsma.com/spectrum/wp-content/uploads/2018/12/Considerations-for-the-3.5-GHz-IMT-range-v2.pdf.

using a 2:1. Mobile systems using TDD transmit only periodically, which leads to lower bit rates.

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.

Intelsat Answer:

Intelsat supports the consideration of the V-Band (60 GHz) and E-Band (70-80 GHz) for backhauling instead of traditional frequency bands. Intelsat would also like to draw the attention of the IMDA to the satellite-based solutions for backhauling. Such solutions have been recognized in multiple reports by 3GPP[3]/[4]. In fact, 3GPP recognizes the added value of satellite coverage as part of the mix of access technologies for 5G and has therefore introduced a specific requirement to support satellite access to Release 15[5] and 16. Overview of the possible satellite roles in 5G, including backhauling, is also being currently developed by the ITU-R WP 4B[6].

vii. CONCLUDING COMMENTS

While no one disputes that mobile data traffic is increasing, the same is true for satellite services. For this reason, Intelsat would encourage IMDA to first improve mobile network density and efficiency within existing spectrum before seeking additional spectrum which is already extensively used by other services.

While the 3400-3700 MHz band may be lightly used in Singapore, neighbouring countries have launched a number of satellites that make use of this band more extensively and measures will have to put in place to ensure cross-border protection of co-frequency satellite earth stations. Deployments in Singapore would need to be limited to small cells to ensure that cross-border PFD limits are met. It remains to be seen whether it is practicable for Singapore satellite users in the 3400-3700 MHz band to migrate to higher bands given capacity and other constraints.

Intelsat would finally like to highlight that the satellite industry is counting on continued access to C-band spectrum at 3700-4200 MHz in future satellite deployments due to continued demand for satellite services. In particular, if more C-band spectrum is opened for IMT, it would be very difficult to provide effective and efficient services, and very costly if not impossible for satellite services to

[3] TR 38.811 – "Study on New Radio (NR) to support non-terrestrial networks (Release 15)," V1.0.0 (2018-06).
[4] TS 22.261 - "Service requirements for next generation new services and markets; Stage 1," v.15.7.0 (2018-12).
[5] TS 22.261 - "Service requirements for next generation new services and markets; Stage 1," v.15.7.0 (2018-12).
[6] ITU-R M.[NGAT_SAT] - "*Key elements for integration of satellite systems into Next Generation Access Technologies.*"

relocate to alternative bands. Furthermore, IMDA would find it very difficult to protect neighbouring countries using this band because of its superior propagation characteristics.

Finally, Intelsat would like to thank the IMDA for the opportunity to comment, and courteously asks that the IMDA takes careful account of our comments.