COMMUNICATIONS ALLIANCE LTD

COMMUNICATIONS ALLIANCE

SATELLITE SERVICES WORKING GROUP

SUBMISSION

to the

Australian Communications and Media Authority's (ACMA)

Proposed spectrum re-allocation declaration for the 3.4 GHz and 3.7 GHz bands

4 May 2022

CONTENTS

INTRODUCTION

The Communications Alliance Satellite Services Working Group (SSWG) welcomes the opportunity to provide this submission in response to the Australian Communications and Media Authority's *Proposed spectrum re-allocation declaration for the 3.4 GHz and 3.7 GHz bands* Consultation Paper.

About Communications Alliance

Communications Alliance is the primary telecommunications 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, 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 Issues for Comment

The SSWG provides the following responses to the questions presented in the Consultation Paper.

Planning options - Urban excise

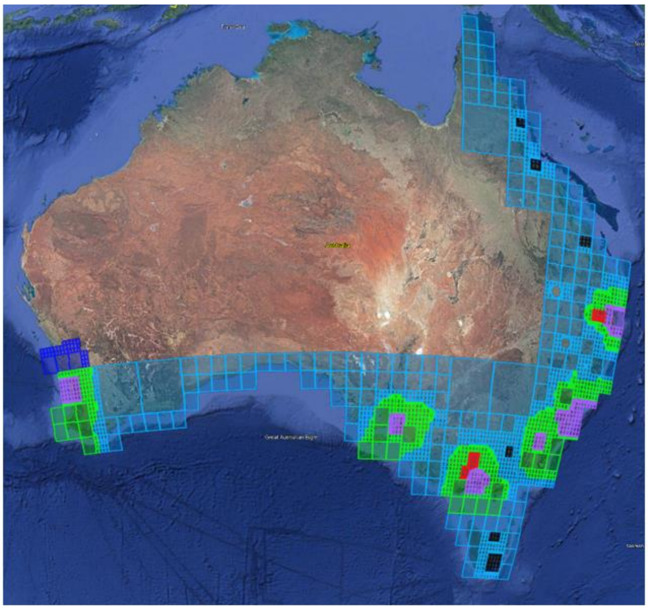
Comments are sought on the ACMA's preferred approach to:

1. **issue spectrum licenses in the 3400 – 3475 MHz frequency range in urban excise areas in accordance with Option A.**
2. **allocate spectrum in the 3800 – 4000 MHz for LA WBB using the segmentation approach.**

Regarding the ACMA's preferred approach to allocate spectrum in the 3800 – 4000 MHz for LA WBB using the segmentation approach, the SSWG believes that the segmentation approach would be better than the top down/bottom-up approach to allocate spectrum in the 3800 – 4000 MHz for Local Area Wireless Broadband (LA WBB). However, the segmentation approach seems to be only applied to high demand areas (metro and major regional) including urban excise areas. The segmentation approach between macro cell LA WBB and restricted cell LA WBB seems to not apply for other regional areas in the band 3750/3800 – 4000 MHz . Based on this, it is assumed that the ACMA expects that there will be a lower probability of LA WBB deployment in other regional areas. The SSWG agrees with the ACMA expectations.

Planning arrangements in 3400 – 3575 MHz and 3700 – 3800 MHz

Comments are sought on the ACMA's preferred planning option (Option 3), which updates the previous preliminary planning decisions (Option 1). Please provide evidence in support of your comments.



Key: purple = metropolitan, red = major regional centres 1, black = major regional centres 2, light blue = regional area 1, green = regional area 2, dark blue = regional WA central.

Figure 1: Map of proposed SL lot boundaries[1]

[1] Source: ACMA's Proposed spectrum re-allocation declaration for the 3.4 GHz and 3.7 GHz bands

Regarding the ACMA's preferred planning Option 3, the SSWG understands the aim to promote specifically the use of WA WBB from 3.4 GHz all the way to 3.8 GHz in metropolitan and major regional areas. It is, however, not clear to us why there would be a push to vacate FSS in the 'other regional' region and in particular the Regional 1 area. As seen on the map in Figure 1, the Regional 1 area represents a large portion of the Australian territory. The map in Figure 2 shows that the Regional 1 areas are mostly very sparsely populated and very similar to the remote areas in terms of population density. The SSWG would support the preliminary ACMA staff views in the [TLG v3 doc](#) (pg 3) that 'FSS services can continue to be licensed using the site based FSS receive apparatus licence type in remote areas and in 'other regional areas'.

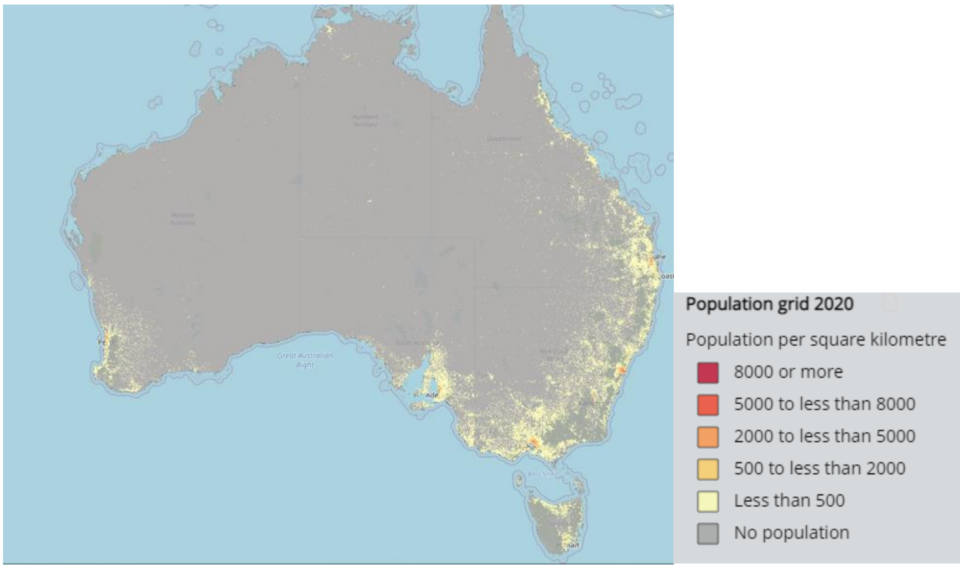


Figure 2: Regional population Australia 2019-2020[2]

The SSWG therefore seeks clarity on the reason behind the proposal to vacate FSS use in the 3.7 – 3.8 GHz band from Regional 1 area. Regional 1 area has low population density, compared to major regional areas, resulting in low numbers of WBB services and therefore enabling FSS to also be assigned, making more efficient use of the spectrum available.

The ACMA is proposing to have up to 15 MHz of restricted-use bandwidth between shared frequency boundaries, between spectrum licences and AWLs at 3800 MHz for metro and 3750 MHz for major regional areas. The SSWG would suggest that the ACMA should consider that the restricted-use bandwidth should straddle the new spectrum allocation and AWL allocation rather than AWL users have this imposed entirely in their band.

It is understood from the [3400-4000 MHz Technical Liaison Group v3 paper](#) (and the recent 3.4 – 4 GHz Tune-up meeting) that the spectrum licensing technical framework will be discussed at the yet to be restarted TLG. The SSWG would raise similar concerns identified in the SSWG submission to the '*Allocation of AWLs in the 3.4 – 4.0 GHz band in remote Australia*' (IFC: 11/2022) consultancy paper, that the protection and coordination with Earth receive stations by WBB services above and below Earth receive stations as currently proposed by the ACMA is not practical and should not be applied. The

Consultation paper (March 2022), Figure 19

[2] Source: Regional population 2019-20: population grid (arcgis.com)

concerns raised in the 3.4 – 4.0 GHz band in remote areas will be similar in the 3.7 – 4.0 GHz band in metro and regional areas.

The SSWG believes that the ACMA's preferred planning option (i.e. Option 3), to allocate WA WBB and LA WBB particularly in the 3700 – 4000 MHz band are likely to result in costly earth station relocation and/or re-tuning costs by the FSS incumbents and significant negative financial impact due to revenue loss. The SSWG urges the ACMA to seriously consider compensating incumbents for at least the associated costs and losses.

The SSWG and its members have previously suggested that the ACMA compensate incumbents, especially when the proceeds of the subsequent spectrum re-allocation of the spectrum to a new, 'higher value' use exceeds the incumbents' costs and losses[3]. If the ACMA's reallocation decision creates surplus benefit (as reflected in the re-allocation proceeds) that exceeds the losses, then it is only fair that that those harmed by the ACMA's decision are compensated, e.g., by using the re-allocation proceeds. Such a result would be closer to the theoretical Pareto efficient outcome where at least one person is better off, and no one is worse off, because the 'winners' have compensated the 'losers.'

Licence type

Comments are sought on the ACMA's proposal to issue spectrum licenses in the 3.4 GHz (including in regional areas and in urban excise areas) and 3.7 GHz bands. Please provide evidence in support of your comments.

Aligned with the SSWG comments to Question 2 above, the SSWG would like to clarify the need to issue spectrum licenses in other regional areas (e.g. regional area 1 and regional area 2) for the band 3700 – 3750 MHz for the same reasons mentioned in Question 2 above.

Specified parts of the spectrum

Comments are sought on the ACMA's proposal to declare for re-allocation the parts of spectrum in accordance with our proposed planning option (Option 3, 'Planning options', above). The ACMA welcome stakeholder views on the parts of the spectrum proposed for re-allocation, particularly the inclusion of the frequency ranges 3475 – 3492.5 MHz, 3492.5 – 3510 MHz, and 3510 – 3542.5 in specified geographic areas as described under Option 3 in 'Planning options'.

Although it is understood that this consultation mainly focuses on reallocating the 3.4 GHz and 3.7 GHz bands to spectrum licences, once the reallocation for spectrum licences is declared for the 3700 – 3750 MHz band for major regional areas (Option 3) and 3700 – 3800 MHz band for metro areas, it is understood that new or varied FSS licensing requirements in these bands will need to be taken up in the 3750/3800 – 4200 MHz band subject to the AWL framework. As mentioned in response to Q.2, it is understood that the AWL frameworks in the 3750/3800 – 4200 MHz band will be discussed in the restarted TLG. Since the plan is to push FSS out of the 3700 – 3800 MHz band, the inappropriate nature of AWL for FSS Earth receive licensing is raised here. The detail technical study presented in Annex 1 of this document shows that the distance of the FSS AWL would need to be quite large in order to ensure the protection of FSS ES deployment within the AWL from a neighbouring WBB AWL. It is subsequently shown that operating FSS under AWL licensing

[3] Communications Alliance CA SSWG response to Five Year Spectrum Outlook 2017-21. pp 20-21. https://www.commsalliance.com.au/__data/assets/pdf_file/0009/59598/CA-SSWG-response-to-Five-Year-Spectrum-Outlook-2017-21.pdf

scheme would therefore not be an efficient use of spectrum. A proposed alternative approach to the coexistence of FSS and WBB in metropolitan and regional areas is proposed on the basis of FSS operating under Apparatus Licences (ALs) in combination with a defined coordination procedure.

The conclusions referring to the detail technical studies contained in Annex 1 are as follows:

(a) The study identifies that using AWLs for FSS receiver protection will result in significantly (and more crucially, unnecessarily) large licence areas, which can be avoided in many cases by ALs and taking into account the specific deployment environment and configuration of both the FSS ES and WBB stations. The potential unintended consequences to FSS of imposing AWLs in the manner currently proposed could lead to one type of technology (in this case, FSS) being systematically disadvantaged vis-à-vis other services in the same region and band, therefore potentially driving FSS out. Licensing FSS ES receivers using current AL methodology will produce a more spectrum efficient arrangement and allow more FSS ES receivers to continue to operate.

(b) In the adjacent band case, a minimum guard-band between WBB stations and FSS ES is required to avoid the FSS ES Low-Noise Block downconverters (LNBs) from being driven into saturation. We would welcome further discussions on the matter to properly identify this minimum required frequency separation to ensure the effective use of filters.

Re allocation period and deadline

Comments are sought on the ACMA's proposal for a reallocation period of 5 years from the commencement of the re-allocation declaration and a re-allocation deadline of 12 months before the end of the re-allocation period. Please provide evidence in support of your comments.

Regarding the ACMA's proposal for a re-allocation period of 5 years from the commencement of the re-allocation declaration and a re-allocation deadline of 12 months before the end of the re-allocation period, the SSWG supports such proposal.

Annex 1
Detail Technical Studies on FSS and WBB coexistence framework in the 3.7 – 4.2 GHz band

1 Introduction

Annex 1 provides the technical details study on the current proposal made by the ACMA for metropolitan and regional areas sharing between the FSS and the LA WBB services. This report then raises a number of considerations for efficient spectrum sharing in these areas between the aforementioned services.

This report proposes to address the following topics:

1. Review of the current proposed framework proposed in the Consultation Paper IFC# 10/2022 for the 3.7 – 4.2 GHz band. The main points proposed to address concern regarding the appropriateness of AWL licensing for FSS space-to-Earth in the 3.8 – 4.0 GHz band
2. Propose an alternative approach for the coexistence between WBB and FSS to the current proposed framework

Most of the content of Annex 1 has been submitted to the ACMA Technical Liaison Group (ACMA TLG) as a joint satellite submission on the 'FSS and WBB Metro and Regional proposed coexistence framework in the 3.7 – 4.2 GHz band' on 9 February 2022.

2 Technical study to determine separation distances between FSS and WBB

This study aims to determine the required separation distances between FSS and WBB deployments in order to meet the FSS ES protection levels defined by the ACMA, both for in-band and in adjacent band sharing scenarios. In addition, this section provides an estimation of the required size of the AWL for the FSS to protect FSS ES deployment from an adjacent WBB AWL. For this study, the impact of WBB deployment into FSS is assessed by considering the emissions of 5G Base Station (BS) deployments.

It is important to note that 'adjacent band' implies that the WBB transmitter is in the 3.4 – 3.8 GHz band and FSS ES receiver in the 3.8 – 4.2 GHz band. In-band implies that the WBB transmitter is in the 3.8 – 4.0 GHz band and FSS ES Rx in the 3.8 – 4.2 GHz band.

3 FSS assumptions

1. Protection level given by maximum interference level for both in-band and out of band case: Imax = –28.6 dBm/MHz not to be exceeded for more than 20% time. This is equivalent to –158.6 dBW/MHz.

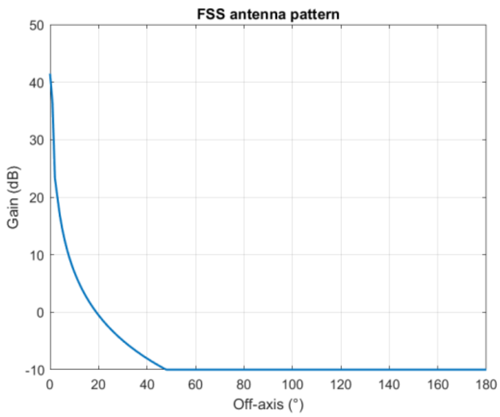
Different elevations of the FSS ES were considered: 10, 15, 30, 45 and 60 degrees.

These different elevation angles of the receive earth stations are based on the below table which provides an example of elevation angles for some Intelsat's operational satellites for services in metropolitan areas:

Elevation Assessments (Metropolitan Areas)								
No.	**Intelsat satellite name**	**Orbital Location**	**Elevation @ Adelaide**	**Elevation @ Brisbane**	**Elevation @ Canberra**	**Elevation @ Melbourne**	**Elevation @ Sydney**	**Elevation @ Perth**
1	Intelsat 18	180E	30.5	46.2	37.6	33	40	13.3
2	Intelsat 19	166E	40.1	54.8	45.2	40.9	47.5	25.1
3	Horizons 3e	169E	38.2	53.3	43.9	39.5	46.2	22.6

2. Antenna diameter: 3.8 m
3. Resulting FSS antenna gain towards 5G interferer following S.465:

Elevation (deg)	10	15	30	45	60
Antenna gain (dBi)	7	2.6	–4.9	–9.3	–10



Note: *For elevations greater than 48 degrees the antenna gain is –10 dBi and does not change as per ITU-R S.465.*

4. Antenna height considered: 10 m

4 5G assumptions

1. Power considerations:
   a. ACMA Spectrum license[4] maximum allowable TRP for in band case (cf. Condition 14 of Schedule 2): 48 dBm/5MHz.

      Note: *This is actually higher than what is currently agreed at WP5D (46 dBm for bandwidths of **40 or 80 or 100 MHz**). This means that the ACMA TRP is 11 to 15 dB higher.*

   b. ACMA Spectrum license maximum allowable TRP (unwanted emission limits) for AAS when considering 10MHz frequency separation (cf. Condition 7 of Schedule 2): – 6 dBm/MHz.

4 Based on a typical ACMA Spectrum licence for the 3.4 GHz band available in ACMA's RRL

2. The study considers an IMT macro urban/suburban AAS antenna pointing towards the FSS receiver. The AAS antenna gain was modelled following the characteristics described in Annex 4.4 to the WP5D/716 chairman's report. The relevant characteristics for the 5G systems operating in the 3.4 – 4.0 GHz spectrum were extracted and are presented in the Annex 2 to this document. The maximum gain is calculated by multiplying the antenna elemental gain. In the logarithmic domain this yields: 6.4 + 10 log (8 x 4 x 3) = 26.2 dBi.

   Note: *More explanation can be provided for this step, if needed.*

3. Antenna height considered (based on the WP5D characteristics presented in Annex 2: 20 m

5 Propagation model

ITU-R recommendation P.452 was used for this case with an associated time percentage of 20% (linked to the ACMA's protection level for FSS ES). No clutter was considered in this first evaluation as the aim is to determine the coordination distance that would be needed to protect FSS ES. The coordination distance needs to consider all possible deployment configurations, including the case where there is no clutter loss on the path.

6 Estimation of the FSS AWL size to protect FSS ES

In addition to the protection level of –128.6 dBm/MHz to be met at the FSS ES receiver, the ACMA also defines a device boundary limit for the WBB AWL of –90 dBm/MHz for AAS transmitters in Schedule 2 of the S.145 determination:

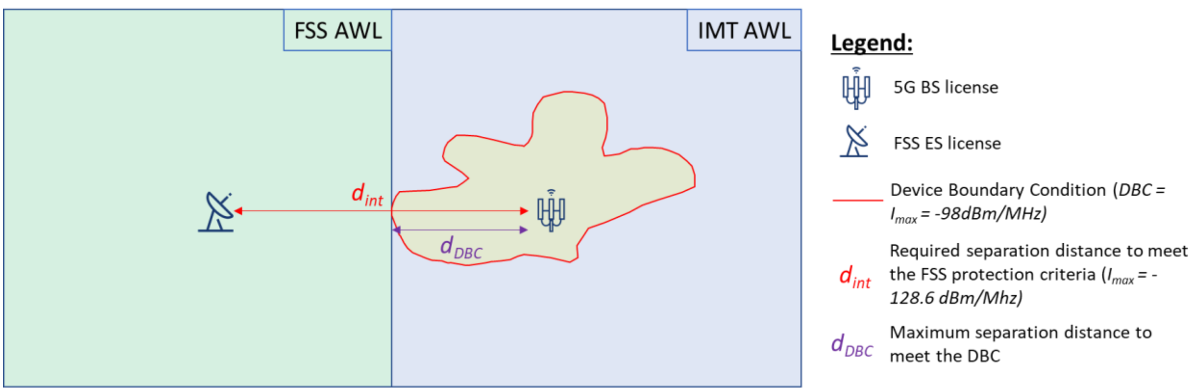
$$RP - MP \leq 0$$

Where:

- $MP = PL + LOP - Gr$
- RP is the horizontally radiated power, measured in dBm per MHz
- PL is the propagation loss (dB)
- G_r is the nominal radiocommunications receiver antenna gain including feeder loss set to 0 dBi
- LOP is the protection level set to –90 dBm/MHz

The above Device Boundary Condition (DBC) equates to having a maximum interference level of $I_{max} = LOP = -90\ dBm/MHz$ at the device boundary.

The following figure illustrates the situation.



Based on the DBC, one can determine the maximum required separation distance for a 5G BS boundary limit (i.e. d_{DBC}). In addition, the required separation distance to ensure that the FSS ES protection criteria is met (i.e. d_{int}) can also be calculated.

An estimation of the minimum FSS AWL distance can then be determined with the following formula:

$$d_{FSS\ AWL_{min}} = d_{int} - d_{DBC}$$

The following sub-sections calculate in turn d_{int} and d_{DBC}.

7 Calculation of d_{int}

The following formula was used for the calculation of the interference with the above assumptions:

$$I_{FSS} = EIRP_{BS} + G_{FSS} - P_{loss}$$

where:

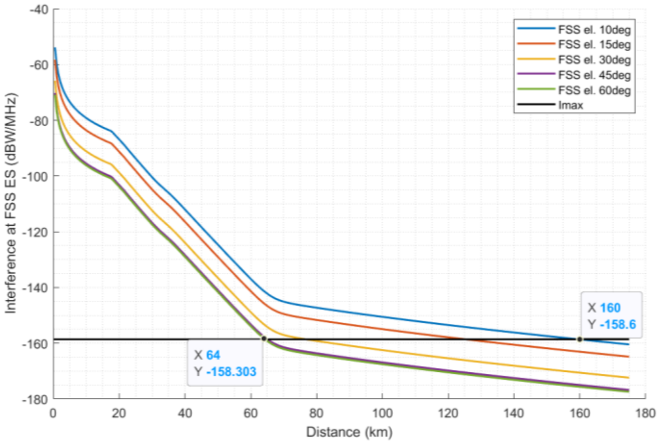
I_{FSS}	is the interference received at the FSS receiver (dBW/MHz)
$EIRP_{BS}$	is the BS e.i.r.p. (TRP + gain) towards the FSS receiver (dBW/MHz)
P_{loss}	is the propagation loss based on P.452 propagation model (dB)

Using this formula and the list of parameters presented in sections 3 and 4, the separation distance can be calculated for both the in-band case and the adjacent band case. As explained in section 4, for the adjacent band case the 5G out-of-band emission limit for a 10 MHz frequency separation was taken as an assumption. In other words, this would mean for example that the 5G BS would not operate above 3790 MHz and the FSS ES victim is assumed to be receiving in the 3.8 – 4.2 GHz. It is important to note that this scenario only addresses the unwanted emissions of 5G falling within the FSS ES operating band.

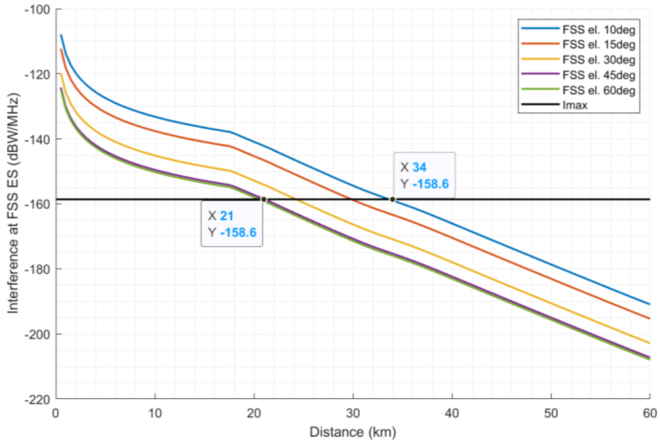
Additional consideration should be made on the impact of 5G BS emissions within 3.4 – 3.8 GHz that could drive the LNB of the FSS ES receivers into saturation if proper filtering is not implemented. FSS ES receivers in the C-band generally use LNB devices that operate from 3.4 to 4.2 GHz. In order to avoid driving the FSS ES LNB into saturation and effectively blocking the FSS ES receiving capabilities, filters need to be implemented to zone out potential 5G emissions in the 3.4 – 3.8 GHz. For such filters to effectively mitigate the interference, enough frequency separation needs to be implemented between the end of the 5G emission range and the start of the receiving range of the FSS ES at 3.8 GHz. Filters to be fitted on the FSS ES side would require larger frequency separation than 10 MHz (assumed for modelling the WBB unwanted emissions) to efficiently filter out WBB emissions below 3.8 GHz. The minimum frequency separation required to effectively filter out 5G emissions in the 3.4 – 3.8 GHz depends on a number of assumptions (e.g. LNB sensitivity, required attenuation, filter specification…). Further discussion on the right amount of guard-band for the effective implementation of filters at the FSS ES is needed.

The curves below represent the interference level versus distance for both the in-band and adjacent band case. The black line represents the protection level for FSS ES as defined by the ACMA:

In-band case
(e.g. 5G in 3.8-4.0 GHz and FSS ES in 3.8-4.2 GHz)

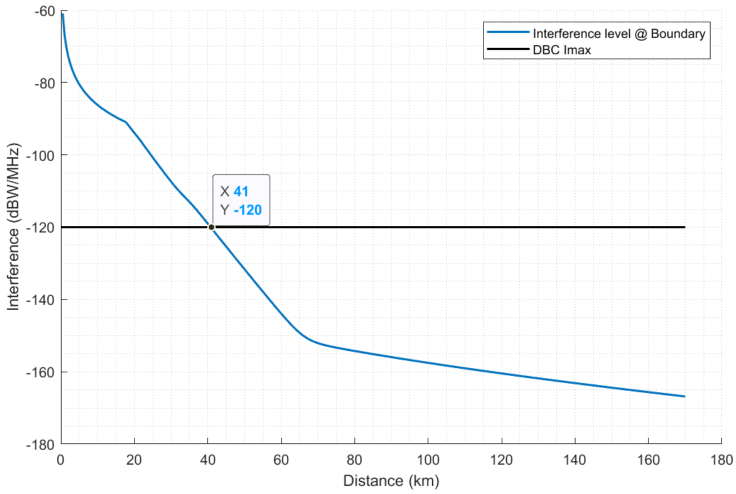


Adjacent band case
(e.g. 5G in 3.4-3.8 GHz and FSS ES in 3.8-4.2 GHz)



8 Calculation of d_{DBC}

In order to obtain d_{DBC} the exact same process was performed as in the previous section by calculating the interference versus distance for the in-band case except for the fact that the receiver gain was set to 0 dBi as specified in Schedule 2 of the S.145 determination.



9 Summary of the study and preliminary assessment

9.1 In-band case (WBB in 3.8 – 4.0 GHz and FSS in 3.8 – 4.2 GHz)

The following table provide the in-band separation distances required for a 5G BS (WBB) to meet both the DBC and the FSS ES protection criteria. The difference between distances provides an idea on the minimum separation distance required for the FSS AWL.

Table 1 – In band coexistence study results

Assuming 5G BS maximum gain (26 dBi)			
FSS ES elevation	**Separation distance to protect FSS (km)**	**Separation distance to meet DBC (km)**	**Minimum FSS AWL radius (km)**
10	160	41	**119**
15	126		85
30	77		36
45	64		23
60	64		23

Based on the results in the above table, in order to consider all possible deployment of FSS in a given AWL license framework, then a minimum radius of **119 km** should be considered for the FSS AWL. If the radius is smaller than 119 km, this means that 5G BS (WBB) in a neighbouring AWL cell could cause harmful interference to FSS receivers depending on their actual deployment characteristics. In other words, in order to accommodate all types of FSS ES deployment within the AWL framework, the radius of the AWL would need to be much larger than 119 km. This would equate to very large areas where both FSS and 5G would not be able to deploy and lead to inefficient use of spectrum.

In addition, not only is the area needed disproportionately large once interference management is considered, but it is also totally unnecessary for FSS given the nature of the service. By enforcing AWLs onto FSS, satellite service providers would effectively be made to take up a coverage far larger than their intended needs leading to unreasonable costs linked to this licensing scheme. We urge ACMA to seriously consider the potential unintended consequences of imposing a license type that is unsuitable for a particular technology type (in this case, FSS). It is envisaged that imposing AWLs in this manner would invariably and systematically disadvantage FSS vis-à-vis other technologies in the same region and band, which we do not believe ACMA intends to do. The result could be FSS being driven out entirely of that region/band.

At this point, we acknowledge the fact that AWL licensing was partially adopted for FSS Earth-to-space in the 28 GHz band. However, we would note that there is a big difference when assessing licensing schemes for FSS ES in the Earth-to-space (transmitting ES) and space-to-Earth (receiving ES). The FSS uplinks in the 28 GHz band are the only FSS services in Australia using the AWL methodology for licensing. There are no FSS downlink Rxs licensed using AWLs and there are very few similarities in licensing requirements between FSS uplink Txs in the 28 GHz band and FSS downlink Rxs in the 3800 – 4000 MHz band.

The ACMA indicates in their list of apparatus licence types that the reason Area-Wide Licences (AWLs) are used is 'to operate multiple radiocommunications devices for any service in a specific geographic area and frequency band.' To our mind, AWL might be suitable for licensing scheme for transmitting stations to provide clear guidance on their emission limits, it is in no way as justifiable licensing scheme for satellite receiving ES. While this might be applicable for WBB services and even some FSS uplink applications in the 28 GHz band, this is not how FSS downlink Rxs in the 3800 – 4000 MHz band are deployed. FSS downlink Rxs in the 3800 – 4000 MHz band often only have one or a small number of antennas in a defined AWL geographic area.

The proposed AWL approach for FSS receivers is the reverse of the first-in-time coordination method, which has been relied on for many years, in which case the first-in-time licensee has priority and new licensees have to find a way to minimise interference to the existing licence (especially an existing receive-only licence).

To conclude, as demonstrated in this study, the AWL would lead to inefficient use of spectrum and impose undue constraints on existing and future FSS operations in the band. We therefore believe that this licensing scheme is not adapted to receiving FSS ES and we would propose an alternative approach as recommended in section 4 of this report.

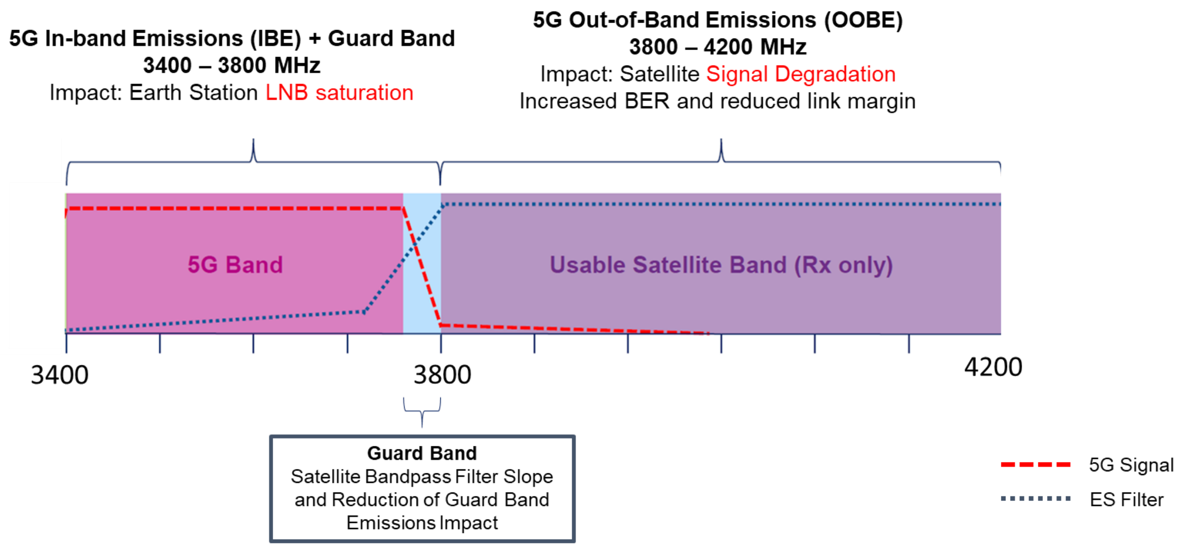
9.2 Adjacent band case (WBB in 3.4 – 3.8 GHz and FSS in 3.8 – 4.2 GHz)

As partly highlighted in section 7, there needs to be a differentiation between the two following adjacent band interference mechanisms:

1. Typically, earth station LNBs are designed to receive the entire 3400 – 4200 MHz band. The IMT/5G (WBB) signals in the 3400 – 3800 MHz band therefore can saturate the amplifier stage in the LNB or bring it into non-linear operation thus blocking reception of signals. The best solution to mitigate the IMT systems' interference is to insert a RF waveguide filter between the output of the antenna and the input of the LNB. The filter could only be operated properly if there is frequency separation (i.e. Guard-band) between the edge of the IMT/5G transmission and the FSS transmission to provide the waveguide filter the necessary bandwidth to reject the 5G interference at the earth station. However, it is still important to note that the implementation of such filters on the FSS earth station receivers presents a certain number of drawbacks (degradation of existing services with a reduction in margin and throughput, filter cost, implementation rollout …);

2. Unwanted (out of band and spurious) emissions of the mobile 5G signal falling within the operating FSS operating band 3800 – 4200 MHz can cause in-band interference to FSS signals. As opposed to the emissions in the 3400 – 3670 MHz that can be mitigated by the implementation of a filter at the FSS earth station, the 5G/IMT unwanted emissions falling within the 3700 – 4200 MHz band cannot be filtered. Regulation on specific IMT/5G unwanted emissions limits versus frequency separation is key in this context to limit the impact of these unwanted emissions on adjacent band operating services.

The following diagram highlights the two different scenarios.



The sharing results in this section cover only the interference mechanism described in point 2 above, i.e. the OOB emissions of 5G falling within the FSS operating band.

The table below presents the results of the required separation distances in order to avoid unwanted interference falling within the FSS ES operating band 3.8 – 4.2 GHz. It is important to note that a 10 MHz frequency separation was already assumed for the 5G BS unwanted emissions to obtain the following results.

Table 2 – Adjacent band coexistence study results

FSS ES elevation	Separation distance to protect FSS 5G Max gain (26dBi) (km)
10	34
15	30
30	24
45	21
60	21

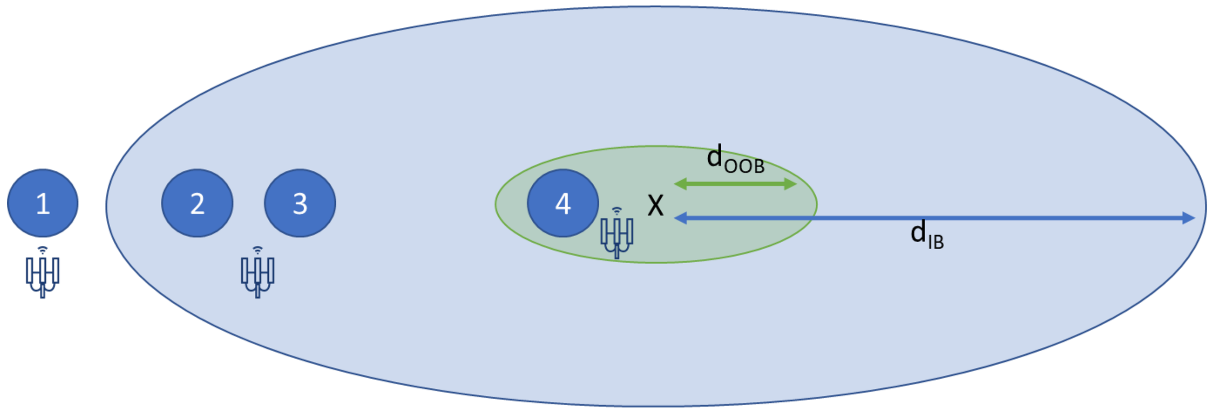
This document does not consider the FSS ES LNB saturation that could be caused from 5G emissions within the 3.4 – 3.8 GHz. For filters to effectively mitigate the interference, enough frequency separation needs to be implemented between the end of the 5G emission range and the start of the receiving range of the FSS ES at 3.8 GHz. The minimum frequency separation required to effectively filter out 5G emissions in the 3.4 – 3.8 GHz depends on a number of assumptions (e.g. LNB sensitivity, required attenuation, maximum insertion loss specification, among others…).

Further discussion on the right amount of guard-band for the effective implementation of filters at the FSS ES are needed. Of concern is the additional costs incurred by FSS operators associated to the installation of filters on existing antennas to guarantee certain levels of rejection in the adjacent band to mitigate potential additional service degradation[5], when the in-band IMT/5G (WBB) emissions currently in the 3400 – 3700 MHz band are expanded into the 3400 – 3800 MHz band.

10 Proposed coordination approach in metropolitan and regional areas

Based on the considerations exposed in this report, this section aims at providing an alternative framework to enable coexistence between FSS and WBB in the 3.7 – 4.2 GHz band in metropolitan and regional areas. The proposal is based on the assumption that the FSS ES would be operating under an AL at a known location. The above separation distances, or the current coordination distances proposed in the RAG[6] of 100 km for adjacent band and 200 km for in band (see 4.3 (1) (c) (i) and (ii)), can then be used as coordination distances. The following diagram summarizes the possible approach to coordination of FSS operating in the 3.8 – 4.2 GHz and WBB in metropolitan and regional areas:

5 The increase in selectivity required by new filters may result in undesirable insertion loss ripple, which will further decrease the C/(N+I) ratio on the FSS.
6 *Radiocommunications Advisory Guidelines (Managing Interference from Spectrum Licensed Transmitters — 3.4 GHz Band) 2015 (legislation.gov.au)*



Case #		Legend	
1	WBB in 3.4 – 4.0 GHz can operate without coordination with the FSS ES		In-band coordination area for WBB using 3.8 – 4.0 GHz
2	Adjacent band WBB in 3.4 – 3.8 GHz can operate without coordination with the FSS ES		Adjacent band coordination area for WBB in 3.4 – 3.8 GHz
3	In-band WBB operation in 3.8 – 4.0 GHz to coordinate on case-by-case basis to protect the FSS ES	**X**	In-band WBB operation in 3.8 – 4.0 GHz to coordinate on case-by-case basis to protect the FSS ES
4	Adjacent band and in-band WBB in 3.4 – 4.0 GHz to coordinate on case-by-case basis to protect the FSS ES	d_{IB}	In-band coordination distance for WBB using 3.8 – 4.0 GHz (e.g. 200 km)
		d_{OOB}	Out of band coordination distance for WBB using 3.8 – 4.0 GHz (e.g. 100 km)

In cases 2, 3 and 4 where the WBB station is deployed at a distance that is shorter than the in-band or adjacent band coordination distance, there is a need to coordinate and to consider the specific deployment environment and configuration of both the FSS ES and the 5G station. Specific mitigation measures need to be considered on the 5G side to mitigate any specific emission towards the FSS ES that might cause unacceptable interference, such as:

1	Use lower transmit power levels for the base station and user equipment.
2	Define a transmit OOBE mask that considers the impact of emissions on the noise floor of FSS.
3	Use Multiple-Input Multiple-Output (MIMO) technology to null the radiation pattern in the direction of earth stations.
4	Deploy microcells near FSS earth stations which have lower transmit powers.
5	Force user equipment to roam to non-C-Band frequencies near FSS earth stations.

11 Abbreviations

AL	Apparatus License
AWL	Area-Wide License
SL	Spectrum License
WBB	Wireless Broadband
FSS	Fixed Satellite Service
ES	Earth Station
LNB	Low Noise Block
DBC	Device Boundary Condition

Annex 2
IMT characteristics

The following tables are extracted from Annex 4.4 to WP5D/716 chairman's report and present the IMT characteristics applicable to the relevant part of the C-band considered in this study report. Only the BS characteristics are presented in this annex.

1 Deployment related characteristics

Table 6-1 provides the deployment-related parameters of IMT BS systems for the frequency bands between 3 and 6 GHz. Implementation of AAS (see Table 9) as well as antenna characteristics in Recommendation ITU-R F.1336 are considered for IMT base stations in these frequency bands. For IMT user equipment / mobile stations, implementation of AAS is not considered.

TABLE 6-1

Deployment-related parameters for bands between 3 and 6 GHz

	Rural (optional)	**Urban/suburban macro**	**Small cell (outdoor)/Micro cell**	**Indoor (small cell)**
Base station characteristics/Cell structure				
Cell radius / Deployment density (non-AAS)	1.2 km / isolated BSs or a cluster of four BSs with the density of 0.001-0.006 BSs/km^2 (Note 2)	Typical cell radius 0.3 km urban / 0.6 km suburban	1-3 per urban macro cell <1 per suburban macro site	Depending on indoor coverage/ capacity demand
Cell radius / Deployment density (AAS)	1.6 km / isolated BSs or a cluster of four BSs with the density of 0.001-0.006 BSs/km^2 (Note 2)	Typical cell radius 0.4 km urban / 0.8 km suburban (10 BSs/km^2 urban / 2.4 BSs/km^2 suburban (Note 2))	1-3 per urban macro cell <1 per suburban macro site	Depending on indoor coverage/ capacity demand
Antenna height	35 m	20 m urban / 25 m suburban	6 m	3 m
Sectorization	3 sectors	3 sectors	Single sector	Single sector
Non-AAS BS downtilt (Note 1)	3 degrees	10 degrees urban / 6 degrees suburban	n.a.	n.a.
Frequency reuse	1	1	1	1
Non-AAS BS antenna pattern (Note 1)	Recommendation ITU-R F.1336 (*recommends* 3.1) ka = 0.7 kp = 0.7 kh = 0.7 kv = 0.3	Recommendation ITU-R F.1336 (*recommends* 3.1) ka = 0.7 kp = 0.7 kh = 0.7 kv = 0.3	Recommendation ITU-R F.1336 (omni: *recommends* 2)	

	Rural (optional)	Urban/suburban macro	Small cell (outdoor)/Micro cell	Indoor (small cell)
	Horizontal 3 dB beamwidth: 65 degrees Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.	Horizontal 3 dB beamwidth: 65 degrees Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.		
Non-AAS BS antenna polarization	Linear/±45 degrees	Linear/±45 degrees	Linear	Linear
Indoor base station deployment	n.a.	n.a.	n.a.	100%
Indoor base station penetration loss	n.a.	n.a.	n.a.	Rec. ITU-R P.2109
Below rooftop base station antenna deployment	0%	Urban: 50% Suburban: 0%	100%	n.a.
Non-AAS BS feeder loss (Note 1)	3 dB	3 dB	3 dB	3 dB
Typical channel bandwidth	40 or 80 or 100 MHz	40 or 80 or 100 MHz	40 or 80 or 100 MHz	40 or 80 or 100 MHz
Maximum Non-AAS BS output power (Note 1)	52 dBm in 40 MHz 55 dBm in 80 MHz 56 dBm 100 MHz	49 dBm in 40 MHz 52 dBm in 80 MHz 53 dBm in 100 MHz	24 dBm in 40 or 80 or 100MHz	24 dBm in 40 or 80 or 100 MHz
Maximum Non-AAS BS antenna gain (Note 1)	18 dBi	18 dBi	5 dBi	0 dBi
Maximum Non-AAS BS output power/sector (e.i.r.p.) (Note 1)	67 dBm in 40 MHz 70 dBm in 80 MHz 71 dBm in 100 MHz	64 dBm in 40 MHz 67 dBm in 80 MHz 68 dBm in 100 MHz	29 dBm in 40 or 80 or 100 MHz	24 dBm in 40 or 80 or 100 MHz
Network loading factor (base station load probability X%) (see section 3.4 below and	50%	20%, 50%	20%, 50%	20%, 50%

	Rural (optional)	Urban/suburban macro	Small cell (outdoor)/Micro cell	Indoor (small cell)
Rec. ITU-R M.2101 Annex 1, section 3.4.1 and 6)				
Average Non-AAS BS power/sector (e.i.r.p.) taking into account activity factor (Note 1)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)
TDD / FDD	TDD	TDD	TDD	TDD
BS TDD activity factor	75%	75%	75%	75%

Note 1: This parameter is only applicable for non-AAS base stations. Antenna characteristics for AAS base stations (for frequency bands above 1710 MHz) are provided in Table 9.

Note 2: "1 BS" = 1 sector in 3-sector cell.

2 Beamforming antenna characteristics

TABLE 9

Beamforming antenna characteristics for IMT in 1 710-4 990 MHz

		Rural macro	Suburban macro	Urban macro	Urban small cell (outdoor)/Micro cell	Indoor (small cell)
1	**Base station antenna characteristics**					
1.1	Antenna pattern	Refer to the extended AAS model in Table A of Annex 3			Refer to section 5 of Recommendation ITU-R M.2101	N/A
1.2	Element gain (dBi) **(Note 1)**	6.4	6.4	6.4	6.4	N/A
1.3	Horizontal/vertical 3 dB beam width of single element (degree)	90º for H 65º for V	90º for H 65º for V	90º for H 65º for V	90º for H 65º for V	N/A
1.4	Horizontal/vertical front-to-back ratio (dB)	30 for both H/V	30 for both H/V	30 for both H/V	30 for both H/V	N/A
1.5	Antenna polarization	Linear ±45º	Linear ±45º	Linear ±45º	Linear ±45º	N/A
1.6	Antenna array configuration (Row × Column) **(Note 2)**	4 × 8 elements	4 × 8 elements	4 × 8 elements	8 × 8 elements	N/A
1.7	Horizontal/Vertical radiating element/sub-array spacing, d_h /d_v	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 0.7 of wavelength for V	N/A
1.7a	Number of element rows in sub-array, M_{sub}	3	3	3	N/A	N/A

1.7b	Vertical radiating element spacing in sub-array, $d_{v,sub}$	0.7 of wavelength of V	0.7 of wavelength of V	0.7 of wavelength of V	N/A	N/A
1.7c	Pre-set sub-array down-tilt, $\vartheta_{subtilt}$ (degrees)	3	3	3	N/A	N/A
1.8	Array Ohmic loss (dB) (Note 1)	2	2	2	2	N/A
1.9	Conducted power (before Ohmic loss) per antenna element/sub-array (dBm) (Note 5, 6)	28	28	28	16	N/A
1.10	Base station horizontal coverage range (degrees)	±60	±60	±60	±60	N/A
1.11	Base station vertical coverage range (degrees) (Notes 3, 4, 7)	90 - 100	90 - 100	90 - 100	90 - 120	N/A
1.12	Mechanical downtilt (degrees) (Note 4)	3	6	6	10	N/A
1.13	Maximum base station output power/sector (e.i.r.p.) (dBm)	72.28	72.28	72.28	61.53	N/A

Note 1: The element gain in row 1.2 includes the loss given in row 1.8 and is per polarization. This means that this parameter in row 1.8 is not needed for the calculation of the BS composite antenna gain and e.i.r.p.

Note 2: For the small/micro cell case, 8 × 8 means there are 8 vertical and 8 horizontal radiating elements. For the extended AAS model case, 4 × 8 means there are 4 vertical and 8 horizontal radiating sub-arrays.

Note 3: The vertical coverage range is given in global coordinate system, i.e. 90° being at the horizon.

Note 4: The vertical coverage range in row 1.11 includes the mechanical downtilt given in row 1.12.

Note 5: The conducted power per element assumes 8 × 8 × 2 elements for the micro/small cell case, and 4 x 8 x 2 sub-arrays for the macro case (i.e. power per H/V polarized element).

Note 6: In sharing studies, the transmit power calculated using row 1.9 is applied to the typical channel bandwidth given in Table 5-1 and 6-1 respectively for the corresponding frequency bands.

Note 7: In sharing studies, the UEs that are below the base station vertical coverage range can be considered to be served by the 'lower' bound of the electrical beam, i.e. beam steered towards the max. coverage angle. A minimum BS-UE distance along the ground of 35m should be used for urban/suburban and rural macro environments, 5 m for micro/outdoor small cell, and 2 m for indoor small cell/urban scenarios.

3 IMT antenna pattern model

The following antenna pattern was extracted from Annex 3 of Annex 4.4 to the WP5D/716 chairman's report.

This Annex provides modelling information on extension of IMT array antenna model to support sub-array structures with fixed sub-array down-tilt. A sub-array is a radiating element constituted by multiple elements passively combined to a single RF transmission line using a common element excitation, which is connected to a single transceiver branch.

The intention with this AAS model extension is to provide a tool to better represent and adapt radiation pattern characteristics for base station with AAS sub-array antenna geometries commonly used for operating within 1710 to 4990 MHz.

For AAS antenna geometries with individual element excitation, the existing AAS model defined in ITU-R M.2101 and parameters provided previously do apply.

An extended version of the AAS array antenna model is created to support vertical sub-array geometries with fixed sub-array down-tilt. The model equations are summarized in below Table A.

TABLE A

Extended AAS model

Description	Equation
Peak normalized element radiation pattern	$A(\theta,\varphi) = -\min\left[-\left(-\min\left[12\left(\frac{\varphi}{\varphi_{3dB}}\right)^2, A_m\right] - \min\left[12\left(\frac{\theta-90}{\theta_{3dB}}\right)^2, SLA_v\right]\right), A_m\right]$
Peak gain normalized element radiation pattern	$A_E(\theta,\varphi) = G_{E,max} + A(\theta,\varphi)$
Sub-array excitation	$w_m = \frac{1}{\sqrt{M_{sub}}}\exp\left(j2\pi(m-1)\frac{d_{v,sub}}{\lambda}\sin(\theta_{subtilt})\right)$
Sub-array radiation pattern	$A_{sub}(\theta,\varphi) = A_E(\theta,\varphi) + 10\log_{10}\left(\left\lvert\sum_{m=1}^{M_{sub}} w_m v_m\right\rvert^2\right)$, where $v_m = \exp\left(j2\pi(m-1)\frac{d_{v,sub}}{\lambda}\cos(\theta)\right)$
Array excitation	$w_{m,n} = \frac{1}{\sqrt{MN}}\exp\left(j2\pi\left((m-1)\frac{d_v}{\lambda}\sin(\theta_{etilt}) - (n-1)\frac{d_h}{\lambda}\cos(\theta_{etilt})\sin(\varphi_{escan})\right)\right)$ Where *M* and *N* is corresponding to (Row × Column) in Table 9, row 1.6.
Composite array radiation pattern	$A_A(\theta,\varphi) = A_{sub}(\theta,\varphi) + 10\log_{10}\left(\left\lvert\sum_{m=1}^{M}\sum_{n=1}^{N} w_{m,n} v_{m,n}\right\rvert^2\right)$, where $v_{m,n} = \exp\left(j2\pi\left((m-1)\frac{d_v}{\lambda}\cos(\theta) + (n-1)\frac{d_h}{\lambda}\sin(\theta)\sin(\varphi)\right)\right)$ Where *M* and *N* is corresponding to (Row × Column) in Table 9, row 1.6.

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