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Shri Syed Tausif Abbas 10 January 2022

Networks, Spectrum and Licensing
Telecom Regulatory Authority of India
Doorsanchar Bhawan, Jawaharlal Nehru Marg, New Delhi - 110002
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Subject: Consultation Paper No. 8/2021 on "Auction of Spectrum in frequency bands identified for IMT/5G"

Dear Sir/Madam,

AsiaSat welcomes TRAI's consultation paper on 30th November 2021 and is pleased to offer its response below.
AsiaSat is an operator of FSS geostationary satellites which have been used to serve India for more than 30 years, ever since the inception of the company and the launch of the first satellite in 1990. In the below, AsiaSat will limit its comments to the frequency bands 3 300-3 670 MHz and 24.25-28.5 GHz which are the frequency bands where there could be issues in respect of regular FSS satellites. Moreover, in offering its comments, AsiaSat are limiting these to only issues which are relevant to the technical compatibility with FSS.
AsiaSat would welcome any questions or requests for clarification from TRAI in respect of the below comments.

COMMENTS RELATED TO C-BAND (RELEVANT TO 3 300-3 670 MHZ)
C-band use by satellite

Due to its high resilience to rain fade and instant connectivity, C-band is heavily used for satellite communications in India as in the rest of the Asia Pacific Region using a large number of Indian and international satellites for a multitude of services including very small aperture terminal (VSAT) networks (also used for disaster relief operation), internet services, backhaul for cellular networks, point-to-multipoint links, satellite news gathering, transfer of TV content between studios, TV broadcasting to satellite master antenna television (SMATV), direct-to-home (DTH) receivers and feeder links for mobile satellite services. FSS satellites also are expected to become an integral part of the 5G infrastructure, offering several 5G applications, e.g. Internet of Things and Massive Machine Type Communications. Noting the effects of climate change with more and more intense rain in some regions and more extreme weather leading to more natural disasters, the importance of having satellite links that can combat such conditions is ever increasing.
With C-band satellites located about every second degree along the geostationary arc, the C-band FSS frequency resources are heavily reused. It is also worth to note that most C-band satellites also are controlled through C-band signals (telemetry, tracking, command and ranging).

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The wide coverage of satellites in C-band enables services to be provided to sparsely populated and geographically remote areas and over large distances within India as well as between India and other countries and continents. Furthermore, due to its lower frequency compared to other alternative FSS frequency bands, in particular in regions characterized by high rain attenuation, C-band is the only realistic satellite band where FSS services can be provided with high availability.

Satellite C-band spectrum

FSS C-band is commonly referred to as three sub-bands:

1. "Standard C-band" (3 700-4 200 MHz (space-to-Earth (downlink)) / 5 850-6 425 MHz (Earth-to-space (uplink)))

2. "Extended C-band" (3 400-3 700 MHz (space-to-Earth) / 6 425-6 725 MHz (Earth-to-space))

3. "Planned C-band" (4 500-4 800 MHz (space-to-Earth) / 6 725-7 025 MHz (Earth-to-space))(These bands are subject to the special allotment Plan and the other provisions of Appendix 30B of the Radio Regulations)

For this consultation, AsiaSat believes that there is no need for discussion on Planned C-band.
In respect of standard and extended C-band, several satellites use these bands in their entirety. To achieve an economic and efficient satellite design, a common design seen in many satellites serving the Asia-Pacific region is to use the entire standard C uplink band, 5 850-6 425 MHz with one single conversion frequency of 2225 MHz in the satellite. The resulting downlink band then becomes 3 625-4 200 MHz, i.e. entire standard C downlink band and the upper 75 MHz of the extended C downlink band.

Compatibility issues

The 3 300-3 670 MHz band considered by TRAI for IMT/5G overlaps with the 3 400-4 200 MHz FSS downlink band and receiving FSS earth stations may be interfered by IMT/5G transmitting base stations and user terminals. The issue on incompatibility in C-band downlink between FSS and various broadband terrestrial applications to individual users is not new. Extensive studies (see Annex 1 for a list of some relevant reports) have been carried out in ITU and APT and there is also significant practical experience gained from deployment in Asia-Pacific and other parts of the world. All the studies and the practical experience lead to the same conclusion; that co-existence between FSS and IMT/5G in overlapping or adjacent frequency bands in the same geographical area is not feasible. The reach of the geographic area of incompatibility depends on many factors such as characteristics and type of deployment of IMT/5G, size of guardband between IMT/5G and FSS, levels of unwanted emissions of IMT/5G, use of adjacent band rejection filters on FSS receiver front-ends etc. It is also worth to note that prior to IMT/5G, there were broadband wireless access (BWA) networks, often referred to as WiMax, deployed in several countries in the 3 400-3 600 MHz band. For non-technical reasons, these networks were not successful. However, in the countries where WiMax was tried

introduced, massive disruptions to FSS reception in the entire 3 400-4 200 MHz band was encountered, confirming the APT and ITU studies and reports.
There are three different interference mechanisms which will impact FSS reception:

1. **Co-frequency interference**
   Due to the long distance to the satellite and the power limitations of the satellite, the incoming FSS signal's power flux density at the earth station location is very low. IMT equipment which is much closer to the earth station can produce significantly higher power levels at the input to the FSS receiver than the desired satellite signal.

   Depending on the type of IMT deployment considered, studies have shown that separation distances required to offer adequate protection of FSS receivers in respect of co-frequency interference are in the range of five to tens of kilometres for IMT small-cell indoor deployment to several hundreds of kilometres for IMT macro-cell outdoor deployment. It may also be worth noting that in USA, FCC has established a 150 km protection zone around 86 earth stations operating in the 3 650 – 3 700 MHz range to protect them against terrestrial interference.

2. **Adjacent band interference**

   a. <u>Unwanted out-of-band emissions of IMT/5G transmitters</u>

      Due to the very low power level of the incoming FSS signals, unwanted emissions generated by IMT/5G base stations or user terminals operating in an adjacent frequency bands, can create interference to FSS receivers.

      Depending on the type of IMT deployment considered, studies have shown that the separation distances required to offer adequate protection to FSS receivers in respect of out-of-band emissions of IMT/5G transmitters, assuming no guardband between the satellite and IMT/5G signals, are in the range of less than a kilometer for IMT/5G small-cell indoor deployment, some few kilometres for IMT/5G small-cell outdoor deployment and tens of kilometres for IMT/5G macro-cell outdoor deployment. This required separation distance may be possible to reduce by use of a guardband between the two signals and by imposing tighter requirements in respect of unwanted emission levels, e.g. by use of filters on IMT/5G transmitters.

      It is important to note that since unwanted emissions of IMT/5G will fall in the band to be received by FSS, use of filters on FSS receivers will have no effect in respect of mitigating interference due to unwanted emissions of IMT/5G transmitters.

b. FSS receiver LNA/LNB overdrive

Earth station low-noise amplifiers (LNAs) and low-noise block down-converters (LNBs) are optimized for reception of the very low power level of the incoming satellite signal and, hence, have a very high sensitivity and their dynamic range adjusted to these very low power levels. Incoming IMT/5G signals at much higher power levels can severely affect the operating point of the LNA/LNB and drive it out of its dynamic range to where it exhibits a non-linear behaviour. This results in the creation of intermodulation products and gain compression which in turn result in distortion and loss of the FSS signal.

Typically, to achieve a low noise figure to allow reception of the very low incoming satellite signals, LNAs and LNBs are wideband devices with a flat frequency response over the wanted frequency range, having the bandwidth defining filtering only at intermediate frequency (IF) stage, not at the RF stage. As a result, IMT/5G emissions in adjacent bands will have the capability to overdrive the LNA/LNB.

Depending on the type of IMT/5G deployment considered, studies have shown that the separation distances required to offer adequate protection to FSS receivers in respect of LNA/LNB overdrive are about a kilometre in respect of IMT/5G small-cell deployment and around 9 kilometres in respect of IMT/5G macro-cell deployment.

By use of waveguide filters before the front-end receiver of the FSS earth stations in combination with a guardband between the IMT/5G signals and the FSS signals to enable the filters to produce the required discrimination of the IMT/5G signals, these separation distances can be reduced. In other countries where waveguide filters are being used, it is seen that a minimum discrimination of about 45 – 60 dB is considered. In considering use of waveguide filters on the FSS front-end, consideration needs to be given to the cost and practicality of installing such filters on all the FSS C-band antennas already in use in India.

C-band IMT/5G in other countries in Asia-Pacific

To get a picture of what other countries in the Asia-Pacific region is doing, how and what portion of the band is protected for FSS, the below table summarizes the situation in some Asia-Pacific countries.

	IMT/5G	Guardband	FSS	Comments
Singapore	3 450-3 650 MHz	50 MHz	3 700-4 200 MHz	3600–3650 MHz and 3450–3500 MHz limited for indoor and underground use. Exclusion zones to protect critical FSS operations (*e.g.*, TT&C stations) and 5 precautionary zones for high density areas of C-band FSS operations.
Hong Kong	3 300-3 600 MHz	100 MHz	3 700-4 200 MHz	3 300-3 400 MHz limited to indoor deployment. Exclusion zones to protect TT&C stations
China	3 300-3 600 MHz	100 MHz	3 700-4 200 MHz	3 300-3 400 MHz limited to indoor deployment. Adoption of interference coordination areas with a specific separation distance between IMT and FSS
Indonesia	3 400-3 600 MHz	100 MHz	3 700-4 200 MHz	
Myanmar	3 400-3 520 MHz	105 MHz	3 625-4 200 MHz	

In considering IMT/5G deployment in India, in particular in areas close to the borders, it is also important to note that required protection of other services, including FSS, in neighboring countries needs to be observed. The Radio Regulations contain pfd limits for this purpose.

AsiaSat also notes the concerns currently raised by the aviation authorities in respect of the impact of IMT/5G C-band deployment on performance of aviation altitude radars and air traffic safety. TRAI may want to ensure that no IMT/5G deployment could put air traffic safety at risk.

Comments on questions related to 3 300-3 670 MHz

In response to some selected questions related to 3 300-3 670 MHz, AsiaSat is offering the below comments:

Q8

Whether entire available spectrum referred by DoT in each band should be put to auction in the forthcoming auction? Kindly justify your response.

AsiaSat understands the intent of TRAI to be to allow IMT/5G in the lower part of C-band downlink while protecting FSS in 3 700-4 200 MHz. Noting that, as discussed above, a large number of the satellites serving India has downlinks in the 3 625-4 200 MHz band, to allow the transponders in these satellites to be able to continue to be used efficiently in India, AsiaSat would recommend that the 3 625-4 200 MHz band be appropriately protected for FSS reception in India. For this reason, AsiaSat would suggest that India do not put out for auction the upper part of the band and rather put out for auction bands from 3 300 MHz up to around 3 550 MHz, allowing a realistic guardband to protect FSS in 3 625-4 200 MHz.

Q.16
Is there a need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands or it should be left to the TSPs to manage the interference by mutual coordination and provisioning of guard bands? Kindly provide justification to your response.

In respect of interference from IMT/5G into FSS receivers, since this interference is one-way, i.e. from IMT/5G transmissions into FSS reception, individual TSPs would have no motivation or incentive to implement interference mitigation measures to protect FSS. AsiaSat therefore is of the view that interference mitigation measures to be implemented by the IMT/5G operator need to be obligated in the licensing conditions for IMT/5G and cannot left for the TSPs to manage.

Additionally, it is to be noted that there are a large number of C-band antennas in operation in India today and consideration needs to be given as to who would be responsible for and who would bear the cost of implementing required interference mitigation techniques against IMT/5G on the FSS side, e.g. purchase and installation of front-end filters, relocation of FSS antennas to achieve site shielding, change to larger antennas etc. It may be noted that in some countries, the cost of implementing interference mitigation measures are compensated by the government.

Noting that operation of IMT/5G and FSS in overlapping bands require very large exclusion zones around FSS earth stations, an opening up for IMT/5G in, or immediately adjacent to, bands currently used by FSS earth stations could require migration to other frequencies or other frequency bands for the FSS receivers. Consideration in this respect needs to be given to who would compensate for the cost of such migration and also, especially in respect of Indian satellites, who would compensate for the in-orbit satellite transponders that now become unusable. AsiaSat notes that in USA, FCC is compensating FSS operators to migrate customers to other frequency bands to free up spectrum for IMT/5G.

Q.17
In case your response to the above question is in affirmative,

a. whether there is a need to prescribe provisions such as clock synchronization and frame structure to mitigate interference issues, as prescribed for existing TDD bands, for entire frequency holding or adjacent frequencies of different TSPs? If yes, what should be the frame structure? Kindly justify your response.
b. Any other measures to mitigate interference related issues may be made along with detailed justification.

Should India decide to open up any portion of the 3 400-3 670 MHz portion of the suggested band for IMT/5G, consideration needs to be given to in-band interference. As described above, achieving in-band compatibility would require very large exclusion zones around earth stations. Such exclusion zones would not be realistic to establish around a large number of earth stations. However, it could be that a limited number of earth stations could be grandfathered for in-band operation with defined exclusion zones around them where ITM/5G would not be deployed in C-band. In particular if there are satellites with C-band TT&C links that are controlled from Indian territory, careful consideration of interference is required to ensure the safe control and operation of the satellites.

Should India decide to open up for IMT/5G in the entire 3 300-3 670 MHz band, this would leave only 30 MHz of guardband to FSS in 3 700-4 200 MHz. This would put extreme requirements on both limitations on unwanted emissions of IMT/5G transmitters and on characteristics of front-end filters for FSS receivers. Also noting the much wider guardband chosen by other administrations, AsiaSat questions if such requirements can realistically be met using commercially available equipment and if IMT/5G operators would be prepared to accept such limitations, tighter than that of regular IMT/5G specifications, in respect of their unwanted emissions. Careful consideration of what would be a realistic and reasonable guardband to allow operation with regular commercially available equipment therefore is required.

No matter what portion(s) of the 3 300-3 670 MHz band is eventually decided opened up for IMT/5G, the entire band or 3300-3550 MHz as suggested by AsiaSat, there is a need for adjacent band interference mitigation measures. Possible interference mitigation measures include:

- Sufficient guardband;
- Specified limitations on unwanted emissions of IMT/5G equipment, achieved e.g. by use of additional filters;
- Use of FSS front-end waveguide filters;
- Site shielding for IMT/5G base stations and/or FSS receive earth stations;
- Power limitations on IMT/5G base stations;
- Limitations on deployment, e.g. only indoor low power deployment in frequency bands closer to FSS;
- Exclusion zones around selected teleports and earth stations (even with a sufficient guardband and filters implemented, the need for separation distances to achieve compatibility is only reduced, but not entirely eliminated).

As pointed out in the response to Q16, it is important that any such interference mitigation measures become an integral part of the licensing conditions for IMT/5G since the TSPs later would have no incentive or motivation to implement such measures.

Q.20
What should be associated roll-out obligations for the allocation of spectrum in 3300-3670 MHz frequency band? Kindly justify your response.

AsiaSat believes that in the roll-out plan for IMT/5G in the portion of C-band which is allocated for IMT/5G in India, the various special measures and limitations for different sub-bands, including those to mitigate interference into FSS, e.g. those mentioned in the comments to Q17 above need to be clearly specified.

Q.49

Whether the valuation of the 3300-3670 MHz spectrum band should be derived from value of any other spectrum band by using technical efficiency factor? If yes, what rate of efficiency factor should be used? If no, which other method(s) should be used for its valuation? Please justify your response with rationale and supporting documents, if any.

While having no particular view on the valuation of C-band spectrum, AsiaSat believes that it would be reasonable to assume that sub-bands with little compatibility difficulties with FSS, e.g. those with good frequency separation to the FSS used bands, would be more attractive to IMT/5G operators and thus might attract higher prices. It might be logical to consider enabling IMT/5G operators to give differentiated offers for different sub-bands.

Q.69

To meet the demand for spectrum in globally harmonized IMT bands for private captive networks, whether the TSPs should be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location? Kindly justify your response.

AsiaSat would see no particular difficulties if frequency bands allocated to TSPs through the auctions are leased for private captive networks provided that all conditions for its use, e.g. requirements to enable compatibility with FSS, is transferred to the operators of these networks.

Q.73

In case it is decided to earmark some quantum of spectrum for private captive networks, either on exclusive or shared basis, then

a) Spectrum under which band(s) (or frequency range) and quantum of spectrum be earmarked for Private Network in each band? Inputs may be provided considering both dedicated and shared spectrum (between geographically distinct users) scenarios.

b) What should be the eligibility conditions for assignment of such spectrum to private entities?

c) What should be the assignment methodology, tenure of assignment and its renewal, roll-out obligations?

It is understood that in respect of C-band, this idea is to explore identifying spectrum for private captive networks in the FSS downlink bands above those identified and allocated for IMT/5G (in the consultation paper, it is noted that the entire remaining 3 670-4 200 MHz is mentioned).

AsiaSat would advise strongly against this.

As mentioned in the introductory paragraphs, C-band FSS is used for a multitude of applications throughout the entire India, including very small aperture terminal (VSAT) networks (also used for disaster relief operation), internet services, backhaul for cellular networks, point-to-multipoint links, satellite news gathering, transfer of TV content between studios, TV broadcasting to satellite master antenna television (SMATV), direct-to-home (DTH) receivers and feeder links for mobile satellite services. FSS satellites also are expected to become an integral part of the 5G infrastructure, offering several 5G applications, e.g. Internet of Things and Massive Machine Type Communications. Receiving antennas for these applications are currently deployed in large numbers in every corner of India. Many of the receiving earth stations of several of these applications are not individually licensed and their numbers, locations or characteristics are not known. Other earth stations like SNG stations or disaster relief earth stations will be nomadic in nature and there location will change according to demand.

Ensuring compatibility with FSS receiving earth stations receiving in the same frequency band requires that transmitters of private captive networks observe a minimum separation distance to all receiving FSS earth stations. However, since the number, location and characteristics of most receiving FSS earth stations are not known, no such separation distance can be guaranteed.

<u>COMMENTS RELATED TO KA-BAND (RELEVANT TO 24.25-28.5 GHZ)</u>
Ka-band use by satellite

In respect of this consultation, as shown in the below figure, there are three bands of relevance in respect of satellite operation: 24.65-25.25 GHz, 27-27.5 GHz and 27.5-28.5 GHz. These are all FSS uplink (Earth-to-space) bands. It may be seen that less than 50% of the band considered by India for IMT/5G are allocated to FSS.

1. The 27.5-28.5 GHz band is a part of the 27.5-31 GHz globally allocated FSS band. Several satellites also in the Asia-Pacific region, already use, amongst others, the 27.5-28.35 GHz band. Globally, there is a trend to develop and deploy "High Throughput Satellites" (HTS) offering wideband connections to end users through large numbers of small spot beams with extensive frequency re-use. This includes applications addressing maritime, aeronautical and land mobile user terminals ("ESIMs" (Earth Station In Motion)). In Europe, the European Communications Commission (ECC) has assigned the 27.5-31 GHz band for satellite uplinks, but not 5G. Furthermore, it is notable given the importance of the band for FSS worldwide, that WRC-15 in identifying frequency bands to be studied as potential candidate bands for IMT/5G decided NOT to consider the 27.5-31 GHz band as a candidate band for IMT/5G under WRC-19 Agenda Item 1.13. On the contrary, WRC-15 created WRC-19 Agenda Item 1.5 to study use of ESIMs operating in the 27.5-29.5 GHz uplink band (and the 17.7-19.7 GHz downlink band) to further expand the FSS applications for this band and WRC-19 consequently adopted Resolution 169 to facilitate and regulate such use of FSS satellites.

   FSS satellites operating in this band, both geostationary and non-geostationary will also be used to provide 5G applications to end users and are thus instrumental also in respect of the development and deployment of 5G.

   While the user terminals accessing Ka-band HTS satellites normally will transmit at frequencies above 28.5 GHz, the gateways normally will transmit within these bands, in particular starting from 27.5 GHz, but in this Region, also in the 27-27.5 GHz band. As more and more HTS satellites are deployed, one therefore will see increasing activity in these bands.

   There currently is great interest in non-geostationary satellite constellations with large numbers of satellites being built and launched. Practically all of these satellites systems operate in Ka-band. In the band 28.6-29.5 GHz, unlike in most other frequency bands, the Radio Regulations prescribe a coordination process between geostationary and non-geostationary FSS systems. Due to the large number of non-geostationary FSS satellites currently being launched,

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geostationary FSS networks increasingly are eyeing use of gateway uplink bands below 28.6 GHz, i.e. 27.5-28.6 GHz and 27-27.5 GHz.

2. The 27-27.5 GHz band, is allocated to FSS in ITU-R Regions 2 and 3. While this band has been identified for IMT (5G) by WRC-19, it also provides a most valuable opening for FSS gateways and other earth stations addressing HTS networks in this region (see, for example, Australia's NBN HTS satellites, which use this spectrum). As mentioned above, with the current high interest in non-geostationary systems, several of which are already deployed or in the process of being deployed, non-geostationary systems could make access difficult for geostationary satellites in the 28.6-29.5 / 18.8-19.7 GHz where . This makes use of the 27-27.5 GHz band for GSO HTS networks even more important and could prove essential in enabling sufficient uplink bandwidth for geostationary HTS networks, particularly for gateway links.

3. The 24.65-25.25 GHz band is foreseen as being used primarily for BSS feederlinks and in particular associated with BSS in the 21.4-22 GHz band. For this reason, the expected use may be limited to a number of larger earth stations, e.g. > 3.5 m antennas located at teleports or at the premises of the BSS and pay TV providers.

   Since this band was given definitive procedures for use only by WRC-12, noting the 15-20 year lifespan of a satellite, there has been little time to develop and deploy satellites using these bands. It is however known that there are plans in some countries to make use of these bands in future satellites. Over time, one therefore should expect to see use of the 24.65-25.25 GHz band for FSS increasing.

Compatibility issues

While the 3 300-3 670 MHz considered by India for IMT/5G would impact FSS downlink bands, the 24.25-28.5 GHz band would impact FSS uplinks. As a consequence of this, the interference mechanisms and also possible mitigation techniques will be significantly different:

1. IMT/5G transmitters can cause interference to receiving satellites. While one single IMT/5G base station or user terminal may not cause noticeable interference, the aggregation of the interference from all IMT/5G devices within the coverage diagram of a satellite can cause significant interference. Since this aggregated interference will be generated by a large number of IMT/5G transmitters associated with a large number of IMT/5G operators, possibly located in several countries, it will be impossible to identify individual IMT/5G transmitters or operators as being responsible for the interference. For this reason, in identifying the 24.25-7.5 GHz band for IMT/5G, WRC-19 in Resolution 242 include power limits to be observed by individual IMT/5G transmitters with the aim of controlling the aggregated interference.

2. Transmitting earth stations can cause interference to receiving IMT/5G base stations and user terminals in their vicinity. However, with the appropriate interference mitigation techniques implemented by IMT/5G, e.g. use of cognitive radio and software defined radio techniques, it should be feasible for IMT/5G to be introduced without any detrimental impact on development

and deployment of FSS transmitting earth stations.

3. For IMT/5G operation in the frequency bands not overlapping with FSS uplinks, i.e. 24.25-24.65 GHz and 25.25-27 GHz, there will be no compatibility issues and no need for special measures in respect of FSS.

Comments on questions related to 24.25-28.5 GHz

In response to some selected questions related to 24.25-28.5 GHz, AsiaSat is offering the below comments:

Q8

Whether entire available spectrum referred by DoT in each band should be put to auction in the forthcoming auction? Kindly justify your response.

In considering terrestrial 5G within the 24.25-28.5 GHz band, it is important to recognize the need to safeguard the evolution and growth of also the satellite industry in India, including the satellite component of 5G as a part of the overall telecommunications infrastructure to serve its population and to enable India to remain its positon as one of the leading telecommunication communities in the Asia-Pacific region.

Noting that more than 50% of the band considered by India for IMT/5G, i.e. 24.25-24.65 GHz and 25.25-27 GHz, is not allocated by ITU to FSS, AsiaSat would recommend that as a first approach, these portions are considered for auction.

For frequency bands overlapping with FSS uplink bands, if these are to be considered for auction for IMT/5G use, it is important that this would not be to the detriment of the development and deployment of transmitting FSS earth stations. To achieve this, it is important that IMT/5G deployment is able to tolerate interference from FSS uplinks as the deployment of these change in accordance with changing demand. To achieve this, IMT/5G may employ various interference techniques (see comments on Q16 and 17 below).

In respect of the 24.65-25.25 GHz band, there will be very few, if any, earth station antennas in India as of today. Moreover, the use of this band for FSS will predominantly be for feederlinks for BSS which means a limited number of antennas located at teleports or broadcaster or pay TV operator premises, using relatively large antenna size. Such antennas would also normally be individually licensed and their location and characteristics would be known. If considering IMT/5G also in frequency bands overlapping with FSS uplinks, this band would seem to be the one where there would be the least probability of interference into IMT/5G receivers and also where it would be easiest for IMT/5G to implement efficient interference mitigation measures.

In respect of the 27-27.5 GHz band, since this band is not allocated for FSS in Region 1, fewer satellites implement this band than the bands above 27.5 GHz, in particular for satellites that may also be used over Region 1 and this in turn would imply fewer earth stations currently in operation and thus lower chances of interference. This band also was identified by WRC-19 for IMT/5G in RR No. 5.532AB and Resolution 242. As a second choice out of the frequency bands overlapping with FSS, AsiaSat believes that this band could be considered.

In respect of the 27.5-28.5 GHz band, AsiaSat observes that this is a globally allocated FSS band with several satellites with associated earth stations already in operation. Furthermore, it is notable given the importance of the band for FSS worldwide, that WRC-15 in identifying frequency bands to be studied as potential candidate bands for IMT/5G decided NOT to consider the 27.5-31 GHz band as a candidate band for IMT/5G under WRC-19 Agenda Item 1.13. On the contrary, WRC-15 created WRC-19 Agenda Item 1.5 to study use of ESIMs (applications addressing maritime, aeronautical and land mobile user terminals (Earth Station In Motion) using FSS satellites) operating in the 27.5-29.5 GHz uplink band (and the 17.7-19.7 GHz downlink band) to further expand the FSS applications for this band and WRC-19 consequently adopted Resolution 169 to facilitate and regulate such use of FSS satellites. Also, in Europe, the European Communications Commission (ECC) has assigned the 27.5-31 GHz band for satellite uplinks, but NOT IMT/5G.
AsiaSat believes it would be better for India to aim for internationally harmonized bands for deployment of IMT/5G rather than opting for bands which are not and where interference from transmitting FSS earth stations is most likely to occur. Should this band nevertheless be considered for IMT/5G use, this should be on the strict conditions that IMT/5G will tolerate interference from transmitting FSS earth stations as these are deployed and developing over time and will employ required interference mitigation techniques to cope with this. Moreover, IMT/5G should be required to observe the required limitations to adequately protect receiving satellites, e.g. by having the same limits as those contained in Resolution 242 imposed also in this band.

Q.16
Is there a need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands or it should be left to the TSPs to manage the interference by mutual coordination and provisioning of guard bands? Kindly provide justification to your response.

In respect of interference between IMT/5G and FSS, should India decide to open up part of the FSS uplink bands for IMT/5G, AsiaSat is of the view that that this should not be left for the TSPs to manage and that in the licensing conditions for IMT/5G, the relationship with FSS should be made clear. Specifically, these conditions should clarify that;

1. To adequately protect receiving FSS satellites, IMT/5G transmitters should comply with specified limits, e.g. those specified in Resolution 242.

2. IMT/5G should be able to cope with the interference from transmitting earth stations as deployment of these change over time with changing demand. For this purpose, it should be made clear that the "first come, first served" principle would not apply and that complaints cannot be made about interference from new earth stations. The licensing conditions could also contain requirements for mitigation measures for IMT/5G to cope with interference from transmitting earth stations, e.g. use of cognitive radio and software defined radio, but this could also be left for the TSPs to consider themselves.

Without clear guidelines on the interference management between IMT/5G and FSS, TSPs could cause interference to receiving satellites with little options to rectify it after the deployment and TSPs could also have false expectations in respect of deployment of new FSS earth stations.

Q.17
In case your response to the above question is in affirmative,

a. whether there is a need to prescribe provisions such as clock synchronization and frame structure to mitigate interference issues, as prescribed for existing TDD bands, for entire frequency holding or adjacent frequencies of different TSPs? If yes, what should be the frame structure? Kindly justify your response.
b. Any other measures to mitigate interference related issues may be made along with detailed justification.

Should India decide to open up any portion of Ka-band which overlaps with FSS for IMT/5G, consideration needs to be given to both interference from transmitting IMT/5G into receiving satellites and from transmitting FSS earth stations into receiving IMT/5G. Unlike for C-band, both these interference mechanisms are expected to be an issue only in respect of in-band interference.
The resulting interference from transmitting IMT/5G into receiving FSS satellites will be an aggregation of interference from all IMT/5G transmitters in the frequency band within the coverage area of the FSS satellite receiving beam. Mitigation of this interference is obtained through individual IMT/5G transmitters adhering to power limits which take into account an expected number of simultaneously co-frequency IMT/5G transmitters within the coverage of a satellite beam. WRC-19 Resolution 242 contain such power limits for IMT/5G transmitters in the 24.25-27.5 GHz band. Should India decide to consider portions of the 27.5-28.5 GHz band for IMT/5G, the same limits could be considered also for this band.
For interference from transmitting FSS earth stations into IMT/5G receivers, it is important that IMT/5G receivers are designed to cope with the interference that they receive without seeking to limit the further development of FSS and deployment of transmitting FSS earth stations. Techniques that could be considered for IMT/5G to mitigate interference from transmitting FSS earth stations include:

- Cognitive radio (/software defined radio)
  While in principle FSS earth stations can transmit at any frequency from any location at any time, it is known that no single earth station will transmit in the entire IMT/5G band (also noting that more than 50% of the considered Ka-band for IMT/5G doesn't even have any FSS allocations in the Radio Regulations). This means that even in the close vicinity of a transmitting earth station, the majority of the spectrum will be interference free. By having the IMT/5G receiver sensing the instantaneous interference environment, a frequency which is free from interference may be chosen for that IMT/5G receiver. Through use of software defined radio techniques, the network can then be configured to optimize performance and minimize/eliminate interference.

- Base station antenna pattern shaping
  Base station antenna pattern shaping is commonly used to direct power and sensitivity towards

the areas where the user terminals are located. However, these techniques can simultaneously also be used to minimize sensitivity towards areas from which interference is coming. Such base station antenna pattern shaping techniques include MIMO, sector disabling and antenna downtilt.

- Cell orientation
  In respect of geostationary satellites, the pointing of the associated FSS earth stations at a given location will be well defined. By organizing the IMT/5G cells such that the base station will be looking towards the back of the FSS antennas rather than looking towards the front, the received FSS interference would be reduced due to the reduced FSS antenna gain. This technique would not be effective in respect of most non-geostationary satellite systems.
- Site shielding
  While it may not be known where a transmitting earth station may be established, use of site shielding around IMT/5G base stations in directions where no IMT/5G user terminals are expected would reduce the probability of receiving interference from transmitting FSS earth stations.
- Indoor or underground deployment
  FSS earth stations are necessarily deployed outdoors. By deploying IMT/5G base stations indoors or in underground areas, significant attenuation of the FSS signals can be achieved.

While most measures to mitigate interference from transmitting FSS earth stations need to be implemented on the IMT/5G side, some measures that can be considered on the FSS side are:
24.65-25.25 GHz
To further mitigate interference into IMT/5G receivers encountered when in the vicinity of transmitting earth stations, which are assumed to be individually licensed, at known locations and with known characteristics, a minimum earth station antenna sizes, e.g. 3.5 m, and minimum earth station elevation angle, e.g. 20° could be considered imposed for new earth stations.
27-27.5 GHz
Provided that earth station antennas are gateway antennas which are individually licensed, at known locations and with known characteristics, a minimum elevation angle of e.g. 20° could be considered imposed for new earth stations.
27.5-28.5 GHz
Many antennas are already deployed in this band. Earth station antennas in this band may well be deployed under a class license, without individual licensing and without knowledge about location and characteristics of individual earth stations. Under such conditions, it is not possible to impose any limitations on the FSS earth stations. However, if earth station antennas are gateway antennas which are individually licensed, at known locations and with known characteristics, a minimum elevation angle of e.g. 20° could be considered imposed for new earth stations.

Q.21
What should be associated roll-out conditions for the allocation of spectrum in 24.25 to 28.5 GHz frequency range? Kindly justify your response.

Noting that more than 50% of the spectrum is not shared with FSS and noting the need for measures on the IMT/5G receiver to mitigate interference from transmitting FSS earth stations, if an IMT/5G operator is allocated spectrum in bands shared with FSS, consideration may be given to also allocate this operator spectrum in bands not shared with FSS to allow in particular use of cognitive radio / software defined radio techniques.

Also, as seen in the comments on Q8, AsiaSat would encourage trying to avoid allocating spectrum for IMT/5G in particular in the 27.5-28.5 GHz band and only consider this band as the last resort.

Q.69
To meet the demand for spectrum in globally harmonized IMT bands for private captive networks, whether the TSPs should be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location? Kindly justify your response.

AsiaSat would see no particular difficulties if frequency bands allocated to TSPs through the auctions are leased for private captive networks provided that all conditions for its use, e.g. requirements to enable compatibility with FSS, is transferred to the operators of these networks.

Q.73
In case it is decided to earmark some quantum of spectrum for private captive networks, either on exclusive or shared basis, then
a) Spectrum under which band(s) (or frequency range) and quantum of spectrum be earmarked for Private Network in each band? Inputs may be provided considering both dedicated and shared spectrum (between geographically distinct users) scenarios.
b) What should be the eligibility conditions for assignment of such spectrum to private entities?
c) What should be the assignment methodology, tenure of assignment and its renewal, roll-out obligations?

It is understood that in respect of Ka-band, this idea is to explore identifying spectrum for private captive networks in the FSS uplink bands above those identified and allocated for IMT/5G (in the consultation paper, it is noted that the 28.5-29.5 GHz is mentioned).

AsiaSat would advise against this.

The 28.6-29.5 GHz band is the band where non-geostationary FSS systems do not operate on a non-interference, non-protected basis in respect of geostationary FSS networks. For this reason, these are the bands where large numbers of transmitting earth stations for user terminals of non-geostationary satellites are expected to operate, operating under a class license, without individual licensing of each earth station and without knowledge about the number, location or characteristics of individual earth stations. Furthermore, under WRC-23 Agenda Item 1.16, ITU is currently studying ESIMs (Earth Stations In Motion – for aeronautical, maritime and land mobile operation) operating with non-geostationary FSS satellites in the 27.5-29.1 GHz band. With such ubiquitous deployment of transmitting FSS earth station antennas, it would seem difficult to employ efficient interference mitigation techniques to avoid interference into IMT/5G.

In respect of interference from transmitting IMT/5G into receiving non-geostationary FSS satellites, AsiaSat notes that the emission levels to protect FSS in WRC-19 Resolution 242 are to protect geostationary satellite networks. AsiaSat is not aware of any limits to protect non-geostationary satellite systems.

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Annex 1

Studies on compatibility studies between FSS and BWA/IMT at C-band downlink

1. Report No. APT/AWF/REP-5, Mar 2008

http://www.apt.int/AWG-RECS-REPS (Report No. 5)

APT Report on "The Coexistance of Broadband Wireless Access Networks in the 3400 - 3800 MHz Band and Fixed Satellite Service Networks in the 3400 - 4200MHz Band"

2. Report ITU-R S.2199, Nov 2010

http://www.itu.int/pub/R-REP-S.2199-2010

Studies on compatibility of broadband wireless access (BWA) systems and fixed-satellite service (FSS) networks in the 3 400-4 200 MHz band

3. Report ITU-R M.2109, 2007

http://www.itu.int/pub/R-REP-M.2109

Sharing studies between IMT Advanced systems and geostationary satellite networks in the fixed-satellite service in the 3 400-4 200 and 4 500-4 800 MHz frequency bands

4. Report ITU-R S.2368, Jun 2015

http://www.itu.int/pub/R-REP-S.2368-2015

Sharing studies between International Mobile Telecommunication-Advanced systems and geostationary satellite networks in the fixed-satellite service in the 3 400-4 200 MHz and 4 500-4 800 MHz frequency bands in the WRC study cycle leading to WRC-1

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