Inmarsat response to IMDA Consultation Paper

5G Mobile Services and Networks

3 July 2017

1. Introduction

Inmarsat is pleased to provide comments to the IMDA in response to the consultation paper "5G Mobile Services and Networks". We hope that this information will assist IMDA in developing the necessary policies to facilitate the deployment of innovative and advanced mobile technology, networks and services in Singapore, while taking into account the current and planned services provided by Inmarsat.

2. Role of satellite services in 5G

The momentum behind 5G in inescapable and the time is right for IMDA, and other regulators to take stock of the current situation and plan for the future. In doing so, it is important to examine not only the requirements for 5G terrestrial systems but also to examine the trends and impact on satellite services, which will continue to provide important services in Singapore and elsewhere.

Satellite communications has traditionally found a major role is supporting mobile and global communications. Examples are:

1. The provision of mobile communications directly to users in remote areas, using small portable user terminals. Today such communications range from low data rate M2M applications to "broadband" data connectivity with data rates around 0.5 Mbit/s.
2. The provision of mobile broadband service to passengers on ships and aircraft. For instance, connection of pico-cells or WiFi routers in the aircraft cabin may be accomplished by L-band MSS systems or FSS systems operating in the Ku-band and Ka-band.
3. The provision of backhaul to mobile stations in remote areas, where terrestrial infrastructure is poor. This is typically accomplished using VSAT satellite terminals operating in C-band, Ku-band and Ka-band.
4. Distribution of data within the network. For example broadcast content is distributed to the edge of the network to support high-speed and efficient download to users.

Inmarsat currently has a major role throughout the world in providing some of these satellite applications, in particular those described in bullets 1 and 2 above. Inmarsat also provides other services related to the safe operation of ships and aircraft, such as GMDSS (Global Maritime Distress Safety System) and flight tracking/cockpit communications, and it is vital that those operations do not suffer from harmful interference from possible new mobile broadband systems.

Just as current satellite systems support the current generation of mobile broadband communications, current and future satellite systems will also support the three broad use cases for 5G: Enhanced mobile broadband ("eMBB"); Massive Machine-Type Communications ("mMTC"); and Ultra-Reliable and Low-Latency Communications ("uRLLC").

The higher data throughputs anticipated for enhanced mobile broadband ("eMBB") will lead to the demand for increased bandwidth for satellite systems, whether providing backhaul to ships and aircraft or providing service directly to users in remote areas. This will require the introduction of larger, more powerful satellites, operating in higher frequency bands (Ka-band and above). The enormous number of Massive Machine-Type Communications ("mMTC") devices predicted in the future will not always be within the coverage of terrestrial networks and some will rely on satellite connectivity. L-band satellite systems, such as Inmarsat, are well placed to meet those future growth expectations. Low-Latency Communications ("uRLLC") will be supported by satellite communications providing data to the network edge and by broadcasting of software update to devices.

While the majority of users of these use cases will use terrestrial networks, it is important that the users of satellite networks are also taken into account. Even for Singapore, which has a well developed set of terrestrial networks with excellent national coverage, there is a need to look at spectrum regulatory requirements from a global perspective, recognising that Singapore is an important transport hub in the global economy.

Inmarsat today operates in the L-band MSS spectrum, the C-band FSS spectrum and the Ka-band FSS spectrum. In the future we expect to operate also in the Q/V band FSS spectrum. All of these frequency bands are potentially impacted by the possible introduction of 5G or other terrestrial mobile technologies. We describe in more detail below the potential impacts and suggest approaches that could be taken by IMDA.

3. L-band

The band 1427-1518 MHz is considered as a new band for mobile broadband, potentially for 5G mobile systems. The adjacent band, 1518-1559 MHz is allocated to the mobile-satellite service (MSS), used for the downlinks, which means there is potential for adjacent band interference from mobile broadband systems to receiving mobile earth stations.

The Inmarsat satellites currently providing service to users in and around Singapore operate in the "standard L-band" MSS frequencies: 1525-1559 MHz (space-to-Earth) and 1626.5-1660.5 MHz (Earth-to-space). These frequency bands are authorised for Inmarsat and other MSS operators in most APT countries and are used by land, aeronautical and maritime MSS terminals throughout the APT region.

Inmarsat's Alphasat satellite operates in the same standard L-band frequencies but, additionally, operates also in the "extended L-band" MSS frequencies: 1518-1525 MHz (space-to-Earth) and 1668-1675 MHz (Earth-to-space). The Alphasat satellite provides coverage of Europe, the Middle East and Africa. Inmarsat terminals capable of operating in the range 1518-1559 MHz have been available for several years and are gradually being introduced, in some cases replacing older equipment with the more limited frequency range. These terminals would be at risk of interference from mobile broadband systems if the latter were introduced in the adjacent band 1427-1518 MHz without special precautions.

Furthermore, Inmarsat has contracted with Airbus for the delivery of two new geostationary satellites known as "Inmarsat-6". These satellites will also operate in the "standard L-band" and the "extended L-band" frequencies. The first Inmarsat-6 satellite is due for delivery in early 2020 and is planned to start service later that year. The satellite is planned to be located so as to maximise coverage of the Asia-Pacific region and will therefore make the extended L-band frequencies available for use by MSS terminals throughout the region.

Due to the potential for harmful interference to MSS operations, WRC-15 agreed that compatibility studies between IMT and the MSS are necessary and should be taken into account in the frequency arrangements for IMT in the 1.5 GHz band. The need for these studies is recorded in Resolution 223 (Rev. WRC-15).

As is described by IMDA in paragraph 35 of the consultation document, the ITU-R technical studies are currently underway in ITU-R Working Parties 5D and 4C and are not yet concluded. The CEPT has already conducted studies on this compatibility issue and has developed ECC Report 263[1]. These studies are based on the assumption that the band 1427-1518 MHz would be used by terrestrial mobile systems for "Supplementary Downlink" (SDL). Hence the study considers potential interference from transmitting IMT base stations to receiving MSS terminals. No studies so far have considered potential interference from IMT user terminals, and so would not cover the possible use of TDD systems or FDD arrangements for which the band below 1518 MHz is used for the MBB user terminal emissions.

CEPT ECC Report 263 contains the results of extensive studies but does not provide precise recommendations on compatibility measures required to ensure adequate protection. However it is apparent from the studies that a guard band of at least 3 MHz is necessary to avoid harmful interference to MSS operations. Even with a 3 MHz guard band, some power limitation and deployment limitations would need to be placed on IMT base stations. Furthermore, MSS terminals would need to be re-designed with improved filtering, able to reject interference from mobile base stations.

Considering the situation in Singapore in particular, Inmarsat is very concerned about potential future interference to ship earth stations used in and close to Singapore, and to aircraft earth stations operating on aircraft flying in and out of Singapore's airports. Given the high density of shipping around Singapore and the high density of aircraft in Singapore's airspace, it is important that IMDA gives very careful consideration to the potential for adjacent band interference to MSS operations. This is likely to require:

- A guard band with the upper part of the mobile band (i.e. just below 1518 MHz), to allow for the mobile base stations and MES receivers to provide adequate filtering.
- A limit on the out-of-band emissions from mobile stations to protect MSS operations
- Deployment constraints for mobile base stations in the vicinity of the main harbours and airports in Singapore.

In *Question 5)*, IMDA asks the following:

> *IMDA would like to seek views and comments on following:*
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> *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).*

Inmarsat does not take strong view of the choice of frequency arrangement (SDL, TDD or FDD). We do however note that, so far, the studies in the CEPT and the ITU have focussed on interference from the mobile base station to the mobile earth station. If the TDD option or FDD

[1] Available at http://www.erodocdb.dk/doks/doccategoryECC.aspx?doccatid=4

option is pursued, it will be necessary to also consider potential interference from the mobile terminal to the mobile earth station, which will require additional sharing studies.

Taking into account the sharing studies with respect to the MSS conducted by the CEPT, Inmarsat believes that the frequency arrangements for mobile broadband in the band 1427-1518 MHz should include a guard band of 3 MHz below 1518 MHz - i.e. the upper band edge should be 1515 MHz. It is likely that a similar sized guard band is required at the lower band edge to meet the protection requirements for the earth exploration satellite service (passive), as defined in ITU Resolution 750 (Rev.WRC-15). Assuming 5 MHz channels, the frequency arrangements would then be as shown below:

While benefitting compatibility with the MSS, this plan, compared to other options which place only 1 MHz guard band at the upper edge of the IMT band, would require less significant power constraints and/or more easily achievable filter requirements on the lowermost and uppermost IMT channels.

In *Question 6*, IMDA asks:

> *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.*

As described above, Inmarsat supports a 3 MHz guard band at either edge of the band 1427-1518 MHz, giving a total of 85 MHz for mobile broadband. It might be possible to use these guard bands for other applications such as wireless microphones.

4. Extended C-band

In the context of the consultation document, we understand "extended C-band" to mean the frequency band 3400-3600 MHz. This band is partly used by Inmarsat for the feeder downlinks of our L-band MSS network.

In *Question 7*, IMDA asks:

> *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?*

Regarding Inmarsat use of the extended C-band, it is not possible to migrate those operations to other parts of the C-band. This is for two reasons: firstly, the Inmarsat satellites do not tune to the band above 3.7 GHz; secondly, it would not be possible to coordinate the use of the orbital slots used by Inmarsat for the use of the frequencies 3.7-4.2 GHz due to the existence of other GSO satellites at nearby orbital locations which already use those frequencies. Coordination of other orbital locations is also unlikely to be possible, due to the many C-band satellites already in operation. The use of the extended C-band for the feeder links for Inmarsat MSS network is likely to remain necessary for the foreseeable future.

In *Question 8*, IMDA asks:

> *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.*

Regarding potential use of the band 3.4-3.6 GHz for mobile broadband in Singapore, there are some regulatory constraints on the deployment of mobile broadband that should be taken into account. Firstly, the use of mobile systems in this band in Singapore would need to be coordinated with receiving earth stations using the same band in neighbouring countries. For example, Indonesia has a C-band earth station in Batam. This earth station is located about 30 kilometres from Singapore and receives in the 3.5 GHz band. The coordination contour for the Batam earth station is shown in the attachment, which can be seen to include all of the territory of Singapore. Given the short separation distance, and the fact that the interference path is over sea, which normally leads to low propagation losses, it is doubtful that the use of IMT systems could be deployed in Singapore while meeting the protection requirements of this Indonesian earth station and possibly other earth stations in Indonesia.

Furthermore, IMDA is courteously reminded that under the conditions of No. 5.432B of the Radio Regulations, the use of the band 3400-3500 MHz by subject to the application of No. 9.21 with respect to potential interference to other countries and is subject to pfd values at the borders of other countries. In the band 3500-3600 MHz, although similar footnote 5.433A does not apply to Singapore, the use of mobile systems remains subject to meeting the coordination requirements with respect to earth stations in neighbouring countries. Even if IMT systems in the extended C-band are limited to indoor use in Singapore, it is likely that significant constraints will be required to ensure compliance with the requirements of the Radio Regulations. IMDA would need to coordinate the use of the extended C-band with its neighbours before new mobile broadband systems are deployed. It is possible that successful coordination cannot be achieved.

5. Above 6 GHz

WRC-19 agenda item 1.13 aims to address the potential need for spectrum above 6 GHz to support 5G systems ("IMT-2020" in the ITU terminology). Some of the bands in the scope of that agenda item are of direct interest to Inmarsat, in particular the following bands: 37-40.5 GHz, 40.5-42.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-51.4 GHz. These bands contain current allocations to the FSS and/or MSS and are bands of high interest for future use by Inmarsat. These frequency bands are likely to be used initially for feeder links for our satellite services and, in the longer term, might be used also by user terminals. Inmarsat has made a number of filings to the ITU for the coordination of satellite networks in these bands.

We therefore believe that it is important that sharing studies conducted by the ITU-R take account of expected use of these bands by other services, including the FSS and MSS. If these bands are to be

identified for IMT at WRC-19, it should be ensured that satellite systems are also able to operate without interference.

In *Question 11)*, IMDA asks:

> *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)?*

Inmarsat does not believe that there is a good case for making the 28 GHz band available for mobile broadband in Singapore. Better options exist in the bands 24.25-27.5 GHz and 31.8-33.4 GHz, both of which are within the scope of WRC-19 agenda item 1.13, and therefore have good scope for international harmonisation that will in turn lead to wide availability of equipment. The band 24.25-27.5 GHz in particular is already gaining traction in Europe as a priority band for 5G, and is gaining support in other parts of the world. We suggest that IMDA supports this band for 5G in place of any further consideration of the 28 GHz band.

In *Question 12)*, IMDA asks:

> *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?*

The 28 GHz band is currently used by Inmarsat's "Global Xpress" satellites, for both feeder links and links to user terminals. This band is also very widely used by other satellite operators, GSO and non-GSO, for satellite services. Sharing of the 28 GHz band is not likely to be feasible but, as it is not within the scope of WRC-19 agenda item 1.13, there are no sharing studies taking place in this band.

We strongly encourage IMDA to drop any intention to consider the 28 GHz band for mobile broadband in Singapore and to focus on those bands within the scope of AI 1.13.

6. Concluding comments

Inmarsat thanks the IMDA for the opportunity to comment, and courteously asks that the IMDA takes careful account of our comments. We would be pleased to provide further information if necessary, for which the suggested contact point is:

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Attachment

RR Appendix 7 coordination contour for C-band earth station in Batam