COMMUNICATIONS ALLIANCE LTD

COMMUNICATIONS ALLIANCE

SATELLITE SERVICES WORKING GROUP

SUBMISSION

to the

Australian Communications and Media Authority's (ACMA)

Proposed licensing arrangements for 2 GHz narrowband mobile-satellite services and 28 GHz fixed-satellite services

28 February 2022

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Communications Alliance Satellite Services Working Group (SSWG) welcomes the opportunity to provide comments to the ACMA *Proposed licensing arrangements for 2 GHz narrowband mobile-satellite services and 28 GHz fixed-satellite services* Consultation Paper.

2 GHz MSS The SSWG strongly opposes a 2 x 5 MHz allocation to Narrowband MSS in the 2 GHz bands. This would be a bespoke Australian allocation within a service that is naturally constrained by the Keplerian laws of orbital mechanics. It would be, in our view, simply wasted spectrum. Conventional MSS can deliver narrowband services and using the global allocation means this is the most effective and efficient method of delivery.

Rather than design an 'Australia only' band for satellites which must orbit the entire globe, the SSWG suggests the ACMA (and the Department) engage in Agenda Item 1.18 with a view to supressing it and replacing it with a more useful Agenda Item that covers all regions and seeks an additional harmonised MSS band.

28 GHz FSS The SSWG acknowledges a number of significant improvements for FSS deployments outlined in this paper and thanks the ACMA for listening to industry.

There remain a number of issues of concern to SSWG members which are outlined briefly below.

Guard bands and the resulting guard space. This combination is a highly inefficient way to manage spectrum. The SSWG suggests simply defining an out-of-band and spurious levels and allowing deployments based on the performance of the terminals. The SSWG also notes that other services should be required to have at least 25 dBc rejection characteristics which means that, combined with the stochastic nature of any interference, no guard spaces should be needed.

The different treatment of various FSS services is also of concern. AWL-to-AWL coordination is set at –91 dBW/m^2/MHz measured at 5 m above the boundary for 98% of the time (over a 24-hour period). The SSWG asserts that coordination is the same, regardless of the interferer and that in fact some emissions from ESIM are stochastic in nature and therefore far less harmful than fixed FWA systems. The SSWG therefore calls on the ACMA to adopt a single coordination level of –91 dBW/m^2/MHz, applied to all systems measured in the same way. We have also provided an adjusted pfd envelope for A-ESIM, which we believe should also be adopted.

Finally, high value M-ESIM services are severely constrained by AWL which extend past the sea. This is very wasteful of the spectrum space as FWA base stations cannot be constructed in the water. The SSWG strongly suggests M-ESIM be subject to the same –91 dBW/m^2/MHz measured at 5 m above the boundary for 98% of the time coordination requirement and that the boundary of any AWL be adjusted for the mean high-water mark so that this spectrum space can also be put to good use.

About Communications Alliance

Communications Alliance is the primary communications industry body in Australia. Its membership is drawn from a wide cross-section of the communications industry, including carriers, carriage and internet service providers, content providers, platform providers, equipment vendors, IT companies, consultants and business groups.

Its vision is to be the most influential association in Australian communications, co-operatively initiating programs that promote sustainable industry development, innovation and growth, while generating positive outcomes for customers and society.

The prime mission of Communications Alliance is to create a co-operative stakeholder environment that allows the industry to take the lead on initiatives which grow the Australian communications industry, enhance the connectivity of all Australians and foster the highest standards of business behaviour.

For more details about Communications Alliance, see http://www.commsalliance.com.au.

1. 2 GHz introduction

The SSWG welcomes the decision to allocate the 2 GHz MSS bands to MSS service in Australia. However, we remain deeply concerned regarding the proposal to allocate 2 x 5 MHz to narrowband MSS. The SSWG does not support the proposed allocation to narrowband MSS.

Such an allocation would be a bespoke Australian allocation, which is unlikely to be duplicated anywhere else in the world and this is clearly a significant concern. This means that for the MSS operators successful in obtaining Australian licences under these conditions, either the spectrum would be wasted everywhere else or complex switching would be required on board the satellites to switch the band in and out as the satellites passed over Australia. This would be administratively and operationally challenging.

Given there is already an ITU Agenda Item looking at narrowband MSS and there are alternative bands available it would be more efficient to allocate the full 2 x 30 MHz in Australia and wait for or seek to influence the outcome of Agenda Item 1.18.

In any case MSS operators are capable of narrowband transmissions and should the ACMA decide to continue with the 2 x 5 MHz allocation it should be done in such a way that permits use in a fair and equitable manner.

2. 2 GHz narrowband mobile-satellite services

In its consultation paper 46/2021 [1][1], the ACMA proposes to support Narrowband MSS in the bands 2005–2010 MHz and 2195–2200 MHz with:

- the 2195–2200 MHz frequency range supporting earth station receivers.
- the 2005–2010 MHz frequency range supporting earth station transmitters.
- no restrictions proposed on earth station receivers.
- emissions from earth station transmitters above 2010 MHz required not to exceed an EIRP of –66 dBW/MHz to protect adjacent-band services.

2.1 Summary of reasons

The SSWG maintains the bands 2005 – 2010 MHz paired with 2195 – 2200 MHz should not be set aside for narrow band MSS and should instead be retained as a part of the greater MSS band 1980 – 2010 MHz paired with 2170 – 2200 MHz.

This will result in the availability of two 15 MHz paired licences which the SSWG feels is a much more beneficial and efficient use of this spectrum that will provide the opportunity to deliver a portfolio of wide-ranging innovative services to all Australians.

Our proposal is based on the following considerations:

- this would become a bespoke Australian sub-allocation to Narrowband MSS (NMSS) while other countries have allocated the 2005 – 2010 MHz/2195 – 2200 MHz to the more general and inclusive MSS category of service.

[1] *Proposed licencing arrangements for 2 GHz narrow-band mobile-satellite services and 28 GHz fixed-satellite services*, December 2021

- MSS has global (or semi-global depending on the orbits) coverage and to limit the band to an NB-IoT application of the MSS will only allow one subset of service when a panoply of MSS applications should be permitted to meet market demands.
- where orbital coverage is not global it is not segmented by region; rather it avoids low population areas such as the poles.
- we anticipate NMSS satellites to be small to micro-satellites. They will not have the volume to carry multiple payloads and antenna systems.
- a Narrowband MSS allocation is being discussed within the ITU-R. This Agenda Item covers only Regions 1 and 2 and does not include Region 3. In addition, the Agenda Item is not investigating the proposed Australian band, which ends at 2010 MHz.
- any allocation will need to ensure protection for future and existing MSS services.
- be allocated, it should only be as a secondary service and no protection should be sought or given from existing or future MSS services. If the ACMA does go ahead with this allocation, however, the operations in the narrowband section of spectrum must protect the larger blocks and the ACMA should adopt appropriate rules including, if necessary, guard bands. Regardless, any limitations on operations should be limited to the narrowband operations.

2.2 Most effective use of the spectrum and orbits

Noting traditional MSS are also capable of transmitting narrowband signals, the SSWG believes the most efficient use of this spectrum would be as a part of the contiguous 2 x 30 MHz MSS allocation. This means capabilities across a wider variety of services could be offered to the Australian continent and that, generally, the MSS systems would be able to offer these services globally, resulting in more viable business plans and a better use of the global spectrum and orbital resources. Today, there are existing satellite systems that operate on this principal, notably Iridium and Globalstar. Single country or even regional satellite systems have an inherent economy of scale disadvantage compared to global satellite systems.

Allocating 2 x 5 MHz in the upper part of the 1980 – 2010 MHz / 2170 – 2200 MHz band unnecessarily fragments the normal 2 x 15 MHz bandwidth for MSS licences in this band.

2.3 WRC-23 Agenda Item 1.18

WRC-23 Agenda Item 1.18 is also investigating an allocation to narrowband 'IoT' MSS. Studies are looking at only Regions 1 and 2 and are not considering the band proposed by the ACMA. Were another band to be adopted; this would also serve to 'orphan' the Australian allocation.

Currently, the Australian Agenda Item 1.18 position is essentially that it is not a Region 3 issue. However, the outcome of these studies could devalue any allocation to NMSS made nationally. Because other Region 3 Administrations are investigating terrestrial IMT in the band, it is unlikely there would be consensus to add either Region 3 or the Australian band to the Agenda Item. The Agenda Item is also not progressing well due to the nature of virtual meetings and the lack of clarity of Resolution 248 that sets out the terms of reference for Agenda Item 1.18. The SSWG believes it would be beneficial if the agenda item was suppressed and perhaps a new, clearer agenda item proposed for the next WRC cycle that supported 2010 – 2025 MHz.

Regardless, if any allocation is made to Narrowband MSS (aka 'IoT MSS'), it must be a secondary allocation and should not seek protection from existing or future MSS services.

2.4 Comments on other consultation issues

For the other issues raised by the ACMA in the consultation paper, the SSWG submits the following comments:

1. **Transitional arrangements for metropolitan and designated areas (pg. 12)**

   The SSWG considers that the proposed timelines for implementing both NB-MSS and MSS need to be significantly shortened and is willing to work with the ACMA and FreeTV to develop mechanisms to achieve this.

2. **Intention to make the proposed amendments to the CSO class licence by the end of Q1 2022 (pgs. 8 & 14)**

   The SSWG supports the proposed amendments and timing.

3. **Sharing between narrowband MSS (pg. 11)**

   The SSWG considers that the proposal regarding sharing between the narrowband MSS operations and not limiting the number of operators requires more detailed discussion with satellite operators as, it is the view of the SSWG that the parameters offered by the ACMA will not allow for a technically feasible narrowband MSS. In any case any restrictions on NB MSS should not affect the operation of MSS in the remainder of the band.

2.5 Conclusion

The SSWG does not support the proposed allocation to NB MSS.

3. 28 GHz ubiquitous fixed-satellite services

3.1 Summary

The SSWG is pleased the ACMA has considered multiple representations over the life of this project and that it has made significant changes to the way various FSS services are coordinated with and within AWLs in the 27.5 – 28.1 GHz band and IMT in the adjacent 26 GHz band.

Two main issues remain a strong concern for the SSWG; these are protection criteria and guard bands.

The SSWG notes that AWL-to-AWL in the 27.5 – 28.1 GHz band (where both FWA and FSS can deploy within the defined population centres) are coordinated at –91 dBW/m^2/MHz. This is measured at a height of 5 m at the AWL boundary and is applied for 95% of the time in any 24-hour period. The permitted pfd is higher by 8 dB where an active antenna system is used by FWA. The SSWG understands that this pfd limit in RALI MS46 was derived using notional parameters for FWA; however, a different set of parameters and protection criterion were considered in this consultation for the protection of supposedly the same FWA. Such disparity is not justifiable.

Ubiquitous FSS stations on land (land ESIM and VSAT) are permitted to operate up to the boundary of an AWL, in reality the boundary of a defined populated area, in the 27.5 – 28.1 GHz band. This is not the case within defined populated areas (which is indicated in the analysis presented in Appendix 1) where ubiquitous FSS are not permitted. The SSWG opposes this restriction as unnecessary, given the potential for sharing between VSAT and FWA within the defined ‘populated’ areas, large areas of which are typically very sparsely populated and within which many areas can be served by no technology other than satellite. For the operation of land ESIM and VSAT either in the 28.1 – 28.3 GHz band within a defined populated area, or in the 27.55 – 27.7 GHz band outside this defined populated area, ubiquitous FSS requires to apply a 50 MHz guard band (or twice the occupied bandwidth of FSS, if greater than 50 MHz) to mitigate potential adjacent channel interference to primary FWA.

The SSWG appreciates the work that has gone into the decision to allow ubiquitous FSS on land to operate without a guard space but feels FSS is bearing the majority of the coordination burden with FWA despite the two scenarios mentioned above would cover the case where FSS is primary in 27.55 – 27.7 GHz band outside a defined populated area and also primary in the 28.15 – 28.3 GHz band within a defined populated area.

Guard bands are an inefficient use of spectrum resource in this case where other effective interference mitigation arrangements are being applied. To use a simple analogy, the ACMA has correctly deduced that ubiquitous FSS can safely operate up to the boundary of an AWL, based on in band powers (and could go much further by adopting a more permissive approach to sharing within ‘populated’ areas that would be justified based on the analysis in Appendix 1). But in adjacent bands where the combination of transmitter and receiver performance and filtering will mean received powers will be in the order of 45 dB lower at least, the ACMA thinks a guard band is required. The SSWG questions this analysis and requests the ACMA to revisit these calculations.

The SSWG would suggest the ACMA to consider specifying out of band emission power limits at the boundaries of the 27.5 – 28.1 GHz band at the horizon. This approach is more balanced and should take into account required discrimination for mobile and FWA services while not unfairly passing that burden to FSS.

The SSWG further notes that FSS ESIMs for maritime (M-ESIM) and aeronautical operations (A-ESIM) are treated much differently.

M-ESIM are required to meet –112.2 dBW/m^2/MHz but at a height of 30 m on the shore within a defined population area. This is significantly restrictive and will probably result in a requirement to cease operation in most ports. The value of M-ESIM to shipping services is high and this value increases when in port, so this restriction is unjustified given the small incremental benefit to FWA that would be derived. The SSWG believes a single pfd requirement of –91 dBW/m^2/MHz at 5 m for 95% of the time should apply and that AWL should ‘cut off’ at the coast (and thus inside ports).

Finally A-ESIM are subjected to a different pfd via the upper altitude requirements of Resolution 169 (WRC-19). The SSWG believes Resolution 169 should not be used for domestic coordination and the same pfd of –91 dBW/m^2/MHz should be used for low elevation angles adjusted for FWA antenna gains at higher elevation angles using the Resolution 169 formula for A-ESIM.

3.2 General comments

The SSWG has reviewed the *Radiocommunications (Communication with Space Object) Class Licence Variation 2022 (No. 1)* (the draft CSO Class Licence) and is pleased to note that the ACMA has listened to industry concerns and has mostly removed the guard space around the boundaries of the primary FWA areas, however the SSWG notes that there is no justification for the existence of areas within which uncoordinated VSAT are not allowed to operate. Furthermore, guard spaces are wasted spectrum in the case and are not an efficient way to manage interference in interference limited operations. See the issues discussed below.

Studies, including the analysis presented in Appendix 1, show that FWA and typical satellite services can share the same band within the same geography. Therefore the exclusion of 'populated' areas, within which there are thousands of users in Australian who depend entirely on satellite services for a broadband connection, is not warranted. The SSWG notes that there is a natural separation between locations typically served by satellite and those served by terrestrial means, a separation that far exceeds the separations indicated as necessary by realistic studies.

We are also grateful that the ACMA has adopted the more realistic > 3000 m levels from Resolution 169 and applied them to all altitudes. The other levels in Resolution 169 were not based on technical studies and were, in effect, a last-minute proposal from the floor of WRC-19 to finalise the Agenda Item.

Resolution 169 was never intended for internal coordination except in Administrations with borders between them and Administrations not authorising ESIM. Given Australia is an island continent without such borders, Resolution 169 does not and should not apply.

Adopting a more equitable pfd of –91 dBW/m^2/MHz for all services and adjusting it using the envelope in §3.1 of Annex 3 to Resolution 169 , the SSWG recommends the pfd applied to A-ESIM should not exceed:

$pfd(\Theta) = -91$ dBW/m^2/MHz	for	$0° \leq \Theta \leq 0.01°$
$pfd(\Theta) = -87.2 + 1.9 \times \text{Log}\,\Theta$ dBW/m^2/MHz	for	$0.01° \leq \Theta \leq 0.3°$
$pfd(\Theta) = -82.5 + 11 \times \text{Log}\,\Theta$ dBW/m^2/MHz	for	$0.3° \leq \Theta \leq 1°$
$pfd(\Theta) = -82.5 + 18 \times \text{Log}\,\Theta$ dBW/m^2/MHz	for	$1° \leq \Theta \leq 2°$
$pfd(\Theta) = -84.2 + 23.7 \times \text{Log}\,\Theta$ dBW/m^2/MHz	for	$2° \leq \Theta \leq 8°$
$pfd(\Theta) = -62.8$ dBW/m^2/MHz	for	$8° \leq \Theta \leq 90°$

where Θ is the angle of arrival of the RF wave in degrees above the horizon.

3.3 Issues for clarification

In the case of section 8(6)(a) of the draft CSO Class Licence, the SSWG understood that the ACMA was still considering the case of ubiquitous FSS inside the defined populated areas based on the low probability of interference, which would be quite feasible given the conclusion presented in Appendix 1. It now appears the ACMA has decided there is a 'high risk of unacceptable interference', and this is no longer the case. The SSWG opposes this approach as unsupported by studies and the practical reality of successful shared operations between FWA and VSAT in other parts of the band. The SSWG notes that the nbn FWA network, which has the most stringent reliability requirements of any terrestrial wireless service in Australia, is unconcerned about operations within an area shared co-frequency with uncoordinated VSAT in Ka-band.

Separately, the SSWG would like to also seek clarification if the use of VSATs communicating with NGSO satellites are also considered in this consultation. While the identification of ESIMs communicating with NGSO satellites from 27.5 –30.0 GHz will only be made known after WRC-23, Agenda Item 1.16 has no direct relevance to the consideration of fixed VSATs operations. Similar to the implementation of ITU-R Resolution 169 (WRC-19), there are no provisions for VSATs communicating with GSO satellites. As such, the SSWG would highly encourage the ACMA to adopt similar technical conditions on the use of NGSO VSATs in this band if this is not yet already considered.

3.4 Issues SSWG disputes

In section 8(6)(b) of the draft CSO Class Licence, the ACMA has effectively introduced a minimum 50 MHz guard band. Where FSS uses a 100 MHz bandwidth this could also be as high as 200 MHz for a 100 MHz carrier. This is a very conservative assumption that has not been seen implemented for other types of services in Australia. In any case, the SSWG believes that apparatus (AWL) licenced systems should also share the burden of coordination as FSS is indeed primary in the 27.5 – 27.7 GHz band outside defined populated area and also primary in the 28.1 – 28.3 GHz band within defined populated area.

Most importantly, out-of-band (OOB) and spurious emissions are attenuated by the same mechanisms as in band transmissions. So because no boundary is needed for ubiquitous VSAT when FWA selectivity is combined with realistic (not ITU) OOB emission masks for FSS then there is no need for additional guard bands. The SSWG seriously questions the need for guard bands at the 27.5 GHz boundary or at 28.1 GHz, in particular, when equitable sharing of the interference margin is implemented and more realistic system parameter assumptions such as those defined by the ITU are used.

The SSWG would suggest the ACMA to consider specifying unwanted emission power limits in the 27.5 – 28.1 GHz band at the horizon. This approach is more balanced and should take into account required discrimination for mobile and FWA services while not unfairly passing that burden to FSS.

Section 8(6)(c) of the draft CSO Class Licence is overly restrictive and again appears based on very conservative assumptions. In this case, the figure of –17.8 dBW/MHz appears to be derived from a pfd at 30 m above the boundary of –112.2 dBW/m²/MHz. This is a disparity of 21.2 dB in favour of FWA and, given FWA will be operating in an interference limited environment, simply is not justified.

More realistic assumptions, for example a 5 m measurement height and the same pfd of –91 dBW/m²/MHz as applied to FWA, would result in a much better outcome from a spectrum management perspective.

The value of seamless satellite communications for ships as they move into port is very high, and the SSWG contends it is most likely significantly higher that the incremental value derived from excess protection at the shore. The SSWG submits AWLs should 'cut off' at the shore and in ports. This is realistic because it is not possible to establish either FWA base stations or user terminals in the sea.

The SSWG requests the ACMA revisit the calculations this is based on, use a 5 m measurement height and a pfd of –91 dBW/m²/MHz noting that FWA-to-FWA coordination is achieved with a pfd of –91 dBW/m²/MHz measured at 5 m with an additional 95% stochastic element applied. In our view this would permit 'in port' operation of M-ESIM and still permit on land operation of FWA.

Section 8(6)(d) of the draft CSO Class Licence seems to define a guard band everywhere, even when hundreds perhaps thousands of kilometres from any 26 GHz mobile deployments. This is extremely wasteful of the spectrum space. Again if more realistic parameters are assumed together with realistic clutter losses this guard band is most likely unnecessary given operation inside 26 GHz spectrum licenced areas is effectively prohibited. The SSWG requests the ACMA to reinvestigate this wasted spectrum.

Section 8(8) of the draft CSO Class Licence covers M-ESIM. This section requires a pfd of –112.2 dBW/m²/MHz at 30 m AGL within a 26 GHz spectrum licenced area. It is also 21.2 dB more stringent than FWA-to-FWA coordination requirements at AWL boundaries that use the pfd level of –91 dBW/m²/MHz.

In addition, it again uses a 30 m antenna height (hence the 30 m associated with the pfd requirement) as well as a 29 dBi antenna gain. Essentially, this assumes that M-ESIM need to protect a 30 m antenna deployed on the shoreline that is facing the sea with maximum antenna gain. There are unlikely any FWA user equipment in the sea or on vessels, particularly as this band does not support mobile operation, so this does not appear to be a realistic FWA deployment that M-ESIM are required to protect. In case of a FWA deployment with a 29 dBi antenna gain using 0-degree down tilt, we would expect the FWA base station to be around 15 km inside an AWL boundary. In the case of M-ESIM interference into the FWA base station this would introduce significant clutter losses. For FWA base stations closer to the shore, a 20 to 30 m FWA base station would use considerable mechanic and electronic downtilt towards the customer equipment, which would significantly reduce the antenna gain towards the horizon and consequently, reduce the protection requirements of FWA stations from M-ESIM. For example, for a 16 x 16 antenna array with 6-degrees down-tilt in reference to the horizontal plane would reduce the antenna gain from 29 dBi to 14.5 dBi. Recommendation ITU-R M.2134-0 provides some guidance on the mechanic and electronic antenna pointing of base stations near identical to the ones considered in Australia.

The ACMA interference scenario also seems to ignore the fact that the FWA base stations would need to meet the pfd level of –91 dBW/m²/MHz at the licence boundary, even when pointing towards the open seas. It is near impossible for a 30 m antenna with 29 dBi gain that is pointing towards the horizon to meet this pfd level at the licence boundary. Especially, as the shoreline itself is more than likely to be the AWL licence boundary as there cannot be any customer equipment in the sea. This further indicates that a more realistic scenario should be considered to define the pfd limit for M-ESIM.

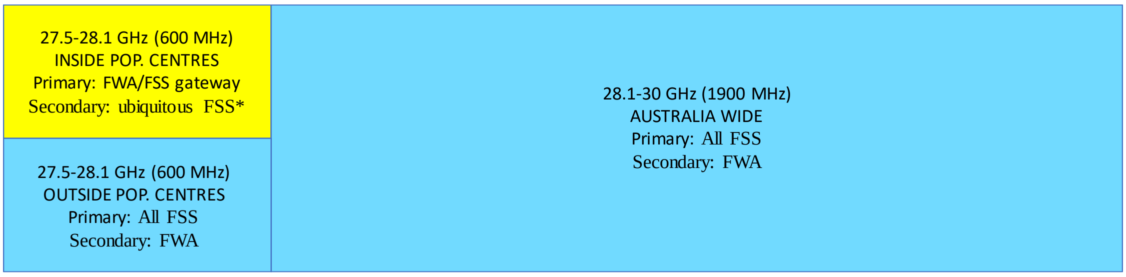
This worst-case scenario used by the ACMA for modelling the pfd limit for M-ESIM will result in lost spectrum space and lost opportunity to shipping and especially to the few ports that are not in a defined populated area but are close (for example Abbott Point in Queensland). Taking these issues into account, the SSWG suggests that the pfd limit should be based on a realistic FWA deployment modelling, with customer equipment pointing inland located on the shore and the base station some distance further inland pointing towards the customer equipment with some downtilt. This configuration resembles the scenario that the ACMA used to establish the pfd limit of –91 dBW/m²/MHz at 5 m above ground for protection of geographically adjacent AWL holders. Therefore, the SSWG strongly suggests that this pfd limit –91 dBW/m²/MHz at 5 m above ground should continue to be adopted for the protection of FWA from M-ESIM.

Attachment A

Impact assessment of nbn's SkyMuster satellite service on planned FWA networks

Introduction

Recent spectrum planning decisions by the Australian Communications and Media Authority (ACMA) have introduced new arrangements in the 27.5 – 29.5 GHz band, inter alia. The new arrangements are summarised in the image below.



As indicated in this diagram, the most prominent feature of the ACMA's spectrum planning decision is the shared nature of the band, i.e. fixed-satellite services (FSS) and fixed wireless access (FWA) are expected to share throughout the 27.5 – 29.5 GHz band. Although the nature of the sharing changes with geography, e.g. whether a service is inside or outside a metropolitan area, there is a clear expectation for sharing to occur cooperatively, with no part of the spectrum denied to either service anywhere in Australia.

nbn is Australia's largest satellite incumbent with large investment in the 27.5 – 29.5 GHz band (among others), known in the satellite industry as the Ka-Band, and all satellite upgrade paths are critically dependent on this band. nbn is also Australia's largest provider of terrestrial wireless broadband services and has acquired 28.5 – 29.5 GHz to enable an upgrade path. As such, nbn is heavily interested in a sharing outcome which is suitable for both services.

This document presents an impact assessment of nbn's SkyMuster satellite service on planned FWA networks operating in the same frequency and geography.

System characteristics

The system characteristics of both the satellite and terrestrial services is shown in Tables 1 and 2 respectively. The Earth station characteristics shown in Table 1 are representative of the user segment of the nbn SkyMuster satellite service. They are derived from real world data and are a true-to-life representation of Australia's most extensive – and in 27.5-29.5 GHz, the only – deployment of very small aperture terminals (VSAT).

The terrestrial system characteristics are shown in Table 2 and are assumed to be an FWA implementation of IMT-2020-like applications.

Parameter	Value	Units
Frequency	28	GHz
Earth station transmit power – clear sky	–73.5	dBW/Hz
Earth station emission bandwidth	12	MHz
Earth station elevation	40	degrees
Earth station antenna gain to horizon	–20	dBi
Earth station transmit duty cycle	1	%
Cross-polar discrimination (circular-to-linear)	3	dB

Table 1. Earth station emission characteristics

Parameter	Base (BS)	User (UE)	Units
Frequency	28		GHz
Noise temperature	290		K
Noise figure	12		dB
Margin	7	10	dB
Activity factor	80	25	%
TDD ratio	20	80	%
Bandwidth	200	67	MHz
Probability of bandwidth overlap with Earth station	100	33	%
Antenna gain	23	17	dBi
Antenna pattern	Recommendation ITU-R M.2101		

Table 2. FWA characteristics

Interference calculation methodologies

To determine the interference potential from Earth stations into FWA employing IMT-2020-type characteristics, two approaches are presented. Both use statistical methods which randomise variables such as location and antenna pointing. The first method is time-invariant and calculates interference margin as a function of distance separating transmitter and receiver. The other calculates a time percentage probability of excess interference as a function of distance between transmitter and receiver.

Margin vs distance

As indicated above, the first calculation of interference potential aims to determine the interference margin as a function of distance between the transmitting Earth station and receiving FWA station. This is done according to the following:

- VSATs are uniformly randomly distributed across a 200 m x 200 m grid
- FWA station is assumed to be at the centre of this grid
- Azimuth angle to each VSAT is determined, along with distance and free space loss at 28 GHz
- For each simulation point, a uniformly randomly distributed value for azimuth pointing of the FWA station is determined and compared with azimuth to VSAT to determine an offset angle
- Gain at calculated offset is calculated according to Recommendation ITU-R M.2101
    - using 4 x 16 elements for BS
    - using 4 x 4 elements for UE
- Off-axis emission level from a VSAT is calculated as:

  $$I_{offaxis} = P_d + G_{offaxis} + 10\log BW_{VSAT} - XPD$$

  where:

  P_d is power spectral density

  $G_{offaxis}$ is the off-axis gain towards the horizon

  BW_{VSAT} is emission bandwidth

  XPD is cross-polar discrimination
- Interference threshold for the FWA station is:

  $$I_{thr} = -228.6 + 10 * \log T + NF + \frac{I}{N} + 10\log BW_{FWA}$$

  where:

  T is noise temperature

  NF is noise figure

  I/N is $10\log(10^{0.1*M} - 1)$ where M is margin

  BW_{FWA} is receiver bandwidth
- Free space loss and FWA antenna gain in the direction of the VSAT is applied to $I_{offaxis}$ to determine received power at the FWA station
- Received power at the FWA station is compared with I_{thr} and a margin calculated
- Margin is plotted as a function of distance for each simulation point
- This approach is similar to that used in Section 4 of Report ITU-R S.2463, which concerns a different band but which otherwise studies a very similar sharing scenario

This method is a relatively straightforward application of the system characteristics given in Tables 1 and 2. Apart from randomly varying the position of the Earth station, the only other variable is the pointing angle, and therefore off-axis gain, of the FWA station.

Also worth noting is the method for calculating the I/N ratio, which necessarily differs from that used in fixed-fixed sharing studies. Particularly, since a FWA base station receives on only a 20% duty cycle, and Earth station transmit duty cycles are 1%, interference can only ever be a short-term phenomenon, if it occurs at all. As such, the long-term I/N threshold[2] used for static sharing between terrestrial services is an inappropriate measure to apply to short-term inter-service sharing scenarios. Rather, this study uses the same method applied in every other assessment of short-term interference, namely, to allow system margins to be temporarily consumed by a short-term interferer. This approach, and the equation given above (using margin to determine I/N) is taken directly from Appendix 7 of the ITU Radio Regulations.

Time percentage as a function of distance

The second calculation methodology considers the time variations inherent in each of the transmitting and receiving stations, according to the following:

- VSAT is placed sequentially at each point in a 150 m x 150 m grid with a 10 m spacing
- FWA station is assumed to be at the centre of the grid
- Distance, free space loss at 28 GHz, and the azimuth angle from FWA station to VSAT are determined for each grid location
- A time series analysis is performed at each grid point
- FWA receive and Earth station transmit times are uniformly randomly distributed across 100,000 time samples, using the duty cycle for each service
- For each time sample, if VSAT is transmitting when FWA station is receiving
    - A uniform random azimuth pointing angle is calculated for the FWA station
    - This pointing angle is compared to the azimuth to the VSAT and an offset is determined
    - The FWA station receive antenna gain at that offset is determined in the same way as the ‘margin vs distance’ analysis above
    - FWA receive gain and free space loss are applied to $I_{offaxis}$ to determine received power at the FWA station
    - Received power at the FWA station is compared with a threshold
    - If received power is above the threshold an interference event is recorded
- For each grid point, the percentage of time points, at which an interference event is recorded, is determined, and scaled by the probability of bandwidth overlap.
- Time percentage of interference events for each grid point is plotted on the 150 m x 150 m grid

[2] The I/N ratio assumed in the development of the apparatus licensing framework for terrestrial services in 27.5 – 29.5 GHz is aimed at helping to determine device boundaries, effectively demarcating adjacent property claims. As such, the application of the I/N threshold in this situation primarily serves a legal, not technical purpose, and should have no bearing on sharing between satellite and terrestrial services.

Results

The results of this sharing study are presented in Figures 1 and 2 below, which display a graph using both interference calculation methodologies, for FWA base and user stations respectively.

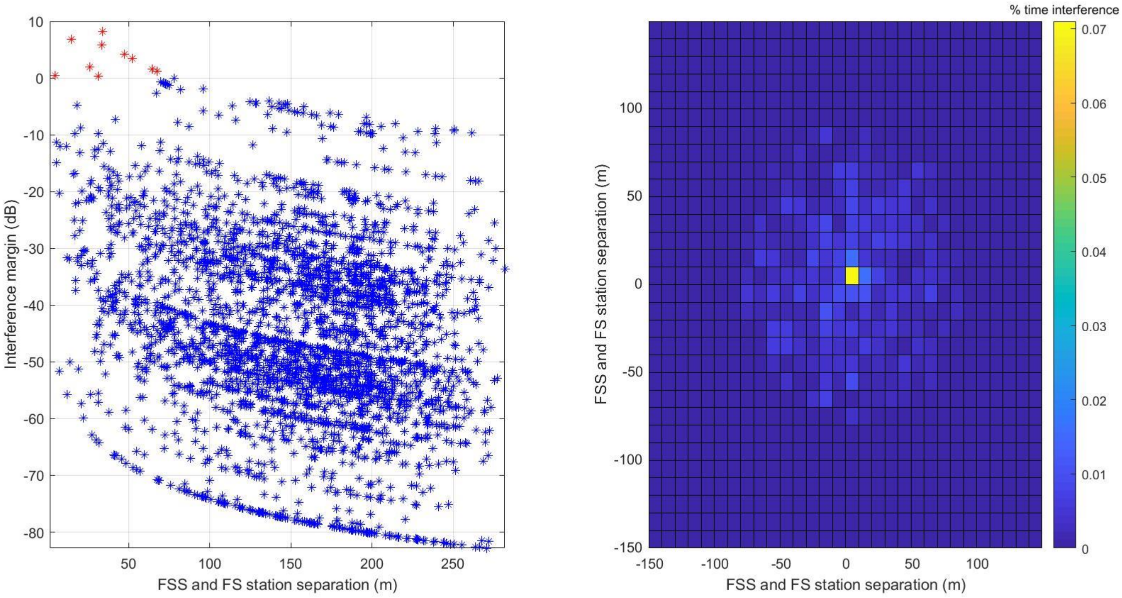


Figure 1. Interference assessment FSS-FWA BS

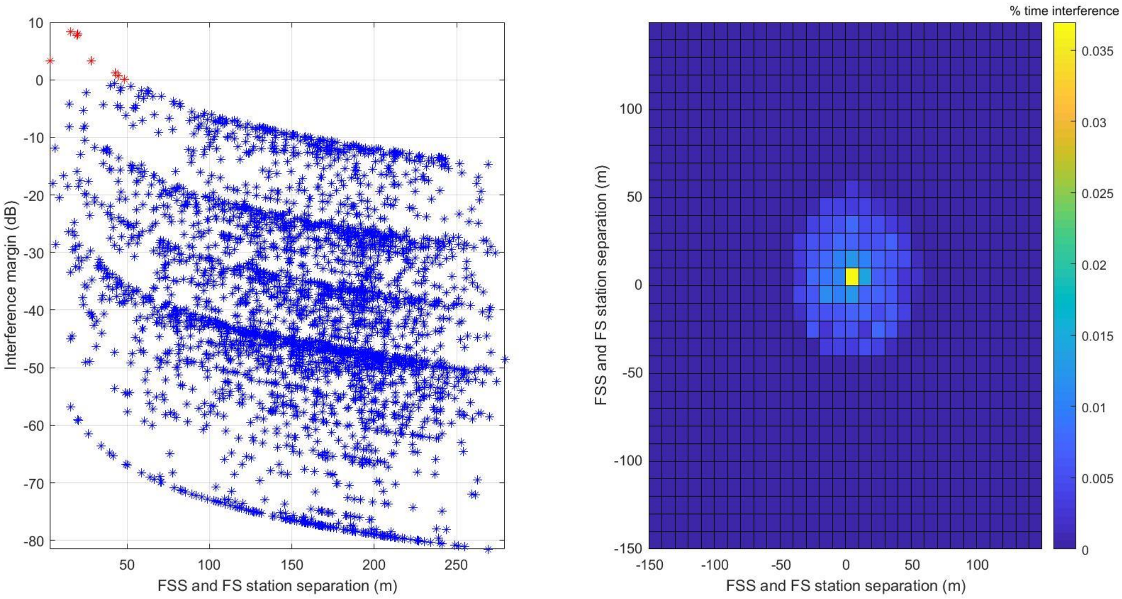


Figure 2. Interference assessment FSS-FWA UE

As shown in Figures 1 and 2, interference is not expected for any separation distance greater than about 100 m (BS) and 50 m (UE). Within these distances, the right panel of each figure shows an interference probability not exceeding 0.1% (BS) or 0.05% (UE) of time. Significantly, there does not appear to be a minimum separation distance within which the two systems are necessarily incompatible.

Not considered in this analysis are several factors which would reduce the interference potential even further, such as clutter, terrain, various fading mechanisms, site management, or atmospheric absorption. A full consideration of all these factors would certainly show an insignificant residual risk of interference but is left out of this analysis for simplicity, given the already extremely low likelihood of interference, even when the potential for interference is not being actively managed.

Conclusions

This document presents the results of a sharing study between transmitting Earth stations with real-world characteristics relevant to the current Australian operating environment, and receiving FWA stations with IMT-2020 characteristics. Results show that, without applying any active mitigation techniques, there is a negligible potential for interference. These results support the conclusion that successful sharing between satellite and terrestrial services can be expected, without any requirement for frequency or geographic separation.

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