Inmarsat response to the ACMA consultation paper on

"Apparatus licences in the 26 GHz and 28 GHz bands - licensing, technical framework and pricing arrangements"

22 September 2020

Inmarsat is pleased to provide comments to the Australian Communications and Media Authority (ACMA) in response to the consultation paper on "Apparatus licences in the 26 GHz and 28 GHz bands - licensing, technical framework and pricing arrangements".

In this consultation paper, the ACMA is proposing to introduce millimetre wave (mmWave) band fifth-generation (5G) wireless broadband (WBB) services in the range 24.7-29.5 GHz, while ensuring ongoing access and protection of apparatus licensed fixed-satellite service (FSS) earth stations in the range 27-29.5 GHz.

WBB networks would be authorised to access the band based on the area-wide apparatus licence (AWL) framework developed by the ACMA. The AWL framework was initially produced for WBB services and is based on the principle that applicants can acquire exclusive rights to a particular amount of spectrum within a specified geographical area. The conditions of the AWL framework also ensure that there would be no interference to other AWL holders operating in adjacent spectrum or adjacent geographical areas to a particular AWL licensee[1]. This allows the WBB service providers to purchase "building blocks" in spectrum and geographical areas required to establish networks of various sizes to suit the markets they intend to serve. The ACMA has proposed that the AWL licensees would be charged a fee of $0.0003 per MHz per population within each of the geographical grid cells the licensees would use for their service.

As highlighted in the consultation paper, the main benefits of the AWL networks are limited to terrestrial networks, as it provides a flexible solution for various WBB operators to tailor their spectrum consumption and area of operation to their business cases[2]. The ACMA has, however, also proposed to use the AWL framework to authorise FSS earth stations operated in the 27-29.5 GHz band. In contrast to terrestrial services, satellite operators can and frequently use the same spectrum within the same geographical area. The AWL framework is, therefore, intrinsically inappropriate for satellite services, as exclusive area-based spectrum licences are not required by satellite operators. In order to address this deficiency of the AWL framework, the ACMA has proposed a number of modifications to the WBB specific licensing conditions to ensure the framework would be capable of accommodating the authorisation of FSS earth stations.

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[1] Interference at the geographical area boundary between adjacent AWLs is managed through power flux density (PFD) limits which apply at the geographic boundary of an AWL. The PFD limits is -83 dBW/m^2/MHz for transmitters which incorporate an active antenna system (AAS) and -91 dBW/m^2/MHz for transmitters without AAS. Interference at the frequency boundary between adjacent AWLs is managed through unwanted emission limits.

[2] The consultation paper provides that the AWLs "*promote deployment of a range of technologies and better align with the potential spectrum denial of services, which should aid in the efficient allocation and use of spectrum. The greater the amount of bandwidth and area over which services are deployed, the greater the denial of spectrum to other users, and therefore the greater the tax imposed*".

The 27.5-30 GHz band is a key frequency range to address the growing needs for broadband satellite connectivity for Inmarsat as well as many other satellite operators. The ACMA has also acknowledge the importance of satellite services in this frequency range in earlier consultation papers and has decided to apply the following spectrum plan:

- In the 28.1-29.5 GHz, FSS earth stations have unconstrained access across Australia;
- In the band 27.5-28.1 GHz, FSS earth stations have unconstrained access in areas outside Australia's large population centres;
- Inside Australia's large population centres in the band 27.5-28.1 GHz, FSS earth stations and AWL licensed terrestrial wireless broadband (WBB) deployments are operated on a co-primary basis.

Inmarsat relies extensively on the 27.5-30 GHz band for both user terminal and gateway operation. The consultation paper notes that the operation of ubiquitous earth stations are out-of-scope and will be addressed in a future consultation, which would revise the Radiocommunications (Communication with Space Object) Class Licence 2015. The CSO Class Licence covers Inmarsat user terminal operation, so the present consultation on Apparatus licences in the 26 GHz and 28 GHz bands is important to Inmarsat for the following reasons:

1) Inmarsat's ability to continue to operate gateway earth stations in Australia in the 27.5-29.5 GHz band under the proposed AWL framework;
2) Sufficient protection of Inmarsat's satellite receivers from terrestrial networks licensed under the AWL framework in the 27.5-29.5 GHz.

Inmarsat is supportive of some of the conditions in the AWL framework, but believes a better solution can be found to authorise earth station operation in the band 27.5-29.5 GHz. Inmarsat is pleased with the additional granularity applied to the calculation of gateway earth station licence fees and the general in-band coexistence conditions between earth stations and WBB stations in areas and frequency bands where the services are co-primary. While we understand the ACMA's desire and acknowledge its efforts to try to find a single licensing vehicle applicable to both terrestrial and satellite services, we urge the ACMA to proceed with caution. The framework has already become quite complex to understand and interpret due to the various exemptions required to extend a terrestrial-based licensing framework to satellite operation and our analysis below shows that even further exemptions need to be introduced to ensure the AWL framework properly addresses the requirements of satellite operation. The ACMA should ask itself whether having a single licence framework for both satellite and terrestrial operation justifies the complex regulations and potential misinterpretation of the rules associated with the combined framework. We believe that the positive regulatory conditions of the AWL can easily be combined with the existing apparatus licensing framework to produce a much clearer and efficient licensing vehicle for gateway earth stations in the 27.5-29.5 GHz band.

With regards to the AWL conditions to protect satellite uplinks from WBB interference, Inmarsat considers that the measures proposed by the ACMA generally offer good protection to satellite services. However, we have strong concerns about the protection offered to satellites that operate at lower elevation angles due to the WBB user terminal GSO arc avoidance exemption for pointing angles up to 11 degrees and the limited applicability of the EIRP mask for elevation angles lower than 15 degrees. Inmarsat frequently uses lower elevation angles for its gateway and user-terminal operation in Australia and such operation seems to receive significantly less protection than satellite operation at higher elevation angles. We are also concerned about the ability of the ACMA to enforce the EIRP mask for WBB operation. Inmarsat analyses these specific conditions in the sections below and provides proposals to ensure full protection of current and future satellite operation.

1. Operation of gateway stations under the AWL framework

Inmarsat believes that the measures used in the AWL framework to ensure coexistence between different WBB operators could also be applied to ensure coexistence between FSS operators and WBB operators in areas within which FSS and WBB operations are co-primary. Inmarsat particularly welcomes the additional granularity added to the calculation of spectrum fees, as the AWL proposes to replace the existing broad population density based FSS apparatus licence fee categories by calculating the population living within the number of 500x500 meter geographical cells (HCIS[3] 00 cells) within which the protection criterion of AWL licensees would be exceeded. Nevertheless, the ACMA has not taken into consideration all the idiosyncrasies of satellite gateway operation and significant further modification is required to ensure the AWL is an appropriate licensing vehicle for gateway earth stations in the 27.5-29.5 GHz band.

Inmarsat has made some specific proposals for further changes below, without which the AWL network would be out-of-step with the operational requirements of gateway earth stations.

Alignment of the framework for 27.5-29.5 GHz band and 17.7-19.7 GHz band

Satellite gateways operate contiguous blocks of spectrum throughout the 27.5-29.5 GHz band for satellite uplink transmissions and throughout the 17.7-19.7 GHz band for satellite downlink transmissions. Satellite gateways cannot function without the paired 17.7-19.7 GHz band, so any measures applied to the 27.5-29.5 GHz framework need to be aligned with the 17.7-19.7 GHz framework.

The consultation paper makes no reference to the 17.7-19.7 GHz band, which would result in the AWL framework applying for the 27.5-29.5 GHz band and the existing earth station apparatus receive licence framework applying in the 17.7-19.7 GHz band. These frameworks have different conditions, which may introduce regulatory uncertainty for satellite operators. For example, different licence durations in the AWL framework and for the 17.7-19.7 GHz band operations would not be appropriate for satellite operation, as gateways cannot operate in only one of these bands.

The two separate frameworks would also create a significant difference in licence fees. According to our estimates, Inmarsat gateway licence for the 17.7-19.7 GHz in Perth would be around 35 times more expensive than the fees calculated for the 27.5-29.5 GHz band under the proposed AWL pricing framework. Based on the spectrum pricing principles indicated in the consultation paper, higher denial of spectrum to other users should result in higher fees. In this case, there is no justifications for the discrepancy of fees, as the

[3] The HCIS is the system used by the ACMA to define geographic areas for radiocommunications licensing and is based on the Australian Spectrum Map Grid (ASMG). HCIS is a naming convention developed by the ACMA that applies unique ‘names’ to each of the cells that make up the ASMG.

"spectrum denial" to fixed point-to-point services in the 17.7-19.7 GHz band would certainly not be higher than the spectrum denial for WBB services in the 27.5-29.5 GHz by the satellite gateway earth stations.

Proposal: the ACMA should align the conditions and spectrum pricing for gateway earth stations in both the downlink and uplink band. This can be resolved via a future consultation paper, but as a transitional measure we propose that for any licensing of gateway uplinks in the 27.5-29.5 GHz, the same licence fee would be used for the corresponding downlink band in the 17.7-19.7 GHz band.

Use of the same frequency band in the same geographical location

One of the main principles of the AWL framework is that an AWL will not be issued if it would overlap with an existing AWL in both frequency and area. The ACMA has recognised that this does not correspond to satellite operation and has created exemptions that would allow new AWLs to overlap in both frequency and area:

1. The AWL is for "FSS-only" use, complemented by the requirement that earth stations operated under the licence must not cause interference to existing or future receivers which operate under an existing "FSS-only" AWL. The existing or future receiver in this case would be interpreted as the satellite, since earth stations do not receive in the 27.5-29.5 GHz band;
2. The new AWLs will not be afforded protection from transmitters operating under the existing AWL(s) in the same area (through inclusion of a 'no-protection' advisory note on the licence) in the case that all the overlapped AWLs include the "FSS-only" condition. This will allow terrestrial service operators to operate on a non-protection basis to satellite gateway earth stations.

Specific consideration needs to be given to satellite gateway operation when applying these exemptions. There are generally a low number of satellite gateway station locations in a given region that provide excellent access to fibre connectivity, high levels of reliability regarding spectrum and interference and large swathes of spectrum. Due to the limited availability of such sites, satellite operators frequently collocate their gateway stations. For example, Inmarsat's gateway location in Perth currently has 11 other satellite earth station licences issued for both NGSO and GSO operation in the 27.5-29.5 GHz.

While, the "FSS-only" licence exemption would allow satellite gateway operators to continue to collocate their gateways in the 27.5-29.5 GHz band, it may also give rise to anti-competitive practises. It should be clearly defined how the consequent AWL licence holders need to ensure the protection of current and future satellites of the initial AWL licence holder for a specific gateway site. Since the gateway sites are limited, the first-licensed satellite operator may claim interference in order to block another satellite operator from using the gateway location. The current rules also provide the opportunity for a satellite operator to apply for a standard AWL to cover its gateway earth station operation and thereby block other satellite operators from using the site. A standard AWL does not have the "FSS-only" condition attached to it, so it cannot be overlapped in area and frequency by other "FSS-only" AWL licenses, even when collocation of the gateway sites is possible.

Proposal: the ACMA should clarify the AWL rules in order to ensure that only the ITU RR processes are followed to address coordination of interference between satellite operators. The AWL framework should not become an alternative means to raise concerns regarding such interference. In addition, satellite earth station operators should only be able to apply for "FSS-only" AWLs, as standard AWLs could be used to block out other satellite operators from collocating their gateways on the same site.

The above exemptions for using the same frequency band in the same geographical area are also inconsistent with the principles the ACMA has provided regarding the licence fees of AWLs. The ACMA has indicated that "*the greater the amount of bandwidth and area over which services are deployed, the greater the denial of spectrum to other users, and therefore the greater the tax imposed*". Satellite gateway operations tend to cover the entire 27.5-29.5 GHz band regardless of the operators and if these stations are collocated, they would also have similar "footprints" in terms of the denial of spectrum and area to WBB operators. Under the current AWL rules, if there are 11 gateway station in a certain gateway location, then the operators would require a separate AWL for each of the stations. Essentially, the satellite operators – in total – would be charged 10 times the spectrum fee, even though the denial of spectrum for WBB operators in terms of population, area and spectrum would be practically the same for each of these AWL licences. Furthermore, satellite gateway earth stations tend to be within enclosed areas that cannot be inhabited by the population nor used by WBB operators without the consent of the owner of the gateway site. This further reduces the area within which there is any spectrum denial to other users of the band.

The ACMA should, instead, incentivise the collocation of satellite gateways, as this would reduce the number of separate gateway station locations required in Australia and thereby minimise the impact on WBB users. This is a policy the ACMA has also pursued in the past for lower frequency bands by establishing protection for "satellite parks" that can be used by satellite operators to collocate their gateways.

The fees for each geographical cell covered by an AWL licence that is shared by more than one satellite operator should be divided by the number of AWL licences that cover the same cell and frequency range. The initial licence fee would be determined based on the number of existing gateway earth station licences issued for the same frequency and geographical area. The ACMA could then review this initial licence fee periodically (e.g. every year) based on the number of overlapping AWL licences, so the fees for the gateway earth station operators would either increase or decrease depending on the existence of other gateway earth stations. The same principle should also apply if WBB operators want to operate services on a non-protected basis within the AWLs issued to FSS gateways. In this case, the licence fees for the gateway earth station should be divided between the number of FSS gateway AWLs and "no-protection" WBB AWLs licenses issued for the same geographical cell and frequency range.

In order to further encourage collocation of future gateways and ensure that the existing gateway locations within Australia's large population centres would remain available for future satellite operation, these locations should be "grandfathered" by applying the rules applicable to operation of gateways outside Australia's large population centres. In this case, the FSS operators would be issued a licence for the single HCIS cell that is used by the gateway location and future WBB service providers would not be able to claim protection from the emissions of the current or future earth stations that are collocated within that single HCIS cell.

Proposal: the ACMA should divide the licence fees for HCIS cells that are shared between multiple FSS operators and "no-protection" WBB operators by the number of AWL licences covering that cell. Furthermore, existing gateway locations that are located within Australia's large population centres should be "grandfathered" by applying the same framework as to the operation of gateways outside the large population centres to all current and future earth stations that are collocated within the same geographical location.

Proposed unwanted emission approach is unsuitable and the levels are impractical for gateway operation

The AWL framework proposes that all transmitters, including gateway earth stations, are required to comply with the same unwanted emission limits. In case of gateway earth stations, however, the unwanted emissions limits would apply only within Australia's large population centres and in the band 27.5-28.1 GHz. We understand that the aim of the unwanted emission limit for satellite operation is to ensure that AWL licensees operating in the adjacent channel to earth stations located within Australia's large population centres and within the band 27.5-28.1 GHz would remain protected.

Inmarsat operates a gateway in Perth, which falls within the area considered as a large population centre, so the unwanted emission limits are applicable to this gateway earth station.

Inmarsat has several concerns about the unwanted emission requirements being proposed by ACMA for gateway earth stations:

- In Inmarsat's view, the unwanted emission requirement is not practical for satellite gateway earth station operation. Gateway earth stations generally operate a contiguous block of spectrum within the entire frequency range of 27.5-29.5 GHz. Even if the gateway station is located within one of Australia's large population centers, there would be no interference to adjacent channel operations within the 27.5-28.1 GHz band, as the entire 27.5-28.1 GHz would be covered by the AWL. Above 28.1 GHz, satellite earth stations are operated on a sole-primary basis, so there is no need to have an adjacent-band co-existence requirement. In case of such contiguous blocks of spectrum, the unwanted emission limit would only be applicable to WBB AWL or spectrum licensees below 27.5 GHz.

- Inmarsat understands that the unwanted emission limits requirement being proposed for gateway earth stations is based on terrestrial base stations spectrum mask operating in the frequency range 24.25 - 33.4 GHz with transmit power of about 34.5 dBm. The approach taken to define the unwanted emissions levels is based on total radiated power (TRP), which is a concept applied to active antenna systems. This concept is not directly applicable to satellite gateway operation with standard parabolic antennas, as the TRP would be equivalent to the power inserted into the parabolic antenna minus the antenna efficiency. The TRP for earth station antennas is normally not measured nor provided by satellite gateway antenna manufacturers, so this methodology is likely to lead to misinterpretation for satellite operation.

- As stated above, the unwanted emission limits are based on WBB transmitter specifications. In the 27.5-29.5 GHz band, the WBB transmitters in Australia can operate with a TRP of up to 25 dBm per 200 MHz channel (equivalent to a power spectral density of 2 dBm per 1 MHz). For a 200 MHz carrier, the AWL framework applies a limit of -5 dBm (measured in 1 MHz) for a frequency separation between 0 to 20 MHz from the channel edge. It is reasonable to assume that for the 200 MHz channel with a TRP spectral density of 2 dBm per 1 MHz, the emissions in the adjacent channel can be attenuated by 7 dB to -5 dBm. The power levels used by gateway earth stations, however, are several magnitudes higher than the terrestrial transmitters. Typical transmit power level of a satellite gateway is around 400 W, which is used for carriers with various bandwidths and individual power levels throughout the entire 2 GHz band. This results in a transmit spectral density of about 23 dBm per 1 MHz when averaged over the entire 2 GHz band, while individual carriers could be transmitted with higher transmit power spectral density levels than 23 dBm per 1 MHz, as the total power of the transmitter is not divided equally between the carriers. We believe it is unreasonable to apply terrestrial unwanted emission limits to satellite gateway earth station emissions that are a 100 times more powerful. Gateway earth stations also use carriers that are significantly smaller than 200 MHz. For example, a typical 32 MHz gateway carrier would need to meet the -5 dBm / 1 MHz unwanted emission limit for a separation between 0 to 3.2 MHz adjacent to the carrier. Assuming the carrier is transmitting with a spectral density of 23 dBm/1 MHz and that the transmit power of the gateway station is roughly equivalent to the TRP (ignoring the antenna efficiency loss) then in order to meet the -5 dBm/1 MHz limit, the attenuation of the unwanted emissions in the adjacent channel would need to be 28 dB. This level of attenuation is unachievable at 0 MHz frequency offset with current technology and would result in gateway operators having to apply a large guard band above 27.5 GHz to meet this limit. Gateway operators need to make use of the entire band 27.5-29.5 GHz band and any reduction in the usable bandwidth within this frequency range may result in a direct reduction in the bandwidth available for user terminals operation. A reduction in usable bandwidth is particularly significant for cases where satellite networks are already in use and have been designed to operate over the entire 27.5-29.5 GHz frequency band for gateway and user-terminal operation.

The unwanted emission limit is intended for the protection of adjacent channel terrestrial networks. However, the coexistence between WBB and FSS does not follow the same logic as coexistence between two WBB stations. Since WBB stations are all pointed towards each other, an unwanted emission level based on the TRP of a station may results in an efficient use of spectrum. It is the opposite of efficient use of spectrum, however, to apply an unwanted emission limit based on TRP to manage adjacent channel emissions from gateway earth stations into WBB stations. In case of gateway earth stations, the interference into the WBB stations in both in-band and adjacent band is based on off-axis interference towards the horizon. The TRP would measure the power radiated in all directions in aggregate, including the power radiated in the main beam, whereas the interference would be caused by the off-axis emissions, which depends on the satellite antenna elevation towards the satellite and the antenna gain pattern. A more efficient way to protect terrestrial services would be to establish a limit towards the horizon that is applicable in the adjacent band.

The ACMA proposed that for systems that use non-AAS antennas, the PFD limit of -91 dBW/m²/MHz needs to be met at the boundary of the AWL to protect an adjacent AWL license holder operating in the same frequency range. According to our calculation for the Inmarsat gateway in Perth, the contours to meet this PFD limit and protect an adjacent AWL licence holder from in-band interference are contained within an area with a radius of less than 2 km. It is safe to assume that interference into the bands adjacent to our gateway operation would be several dBs lower, so the area around the gateway within which there could be adjacent band interference would be almost fully contained by the enclosed area around our gateway station.

Proposal: gateway earth stations should be exempted from the unwanted licence emissions specified in the AWL conditions. The unwanted emissions limits are severely constraining and unpractical for satellite gateway operation.

<u>In-band EIRP of -60 dBW/Hz towards the horizon</u>

The ACMA has proposed that gateway earth stations located within Australia's large population centres and operating in the 27–29.5 GHz band must not exceed an EIRP of -60 dBW/Hz in the direction of the horizontal plane. This is an existing requirement for apparatus licensed earth stations, which seems to be made redundant by the logic of the AWL framework.

The ACMA itself has highlighted in the consultation paper that the AWL allows the "*licensees to tailor the spectrum capacity and geographic reach of the licence to highly specific use-cases*". The AWL licensees that require more capacity and higher spectrum reach simply need to pay higher fees due to the denial of spectrum to other users. The flexibility to address specific use cases should also be extended to operation of satellite gateway earth stations. If satellite gateway operation requires exceedance of the -60 dBW/Hz limit, then this should be permitted. The earth station would require a larger AWL licence in terms of geographical area and AWL licensees in adjacent areas would remain protected by the boundary condition, so there seems to be no direct benefit to the -60 dBW/Hz limit. The power transmitted by satellite gateways needs to be carefully managed in order not to overload the receiver on the satellite. Therefore, the satellite gateway stations would only use more power in cases where there is a specific need for this (e.g. due to satellite architecture, and support of specific links designs), so there would be little benefit to impose another in-band limit on satellite gateway operation.

Furthermore, Inmarsat has analysed the -60 dBW/Hz limit and while it seems to address most gateway operation cases, there are some scenarios for low-elevation operation around 10 degrees for which this spectral density could be exceeded.

Proposal: to remove the -60 dBW/Hz limit on gateway earth station transmissions to the horizon, as this would no longer be necessary under the AWL framework.

2. Protection of satellite receivers from terrestrial interference

In the 27.5-29.5 GHz band there is significant risk that WBB emissions will cause aggregate interference to the satellite receiver. If the interference environment is not properly managed, this type of interference can raise the noise floor of the receiver (or saturate it altogether) and severely limit the satellite services that can be provided. In addition, it is typically complex and costly to manage aggregate interference once it has already occurred. This is because interference would not be limited to a few particular stations at specific locations (as is generally the case for interference between terrestrial stations), since all terrestrial stations contribute to the total interference at the satellite receiver. In this case, interference reduction at the satellite receiver is only possible if limitations are placed on all AWL devices, which would prove to be difficult once the AWLs have already been issued and the deployments are operational.

It is, therefore, important to have a high degree of certainty that the conditions imposed on WBB stations would ensure interference free operation of satellites before WBB services are allowed in the band. We commend the ACMA for its efforts to carefully consider this interference scenario in this consultation paper.

The ACMA proposes the following conditions for WBB base station operation in the 27.5-29.5 GHz throughout Australia:

- The total radiated power (TRP) of WBB transmitters is not to exceed 25 dBm/200 MHz:
    - which is further relaxed to 30 dBm/200 MHz, in case the main-beam of the antenna is *not* steered above the horizon and the operation meets an EIRP mask requirement above 15 degrees of elevation above the horizon.
- Outdoor base stations must have mechanical down tilt equal to or greater than 0˚;
- Outdoor base stations operating in the range 27.5-29.5 GHz must not direct antenna beams (via electrical steering) to an elevation angle above the horizon;
- Outdoor fixed UEs must not direct their antenna beam (via electrical or mechanical steering) to an angle from the GSO arc which is less than the minimum angles in the table below, when the antenna beam is pointed at elevation angles of greater than or equal to 11° above the horizon;

Table 1 GSO arc avoidance separation angles based on WBB user terminal antenna gain

Outdoor fixed UE antenna gain	Minimum separation angle from the GSO arc
< 34.7 dBi	25 degrees
≥ 34.7 dBi	1.5 degrees

Inmarsat is generally content with the protection offered to satellite uplinks, with the exception of two conditions:

(a) the further relaxation of the 25 dBm/200 MHz TRP limit; and

(b) the 11 degree GSO arc avoidance exemption for user terminal operation.

Relaxation of the TRP limit of 25 dBm/200 MHz

The ACMA is proposing that WBB transmitters could operate with a TRP up to 30 dBm/200 MHz on two conditions:

1. the main-beam of the antenna will not be pointed above the horizon (electronically or mechanically);
2. An EIRP mask is met, which is established based on a 8x8 antenna and the Recommendation ITU-R M.2101 antenna pattern for a WBB station operating with a TRP of 25 dBm/200 MHz that is pointing towards the horizon and is as follows:

Table 2 EIRP limit above horizontal plane applicable for WBB stations with TRP above 25 dBm/200 MHz

Column 1	**Column 2**	**Column 3**
Elevation angle above the horizontal plane (*el*)	**Radiated maximum true mean power (dBm EIRP)**	**Specified bandwidth**
15 degrees ≤ *el* < 25 degrees	34	200 MHz
25 degrees ≤ *el* < 55 degrees	34 – 0.43(*el* – 25)	200 MHz
55 degrees ≤ el ≤ 90 degrees	21.1	200 MHz

In principle, Inmarsat agrees that satellite services would remain protected if WBB transmitters comply with an EIRP mask for positive elevation angles, which is established based on a 8x8 antenna array and the M.2101 antenna pattern operating at 25 dBm/200

MHz. It was demonstrated during the studies under WRC-19 agenda item 1.13 that this level offers sufficient protection to satellite services.

The concept of using an EIRP mask for the protection of satellite networks, however, was rejected by administrations themselves during agenda item 1.13 studies. Some administrations raised strong concerns that it is not possible to ensure that the EIRP mask for skywards emissions is actually met by WBB networks. In order to measure the EIRP limit for a 20 m WBB base station, the measurements would need to be taken at a point that is higher than 20 m and over an extended period of time, as the emissions from the station can change during its operation. In particular, this can be the case if the base station antenna is not used to generate a separate beam towards each user terminal, but rather the main beam is used to “beam-hop” between various user terminals to allow access to user terminals on a time-division basis. This would mean that the instantaneous EIRP radiated above the horizon will depend on the location of the user terminal within the cell at any given moment in time.

We understand that this EIRP mask was already applied for satellite network protection below 27.5 GHz. However, the band 27.5-29.5 GHz deserves separate consideration due to the services and the number of satellite networks operating and planned to operate in the band.

The other aspect with regards to the EIRP mask that remains unclear to Inmarsat is why the EIRP mask starts at 15 degrees of elevation. The EIRP mask applies for operation of WBB stations with TRP above 25 dBm/200 MHz. In such a scenario, the WBB stations would not be allowed to steer beams above the horizon, so the EIRP mask could be extended down to 0 degrees of elevation using the methodology proposed by the ACMA.

Inmarsat satellite configuration means that it occasionally can operate stations with satellites that appear lower than 15 degrees from the territory of Australia. This EIRP mask seems to invite WBB stations to operate with a high TRP of 30 dBm, while using antennas that can have wider beams than the 8x8 antenna (hence cause more interference to satellite uplinks), provided they can meet the 8x8 antenna pattern at 15 degrees of elevation. In addition, it has become apparent in the ITU studies that the active beam-steering antennas can produce grating lobes that are almost as strong as the main beam in the direction of the satellites when using certain beam-steering angles. Such a grating lobe could occur at elevation between 0 and 15 degrees but still allow for the EIRP mask to be met at 15 degrees of elevation, which would cause further interference into satellites with low elevation angles from Australian territory.

Proposal: the ACMA should not apply the TRP relaxation based on the EIRP mask, unless the EIRP mask is extended down to 0 degrees of elevation and it is clear that the ACMA can ensure the WBB stations comply with the EIRP mask.

<u>The 11 degree GSO arc avoidance exemption for user terminal operation</u>

Inmarsat has strong concerns regarding the ACMA’s proposal to exempt user terminal (UT) operation from the GSO arc avoidance requirement if the station is operating with an elevation of less than 11 degrees above the horizon. The exemption seems to be modelled assuming a minimum earth station elevation angle of 15 degrees and a satellite antenna beam with 56 dBi gain. Satellite operators also provide connectivity to earth stations with lower elevation angles and are not limited to the use of antennas with 56 dBi gain. Since the modelling of this GSO arc avoidance exemption is based on a limited set of operational satellite parameters, the protection provided to satellite services by this conditions would be limited as well.

Inmarsat has provided a simple analysis in the Annex below, which indicates that it takes less than 50 WBB user terminals that are pointing towards a satellite at a low elevation angle to cause interference. The analysis models a satellite beam over south-eastern Australia with a gain of 52.6 dBi that is used to provide services to user terminals with elevation angles below 11 degrees. This is an alarmingly low number of WBB stations, considering that the modelled beam is covering most of south east Australia's large population centres.

The 11 degree GSO arc avoidance exemption is particularly concerning for Inmarsat, as we operate beams over Australia with elevations lower than 15 degrees in the 27.5-29.5 GHz band. Inmarsat's Ka band network is optimised to provide global coverage to aircraft, vessels and land vehicles. In order to serve Australian customers, Inmarsat can use the overlapping coverage of two satellites in 63E and 180E to deliver the required quality of service. While the elevation in Australia is better for the satellite in 180E, we also use the coverage of 63E to complement beams that cover particular hotspots (e.g. large harbours, airports) with heavy user terminal traffic. This requires us to use spot-beams for which majority of the coverage has elevation angles lower than 11 degrees towards the satellite, similarly to the example illustrated in the figure below. According to the current rules proposed by the ACMA for the GSO arc avoidance exemption, these beams would risk being interfered with by WBB stations and receive significantly less protection than beams on satellites covering Australia that use higher elevation angles.

Australia is an important regional hub for gateway stations to Inmarsat but also to many other satellite operators that provide feeder links to satellites with the majority of the satellite coverage outside Australia. In many of these cases, such gateway spot-beams would operate with lower elevation angles for which a significant amount of the beam footprint would be exposed to UTs operating without the requirement for GSO arc avoidance. For example, Inmarsat is also licensed by the ACMA to operate gateways in Perth and Merredin with its GX satellites at 56.5E and 63E. These gateway beams also operate with low elevation angles, so significant areas within the beam would be exposed to the GSO arc avoidance exemption. The ACMA's proposal to exempt user terminals from GSO arc avoidance risks causing interference to such services, which could reduce the possibility to operate these gateway stations in Australia in the future.

Proposal: Inmarsat proposes that the GSO arc avoidance exemption is reduced from 11 degrees to no more than 5 degrees of elevation. There would still be a risk that interference occurs from stations with elevation angles lower than 5 degrees, but the risk for aggregate interference would be significantly reduced. The ACMA may also consider making the GSO arc avoidance exemption applicable to the WBB UTs based on the transmit power of the UT terminal. In this case, a tighter (5 degree) GSO arc avoidance requirement would apply to all stations operating with maximum allowed power with relaxations in the GSO arc avoidance requirement proportional to reduction of WBB UT transmit power.

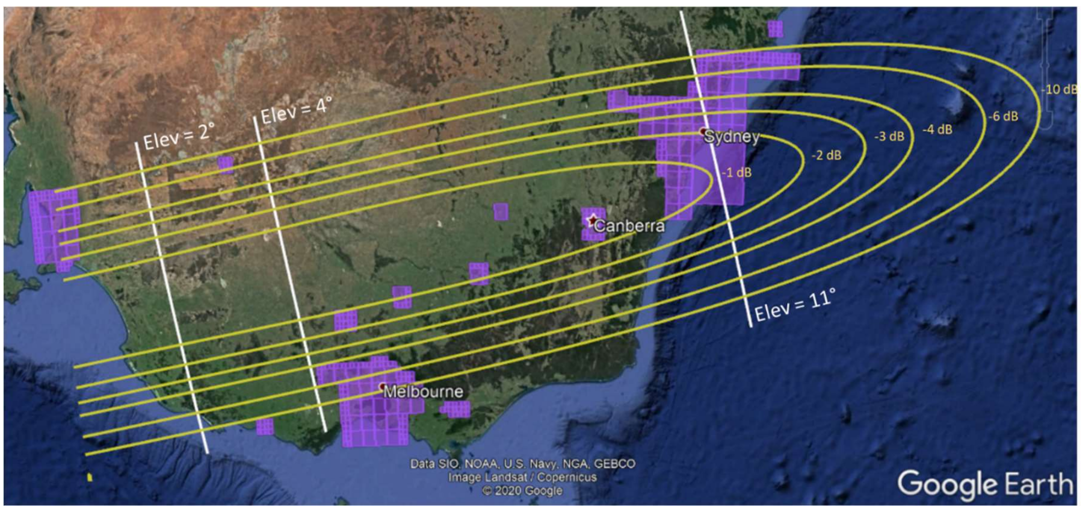
Inmarsat thanks the ACMA for the opportunity to comment on the consultation paper. We would like to invite the ACMA to contact us should further clarification or discussion be required.

Annex: WBB interference into satellites at low elevation angles

The figure below shows an antenna beam covering southeast Australia from the orbital location of 142.5W. This beam is modelled assuming 52.6 dBi gain in the 27.5-29.5 GHz range. The figure provides information on the elevation angles in various portions of the beam together with the -1 to -10 dBi antenna beam contours applicable for this beam.

The figure shows that the beam covers a large number of Australia's large population centres within which the WBB stations are operated on a co-primary basis with satellite networks. The elevation towards the satellite at 142.5W within the majority of the area inside the beam is less than 11 degrees, so the GSO arc avoidance requirement would not protect this orbital location. This can result in a significant number of UT stations that operate with full power in the direction of the satellite that would contribute to the total interference that would aggregate into the satellite receiver.

Figure 1 beam covering southeast Australia from orbital location of 142.5W



In order to get an indication of the interference potential of the WBB UT equipment for the above beam, the number of stations required to exceed the satellite protection requirement is calculated below. The calculation is performed for two different UT configurations (using 4x4 and 8x8 antenna arrays) operating at the maximum allowed total radiated power and pointing directly towards the satellite. For the sake of simplicity, the analysis is limited to the -1 dB satellite antenna gain contour and to a range of elevations between 11 and 4 degrees towards the satellite. The analysis is performed using similar assumptions for satellites stations than used by the ACMA during when establishing the AWL framework in the TLG.

The results of the calculation indicated in the table below show that the satellite interference criterion would be exceeded if there were more than 42 UT stations (assuming 8x8 antenna) or 165 UT stations (assuming a 4x4 antenna) within the considered area. These are *alarmingly* low numbers considering that the satellite antenna -1 dB contour between 11 and 4 degrees of elevation covers an area of 106 111 km^2 and stretches across a large number of the south-east Australia's large population centres. The interference to the satellite would further increase if UT emissions from the remaining satellite antenna contours and elevation angles would be taken into consideration.

The ACMA has previously indicated that the risk for UTs to operate with maximum allowed power towards the satellite is limited, as the UT terminals would be power controlled. Consequently, UTs that operate with higher look angles towards the WBB base station can be assumed to be closer to the base station and operate, therefore, with less power than the ones with lower look angles towards the base stations. However, these considerations are more applicable for WBB stations that communicate with mobile terminals, as the cell radiuses of base stations are limited to a 100-200 meters.

In the 27.5-29.5 GHz, the WBB deployments will be used for FWA services, which inherently seek to maximise the cell radius[4]. This will result in base stations mounted on higher masts and more cases of UT equipment operating with maximum allowed power, as they're located further away from the base station. This results in the UT equipment operating with maximum allowed power for lower look angles towards the base station. Lower look angles towards the base station also translate into lower elevation angles towards satellites, which means that UT equipment will be using full power in cases when the GSO arc protection exemption does not apply. This risks causing interference to satellites that operate beams with lower than 15 degrees of elevation.

We recognise that not all UT stations will be pointed towards the satellites in real deployment situations, but according to the analysis below, less than 50 stations within a sizeable area can already cause interference. It is likely that we currently do not fully understand all the WBB use cases, so a cautious approach with regards to the protection of satellite uplinks is merited.

The ACMA has also indicated that below 11 degrees of earth station elevation the atmospheric losses increase, which reduces the interference levels received by the satellites. This is true, but as indicated in the example below, the atmospheric losses vary only between 2-3.4 dB between 4-11 degrees of elevation and increase to 6 dB for 2 degrees of elevation, so the interference does not reduce significantly until the elevation is below 1 or 2 degrees.

[4] Samsung has trialled FWA solutions with Verizon in the United States and found that the 28 GHz deployments can be used up to 2000 feet (610 m) from the 5G base stations. Furthermore, Ericsson has recently announced that their mmW technology in the 28 GHz band has achieved a range of 3.8 km.

Table 3 Calculation of the number of WBB stations required to produce interference into the satellite

WBA interference into satellite in 28 GHz			
UT parameters	UT1	UT2	
UT total radiated power	-5.0	-5.0	dBW @200 MHz
Elevation angle above horizon	between 4 to 11		degrees
Antenna array (row x column)	8x8	4x4	
Maximum antenna gain	23.0	17.0	dBi
Total power towards satellite	18.0	12.0	dBW/200 MHz
Free space loss (@28 GHz)	213.6	213.6	dB
Atmospheric loss (ITU-R P.676) NOTE 1	3.0	3.0	dB
Polarisation mismatch	1.5	1.5	dB
Total path loss	218.1	218.1	dB
FSS Satellite Location	142.5W	142.5W	
Avg. antenna gain in -1 dB beam (3 dB beamwidth = 0.4 deg) NOTE 2	52.1	52.1	dB
Noise temperature	400.0	400.0	K
Noise power	-119.6	-119.6	dBW/K/200 MHz
I/N criterion	-12.2	-12.2	dB
Permissible interference	-131.8	-131.8	dBW/200 MHz
Interference from 1 station	-148.0	-154.0	dBW/200 MHz
Number of WBB stations to meet permissible interference	**42.0**	**165.0**	
Total interference	-131.8	-131.8	dBW/200 MHz

NOTE 1: atmospheric loss for elevations between 4-11 degrees varies from 2-3.4 dB. 3 dB is selected as an average value.
NOTE 2: The maximum antenna gain of this beam is 52.6 dBi, so 52.1 is assumed to apply on average across the 1 dB contour