



ECC Report **298**

Analysis of the suitability and update of the regulatory technical conditions for 5G MFCN and AAS operation in the 1920-1980 MHz and 2110-2170 MHz band

Approved 8 March 2019

0 EXECUTIVE SUMMARY

The development of this Report was triggered in March 2018 by the need to assess the technical conditions in ECC Decision (06)01 [1] to enable a timely introduction of 5G and AAS, while maintaining adequate protection of other services and applications and to adapt them accordingly. This ECC Report assessed the suitability for 5G of the harmonised technical conditions defined for the 1920-1980 MHz and 2110-2170 MHz frequency band in CEPT Report 39 [2] and adopted in the ECC Decision (06)01 amended in November 2012 ("ECC Decision (06)01 (rev. 2012)" hereafter).

The introduction of AAS systems will be only on the base station side as it is not foreseen for the UE side.

Two main areas were studied:

- Assessment of the suitability of existing band plan and BEM for 5G in the 1920-1980 MHz and 2110-2170 MHz frequency band;
- Coexistence with other services below 2110 MHz (space services in particular) and above 2170 MHz (MSS/CGC and space services);

The development of this Report followed the following steps:

- 1 Review of the regulatory framework, including existing band plan and BEM requirements, for 5G in the 1920-1980 MHz and 2110-2170 MHz frequency band. Section 2 "Existing Regulatory framework for MFCN systems".
- 2 Analysis of the existing BEM and identification of required amendments - Section 3 "Suitability of the current technical framework for 5G";
- 3 Assessment of the coexistence with other adjacent services to the 2110-2170 MHz band (including space services in 2200-2290 MHz) – Section 4 "Coexistence Studies";
- 4 Annex 1 "MFCN parameter values and assumptions for simulations" containing the assumptions and parameters that were agreed as basis for the coexistence studies;
- 5 Annex 2 "Considerations on changes to the necessity of guard bands in the 2 GHz MFCN bands", assessing the need for guard bands.

The Report concludes on the need to update regulatory framework to support the introduction of 5G in the 1920-1980 MHz and 2110-2170 MHz band.

CEPT concluded on an updated band plan for the 1920-1980 MHz and 2110-2170 MHz band and that it is up to each administration to decide, based on its requirements, and considering the impact on existing authorisations in its country within the band and services in adjacent bands, whether and how to migrate from the band plan in previous revisions of ECC Decision (06)01 to the new band plan and any associated conditions.

This analysis confirms that the current BEM remains applicable for non-AAS systems and the need for additional BEM for AAS systems. Identification of required amendments for the additional BEM for AAS MFCNs is given in Section 5 "Recommended Framework".

It is noted that the spurious domain for the base station in this frequency band starts 10 MHz from the band edge and that the corresponding limits are defined in ERC Recommendation 74-01 [3] (for the coexistence studies in this ECC Report the value of -30 dBm/MHz was used).

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LIST OF ABBREVIATIONS

| Abbreviation | Explanation |
|-----------------|--|
| 3GPP | 3rd Generation Partnership Project |
| AAS | Active Antenna System |
| ACLR | Adjacent Channel Leakage Ratio |
| BEM | Block Edge Mask |
| BS | Base Station |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CGC | Complementary Ground Component |
| DA2GC | Direct Air-to-Ground Communication |
| DL | Downlink |
| EAN | European Aviation Network |
| EC | European Commission |
| ECA | European Common Allocation |
| ECC | Electronic Communications Committee |
| EESS | Earth Exploration Satellite Services |
| e.i.r.p. | Equivalent Isotropically Radiated Power |
| E-UTRA | Evolved Universal Terrestrial Radio Access |
| FDD | Frequency Division Duplex |
| FS | Fixed Service |
| FRMCS | Future Railways Mobile Communication Systems |
| IMT | International Mobile Telecommunications |
| LTE | Long-Term Evolution |
| LRTC | Least Restrictive Technical Conditions |
| MFCN | Mobile/Fixed Communications Networks |
| MSS | Mobile Satellite Services |
| MES | Mobile Earth Station |
| MS | Mobile Service |
| MSR | Multi-Standard Radio |
| MSS | Mobile-Satellite Service |
| NLOS | Non Line of Sight |
| NR | New Radio |
| OOB | Out-of-Band |
| OOBE | Out-of-Band Emissions |

| | |
|-------------|--|
| OTA | Over-The-Air |
| RAN | Radio Access Network |
| SEM | Spectrum Emission Mask |
| SRS | Space Research Services |
| SOS | Space Operation Services |
| SUL | Supplemental Uplink |
| TRP | Total Radiated Power |
| TSG | Technical Specification Group |
| UAS | Unmanned Aircraft Systems |
| UE | User Equipment |
| UEM | Unwanted Emission Mask |
| UL | Uplink |
| UMTS | Universal Mobile Telecommunications System |

1 INTRODUCTION

This Report evaluates the suitability for 5G and AAS of the existing least restrictive technical conditions in the 1920-1980 MHz and 2110-2170 MHz band as defined in CEPT Report 39 [2] and implemented in ECC Decision (06)01 [1]. The analysis of this Report accounts for the introduction of 5G new radio (5G NR) as well as Active antenna systems (AAS) in this frequency band. Modifications to the existing least restrictive technical conditions are suggested as applicable.

The analysis assumes that the current technical conditions will also remain as part of the regulatory framework to ensure that current and future deployments of non-AAS MFCN will not be impacted.

Compatibility of AAS MFCN with other services in the adjacent bands to 2110-2170 MHz has been assessed by examining the difference in the antenna gains for non-AAS and AAS MFCN BS in different scenarios. Also, elements from the methodology used in previous CEPT Report 39 and ERC Report 65 [4] have been incorporated in the compatibility analysis. Based on the assessment, the Report identifies amendments to the existing least restrictive technical conditions in terms of updated BEM for AAS MFCN in the 2110-2170 MHz band.

2 EXISTING REGULATORY FRAMEWORK FOR MFCN SYSTEMS

2.1 EXISTING BAND PLAN

ECC Decision(06)01 [1] includes a harmonised spectrum scheme for MFCN including terrestrial IMT systems for the frequency band 1920-1980 MHz paired with 2110-2170 MHz for FDD operation. The duplex direction for FDD carriers in these bands is mobile transmit within the lower band and base station transmit within the upper band. The bands 1920-1980 MHz and 2110-2170 MHz are divided into twelve paired blocks and the minimum block size should be in the range 4.8 MHz to 5.0 MHz.

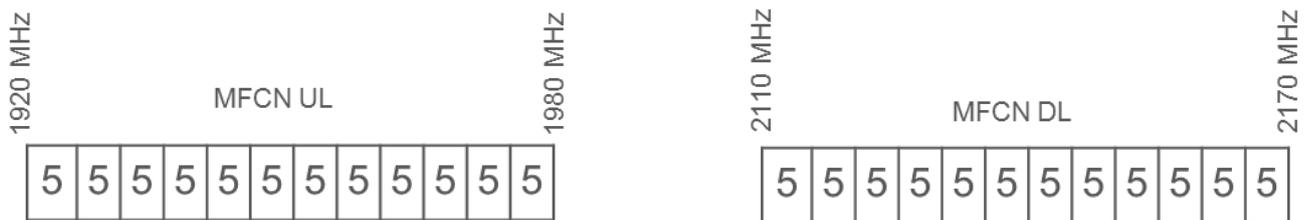


Figure 1: Existing Band Plan

Additionally in Annex 1 of ECC Decision (06)01 [1], the following conditions to ensure coexistence between MFCN systems and other applications operating in adjacent bands are given:

- The block edge nearest to 1920 MHz should start at 1920.3 MHz or above. Where necessary, this frequency can be lowered to 1920.0 MHz for consistency with conditions of some existing authorisations;
- The block edge nearest to 1980 MHz should end at 1979.7 MHz or below. Where necessary, this frequency can be raised to 1980.0 MHz for consistency with conditions of some existing authorisations;
- The block edge nearest to 2110 MHz should start at 2110.3 MHz or above. Where necessary, this frequency can be lowered to 2110.0 MHz for consistency with conditions of some existing authorisations;
- The block edge nearest to 2170 MHz should end at 2169.7 MHz or below. Where necessary, this frequency can be raised to 2170.0 MHz for consistency with conditions of some existing authorisations.

2.2 EXISTING TECHNICAL CONDITIONS – BEM REQUIREMENTS

The harmonised technical conditions are given in ECC Decision 06(01) [1] are in the form of Block Edge Masks (BEMs) based on CEPT Report 39 [2] and the compatibility studies in ERC Report 65 [4].

2.2.1 In-block limits for MFCN

An in-block limit for non-AAS base stations is not obligatory. An in-block e.i.r.p. limit for MFCN FDD BS is not necessary as long as the “BS FDD to BS TDD” scenario does not need to be addressed. However, administrations may choose to set an e.i.r.p. limit between 61 dBm/(5 MHz) and 65 dBm/(5 MHz) in the FDD downlink band if needed on a national or local basis. Furthermore, this limit can be increased for specific deployments, e.g. in areas of low population density provided that this does not significantly increase the risk of terminal station receiver blocking.

An in-block emission limit for terminal stations in the FDD uplink band is specified in Decision 2012/688/EU [6]. A maximum mean in-block power of 24 dBm e.i.r.p. for fixed or installed terminal stations and 24 dBm TRP for terminal stations designed to be mobile or nomadic. Member States may relax this limit for specific deployments, e.g. fixed terminal stations in rural areas provided that protection of other services, networks and applications is not compromised and cross-border obligations are fulfilled.

2.2.2 Out-of-block limits for MFCN BS in the 2110-2170 MHz frequency band

The BEM levels are built up by combining the values listed in Table 1 in such a way that the limit at any frequency is given by the highest (least stringent) value of a) the transition requirements, and b) the in-block requirements (where appropriate). The BEMs are applicable only to base stations within the sub-band 2110-2170 MHz. Notice that BEM values were derived for macro base stations only and might not be appropriate for all other classes of base stations.

Currently, the BEM levels for MFCN base station requirements are specified per antenna. Table 1 defines the out-of-block BEM requirements for FDD MFCN base stations within the spectrum licensed to operators of MFCN networks. The emission limits are all specified as e.i.r.p., and consist of two so-called "transitional region" limits and a baseline limit, which addresses the matter of base station to base station interference between FDD MFCNs. BEM values are based on 3GPP unwanted emission mask given in 3GPP TS 36.104 [7]. More specifically, the out-of-block emission limits within the FDD band has been derived by numerical integration of PSDs of the E-UTRA BS specified in 3GPP TS 36.104. It should be noted that these requirements have been derived from the characteristics of macro base stations, with the assumption of an in-block e.i.r.p. limit of 61 dBm/5 MHz and an antenna gain of 17 dBi.

Table 1: Transition requirements – BS BEM out-of-block e.i.r.p. limits per antenna¹

| Frequency range | Non AAS e.i.r.p. power limit per antenna | Measurement bandwidth |
|--|--|-----------------------|
| -5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge | 16.3 dBm | 5 MHz |
| -10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge | 11 dBm | 5 MHz |
| Other blocks | 9 dBm | 5 MHz |

¹ The BEM level for base stations is defined as per antenna. It is applicable to base station configurations with up to four antennas per sector

ECC Decision 06(01) [1] assumes, the compliance with the BEM is sufficient to ensure coexistence of FDD MFCN BSs. Table 2 describes the relationship between the baseline and transitional power limits defined in ECC Decision 06(01) and the 3GPP unwanted emission mask given in 3GPP TS 36.104.

Table 2: ECC limits and the 3GPP unwanted emission mask

| From TS 36.104 Rel.15 Table 6.6.3.2.2-1: Wide Area BS operating band unwanted emission mask (UEM) | | | | Comparison between 3GPP and ECC limits | | | |
|---|--------------------------------------|---------------------|---------------|---|------|----------------------------------|---------------------------------------|
| Frequency offset (MHz) | 3GPP unwanted emission mask | Average Tx power | Units | 3GPP: Tx Power (dBm/5 MHz) | | 3GPP: e.i.r.p. (dBm/5 MHz) | ECC e.i.r.p. limits (dBm/5 MHz) |
| 0 to 0.2 | -14 | -14.0 | dBm/30 kHz | 8.2 | -0.9 | 16.1 | 16.3 |
| 0.2 to 1 | -14 to -26 | -18.7 | dBm/30 kHz | 3.5 | | | |
| 1 to 5 | -13 | -13.0 | dBm/1 MHz | -6.0 | | | |
| 5 to 10 | -13 | -13.0 | dBm/1 MHz | -6.0 | -6.0 | 11 | 11 |
| 10 to 15 | -15 | -15.0 | dBm/1 MHz | -8.0 | -8.0 | 9 | 9 |

Notice that ECC Decision (06)01 (rev. 2012) [1] does not specify any out-of-band requirement for FDD MFCN. Additionally, ERC Recommendation 01-01 [5] may be considered as reference for cross-border coordination for MFCN in the frequency bands: 1920-1980 MHz and 2110-2170 MHz.

3 SUITABILITY OF THE CURRENT TECHNICAL FRAMEWORK FOR 5G

3.1 SUITABILITY FOR NON-AAS MFCN BASE STATIONS

The term non-AAS (short for non-active antenna systems) refers to MFCN base station (BS) transmitters which are manufactured and supplied separately from the antenna systems. For non-AAS MFCN BS, including 5G NR, the antenna connector would most likely be connected to a passive antenna array, meaning that the resulting antenna gain is fairly invariant (between different implementations and between wanted and unwanted signals). Given the passive nature of the antenna array, setting requirements for non-AAS MFCN BS in terms of e.i.r.p. is appropriate.

Non-AAS MFCN base stations comply with existing least restrictive technical conditions (LRTC) in least in ECC Decision (06)01 [1], given that those requirements were derived from the analysis of the sum of the radiated powers across multiple antenna connectors. Furthermore, non-AAS MFCN BS keeps the same unwanted emissions requirements as the ones given in 3GPP TS 36.104 which were used as basis for deriving existing limits in ECC Decision(06)01 (rev.2012).

Based on the need to avoid disrupting the usage rights that have been already assigned for non-AAS MFCN in the 1920-1980 MHz and 2110-2170 MHz range, it is proposed to maintain the existing out-of-block BEM e.i.r.p. limits as specified in ECC Decision (06)01 and reported in Section 3.

Recent measurements of the OoB emissions of some real UMTS/LTE base stations (non-AAS) show a margin of up to 30 dB compared to the 3GPP mask, which was used in ERC Report 65 (see Annex 2).

3.2 SUITABILITY FOR AAS MFCN

Active antenna systems (AAS) is one of the key features for 5G NR and LTE evolution products. According to Recommendation ITU-R M.2101 [8], an IMT system using an AAS will actively control all individual signals being fed to individual antenna elements in the antenna array in order to shape and direct the antenna emission diagram to a wanted shape, e.g. a narrow beam towards a user. An AAS MFCN BS continually adjusts the amplitude and/or phase between antenna elements resulting in an antenna pattern that varies in response to short-term changes in the radio environment. This is intended to exclude long-term beam shaping such as fixed electrical down tilt.

With the introduction of AAS MFCN BS, the antenna arrays are embedded in the base station without an accessible interface between AAS systems and base station. Contrary to the case of non-AAS MFCN BS, AAS MFCN BS does not have the possibility to install additional external filter between the base station antenna connector and the antenna. This implies that the regulatory BEM requirements must be met by product design, as it has been discussed in ECC Report 281 [9] and CEPT Report 67 [10]. Thus, ECC Report 281 concluded that the unwanted emissions are to be specified as over-the-air (OTA) requirements, rather than as conducted requirement. The OTA emission limits will be expressed in terms of Total Radiated Power (TRP¹) rather than e.i.r.p. This conclusion is in line with 3GPP approach described in 3GPP 37.840 [11] and ECC Report 281, which consider TRP as the most appropriate metric for specifying the ACLR and out-of-block emission limits in the context of interference between adjacent channel mobile networks.

Based on the above observations, suitable technical conditions (BEM in TRP) should be incorporated in the current ECC Decision (06)01 to account for the introduction of AAS MFCN base stations.

¹ TRP is defined as the integral of the power radiated by an antenna array system in different directions over the entire radiation sphere.

3.3 SUITABILITY FOR NR SUPPLEMENTAL UPLINK MODE OF OPERATION

5G NR systems in the 1920-1980 MHz frequency band may operate in Supplemental uplink (SUL) mode, (i.e. 5G NR Uplink operation without a paired downlink 5G NR channel in the 2110-2170 MHz frequency band). This corresponds to 3GPP NR band n84.

The 5G NR UE technical characteristics for SUL mode of operation as specified in 3GPP TS 38.101-1 [12] are aligned with those of a 5G NR FDD UE. In particular, the UE maximum output power (i.e. 23 dBm), the supported channel bandwidths (range from 5 to 20 MHz) and the unwanted emissions limits for SUL (1920-1980 MHz) are all the same as per the non-AAS MFCN UE in FDD operation mode (1920-1980 MHz paired with 2110-2170 MHz).

Therefore, sharing conditions between MFCN UL and adjacent services remains the same whether the SUL mode of operation or the FDD MFCN operation is used. Therefore, the current harmonised framework in the 1920-1980 MHz and 2110-2170 MHz frequency band is considered suitable for NR SUL mode of operation. This of course accounts for the fact that AAS is not considered at the UE side.

4 COEXISTENCE STUDIES

4.1 BAND ALLOCATIONS

Figure 2 shows the services adjacent to the paired frequency band 1920-1980 MHz and 2110-2170 MHz. Notice that the frequency range 1900-1920 MHz was allocated to Direct Air-to-Ground Communication (DA2GC) according to ECC Decision (15)02 [13] in 2015; however, ECC Decision (18)01 [14] approved the withdrawal of ECC Decision (15)02 in July 2018. At the moment, Future Railway Mobile Communication System (FRMCS) is a candidate service to be allocated in 1900-1920 MHz and compatibility studies to ensure protection of MFCN and other adjacent services are ongoing. The introduction of AAS systems will be only on the base station side as it is not foreseen for the UE side.

Note that 5G NR systems in frequency bands 1920-1980 MHz may operate in Supplemental uplink mode (SUL) and that the UE technical characteristics relevant to compatibility studies in this case are aligned as per non-AAS MFCN FDD operation. Thus, sharing conditions between MFCN UL and adjacent services are expected to be kept the same.

The following section focuses in the in-band and adjacent-band coexistence of MFCN DL band.

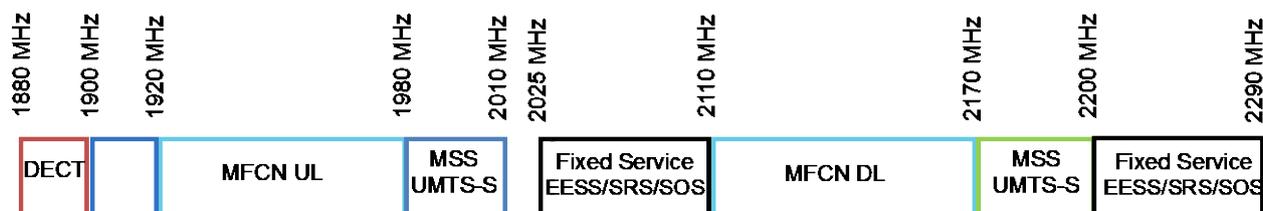


Figure 2: Band allocations for the 2 GHz band

4.2 IN-BAND COEXISTENCE

As assessed in ECC Report 281 [11], the impact of AAS network to a legacy (non-AAS) victim network was studied, by using simulations for the specific class of antenna arrays with specific elements spacing. Results showed that the impact in terms of throughput degradation of the unwanted emissions on the adjacent mobile systems (i.e. inter-MFCN interference) depends on the total amount of interference which is injected into the network. Such studies considered the impact of the different correlation factors and down-tilt values for the AAS network. The studies confirmed that coexistence between AAS and non-AAS networks is feasible.

4.3 ADJACENT BANDS COEXISTENCE

4.3.1 Introduction

The review of technical conditions to enable timely introduction of 5G and, when applicable, AAS, needs to ensure adequate protection of other services and applications.

Compatibility studies are therefore necessary to ensure that AAS systems will not modify the current coexistence conditions with services and applications operating in adjacent frequency bands to the MFCN BS (2110-2170 MHz). The introduction of AAS systems is not foreseen on the UE side. The UE unwanted emissions remain unchanged whether AAS at BS is used or not. Furthermore, the AAS BS receiver is not expected to be more sensitive compared to non-AAS BS receiver, therefore AAS BS will not claim more protection than non-AAS BS.

CEPT Report 39 provides the analysis for deriving the technical conditions and requirements based on the compatibility studies conducted in ERC Report 65 [4]. As seen in Figure 2, the allocated services in the 2 GHz frequency band are Fixed Service (2025-2110 MHz), EESS/SRS/SOS services (2025-2110 MHz (Earth-to-space/space-to-space) and above 2200 MHz(space-to-Earth/space-to-space)), MSS (2170-2200 MHz). The system parameters and the sharing criteria previously used for adjacent compatibility studies between IMT and EESS/SRS/SOS services can be seen from ERC Report 065, more specifically in Annex A, B and D. The relevant parts of the ERC Report 065 summary are reproduced in Table 1.

Table 1: Summary of the carrier separations, based on ERC Report 065 (Table 13)

| Adjacent services | Minimum carrier separation | Calculated Extreme position of the UMTS carrier centre | “Additional” guard band (3) |
|--|----------------------------|--|-----------------------------|
| 2110 MHz EESS/SRS/SOS UMTS (FDD) (section 3.3.2 of ERC Report 065) | 3.0-3.3 MHz (1) | 2112.8 MHz | 0.3 MHz |
| 2110 MHz FS (2) UMTS(FDD) (see section 34 of ERC Report 065) | 8.3 MHz | 2112.8 MHz | - |
| 2170 MHz MSS (s-E) UMTS (FDD) (see section 3.2.3.1 of ERC Report 065) | <3.5 MHz (4) | 2167.2 MHz | 0.9 MHz |

(1) These carrier separations would be required for compliance with Recommendation ITU-R SA.1154. In view of the specific use of the border regions by the space science services, a separation of 2.8 MHz appears to be sufficient.

(2) This separation distance can be implemented by not utilising either the 3 outermost FS channels (1.75 MHz channel spacing) or the outermost FS channel (3.5 and 7 MHz channel spacing) in the upper part of 2025-2110 MHz (ERC Recommendation T/R 13-01). For the lower part of 2025-2110 MHz all 7 MHz channels can be used. At both edges all FS channels with 14 MHz channel spacing can be utilised. It is further recommended to use the 2020-2025 MHz and 2110-2115 MHz UMTS channel preferably in micro and pico-cells.

(3) This is the difference between the calculated and nominal extreme UMTS carrier position. The nominal extreme UMTS carrier position is taken to be 2.5 MHz from the UMTS band edge.

(4) This value is applicable for the sub-urban environment for 10% probability and 0.5 dB loss in MSS fade margin. A smaller carrier separation would impact to the ability to operate MSS on the affected channels due to degradation in the fade margin (see section 3.2.3.3 of ERC Report 065). For the rural environment the required spacing is less.

The following cases are considered:

- EESS/SRS/SOS satellite receivers in the frequency band 2025-2110 MHz;
- EESS/SRS/SOS receiving earth stations in the frequency band 2200-2290 MHz;
- MSS receiving earth stations and CGC receiver terminals in the frequency band 2170-2200 MHz.

It should finally be noted that the possible use of UAS in MFCN networks in these bands could also have an impact on the coexistence with existing services and applications. This case is not the scope of this Report, and it is studied in a separate ECC Report.

The deployment parameters for non-AAS and AAS MFCN used in compatibility analysis can be found in Annex 1.

4.3.2 MSS

ECC Decision (06)09 (rev. 2007) [15] designates the frequency bands 1980-2010 MHz (Earth-to-space) and 2170-2200 MHz (space-to-Earth) for use by systems in the Mobile-Satellite Service (MSS) including those

supplemented by a Complementary Ground Component (CGC). This Decision followed a number of ECC studies, particularly CEPT Report 13 [16] that was developed in response to a mandate from the European Commission. It should be noted that the provisions (Decides-5) of ECC Decision (06)09 requires "that mobile satellite systems operating in accordance with this Decision shall ensure compatibility with terrestrial systems operating in the mobile service in the adjacent bands below 1980 MHz and between 2010-2170 MHz". Notice that WRC-92 identified the frequency bands 1885-2025 MHz and 2110-2200 MHz for IMT-2000, including 1980-2010 MHz (Earth-to-space) and 2170-2200 MHz (space-to-Earth) for the satellite component of IMT-2000. It should be noted that the lower part of the bands 1980-2010 MHz and 2170-2200 MHz are used throughout Europe for Inmarsat's European Aviation Network (EAN) which is already operational. The EAN operational system deploys the use of CGC terminals and MESSs on aircraft.

Furthermore, the technical and operational characteristics of CGC operating as part of a satellite network in frequency bands 2170-2200 MHz (space-to-Earth) and 1980-2010 MHz (Earth-to-space) are specified in the ETSI Harmonised European Standard EN 302 574-1 [17].

4.3.2.1 Compatibility with MSS MES at 2170 MHz

In the comparison between the current interference situation with non-AAS systems and the future situation where a mixed deployment of AAS and non-AAS system will be introduced, the initial focus is on the difference in antenna gain of AAS 5G BS and non-AAS BS. The focus is on the urban case as ERC Report 65 [4] found this scenario as the most challenging, i.e. higher probability of exceeding the interference threshold at MSS MES receivers. The following plot shows the difference in antenna gain from a random MSS MES location at 1.5 m height for two antenna types:

- Non-AAS antenna: Recommendation ITU-R F.1336-4 [18] (one antenna considered);
- AAS antenna: Recommendation ITU-R M.2101 - 8x8 elements (fully correlated).

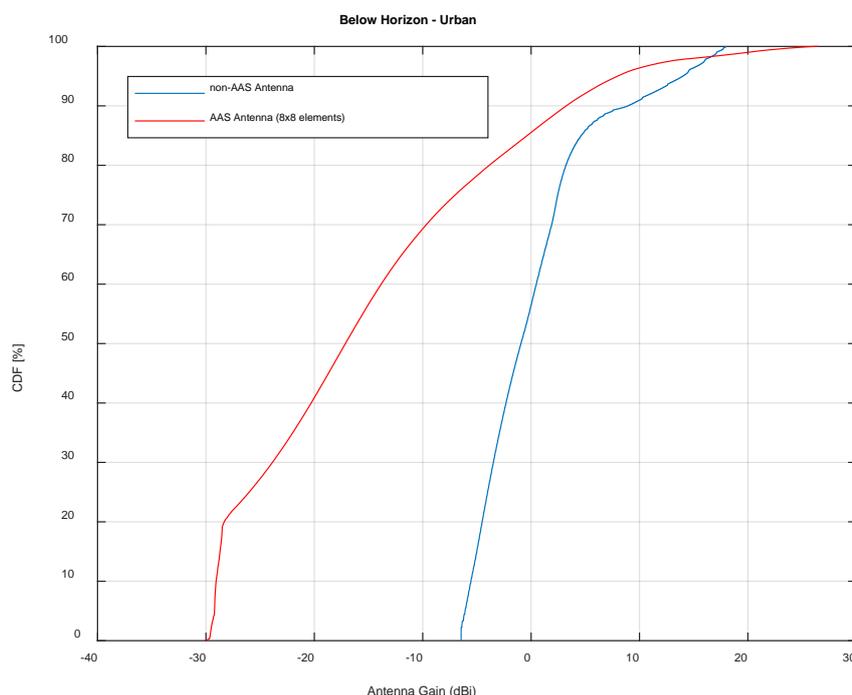


Figure 3: Comparison between antenna gain for AAS and non-AAS system below the horizon in urban scenarios (red curve - AAS antenna 8x8 elements and blue curve – single non-AAS antenna)

Figure 3 shows the comparison between the antenna gain for AAS and non-AAS systems for a random location of a MES within a sector of 120 degrees and 300 m radius. Results of antenna gain analysis indicate that impact of introducing AAS systems is 1.7% probability of more interference compared to the existing condition.

Similar analysis as shown in Figure 3 was also done for the OOB by taking into account that for non-AAS the OOB is defined per antenna in e.i.r.p. and that the maximum number of antennas allowed are 4 per BS per sector (see ECC Decision (06)01 [1]), and taking into account the 9 dB scaling factor that will be applied for the OOB for AAS which is defined per sector in TRP (see Annex 3).

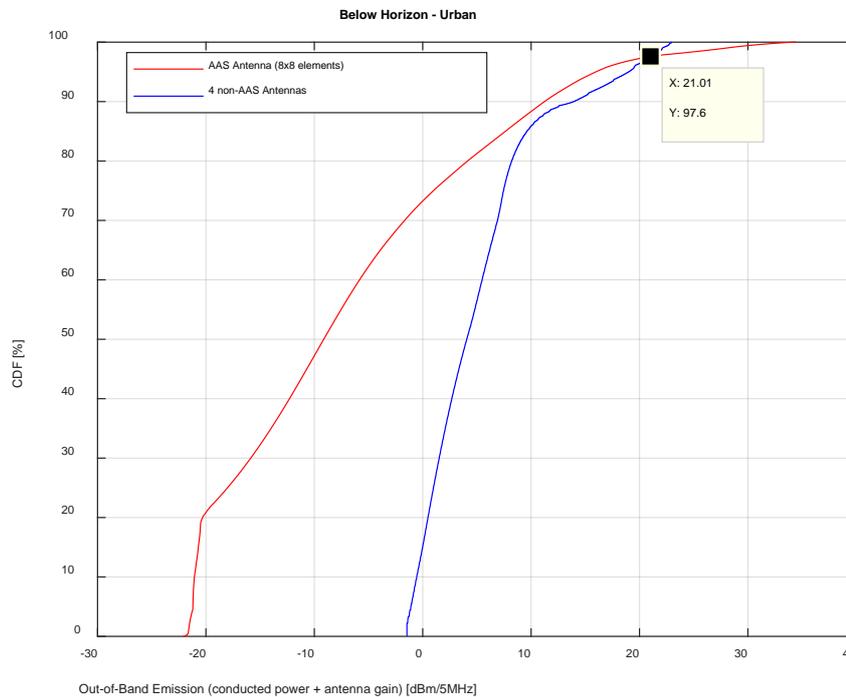


Figure 4: Comparison between OOB for AAS (8x8) and non-AAS (4 antenna) system in urban scenarios (red curve - AAS antenna 8x8 elements and blue curve – 4 non-AAS antenna)

Results of total OOB analysis indicate that impact of introducing AAS systems results in 2.4% probability of more interference compared to the existing condition, while for 97.6% of locations, the interference conditions are more favourable compared to the existing interference conditions which are considered acceptable. Thus, with the assumption described above and assuming that non-AAS BS ACLR being equal to AAS BS ACLR, it can be concluded that the compatibility between AAS BS and MSS MES at 2170 MHz is achieved and no further studies are needed.

4.3.2.2 Compatibility with MSS CGC receivers at 2170 MHz

The impact of the introduction of AAS BS in the compatibility between IMT and MSS CGC receivers on aeroplanes was examined: For this scenario two cases were considered, when the aircraft is in flight mode at 1000 metres height and when the aircraft is on the ground. For the second case (aircraft on the ground), this is covered by the study of interference into MES above. For the in-flight case analysis, the focus was on the difference in antenna gain for the BS elevation angles within a radius of 10 km radius around the CGC receivers at 1000 metres height for two antenna types:

- Non-AAS antenna: Recommendation ITU-R F.1336-4 [18] (one antenna considered);
- AAS antenna: 8x8 elements (fully correlated).

Given the similarities with scenario described in Section 4.3.4 where compatibility with EESS/SRS/SOS (2025–2110 MHz) is analysed, the same methodology for modelling the AAS system behaviour was adopted. That means that statistics over 1000 snapshots were taken where a single user is randomly deployed within the cell radius (urban) and the AAS antenna is steered in elevation and azimuth towards the user. The average antenna gain across all azimuth angles (within a 120 degree sector) for each elevation angle (in the range 5 to 90 degrees) was taken, in line with the approach used in ERC Report 065 [4].

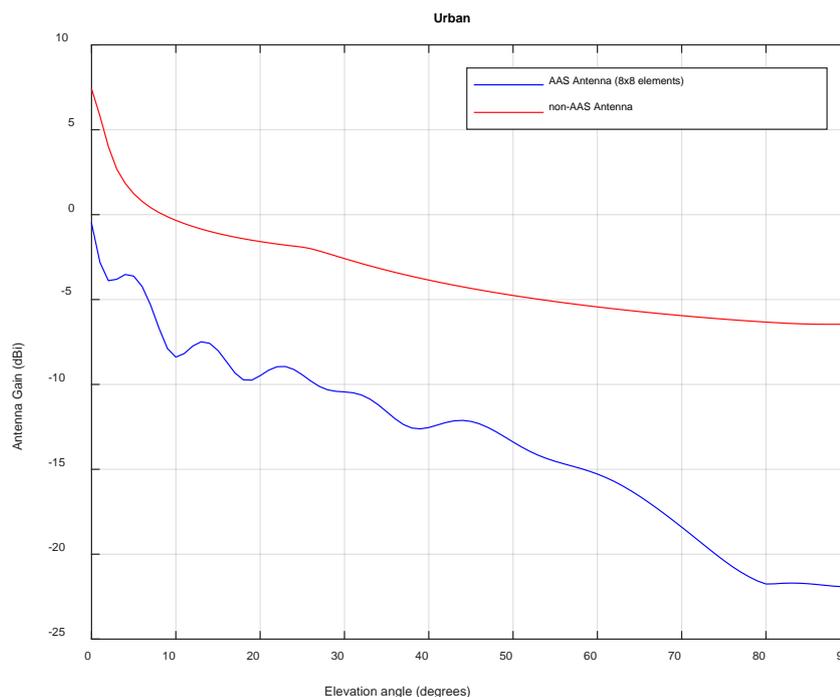


Figure 5: Antenna gains for different elevation angles above the horizon for a cell radius of 300m with the non AAS antenna mechanically downtilted 5 degrees and AAS antenna mechanically downtilted 10 degrees.

From Figure 5, it was observed that the average antenna gain for AAS is always lower than the antenna gains for non-AAS case, the differences range between 5 dB to 15 dB depending on the elevation angle with respect to the CGC receiver. Furthermore, it is worth noticing that the values for non-AAS antenna correspond to a single antenna and, according to current ECC Decision (06)01 [1], BS can have up to 4 non-AAS antennas. Considering the results in Figure 4 and the similarities with scenario described in Section 4.3.4, it can be concluded that the impact of the introduction of AAS BS, with proposed out-of-band limits and with the assumptions outlined above, will not worsen current situation in the compatibility between IMT and MSS CGC receivers at 2170 MHz and no further studies are needed. Only the urban case was studied as ERC Report 065 concluded this was the worst case.

4.3.3 Fixed Service

ERC Recommendation T/R 13-01 [19] and Recommendation ITU-R F.1098 [20] specify channel arrangements for the Fixed Service which should be used for new 2 GHz fixed service networks in order to avoid overlap with the 2 GHz MSS allocations and ensure coexistence with Mobile Services. According to ERC Report 65 [4], a separation distance of 2 km and a carrier separation of 8.3 MHz is required between FS and MS BS operating in adjacent bands. Therefore, a careful deployment and coordination between MS and FS with channel spacing below 14 MHz is needed. Such coordination mechanisms were considered feasible given that fixed services in the 2 GHz band, due to the propagation conditions, mainly will operate in rural areas where long distance links are necessary.

ECC Report 173 [21] on the "Fixed Service in Europe: Current use and future trends post 2016" (updated April 2018) indicates that only 4 administrations use the 2 GHz band with limited density. Furthermore, about 9200 point to point links and about 4100 central stations have been indicated in operation among the four subranges in the 2 GHz band for FS. Notice that a great majority of applications is in one single country (Russia), in the subrange 2400-2483.5 MHz. For other countries addressed in previous questionnaire, the use is reduced (about 300 FS links and no central station). All this information indicates that a much reduced number of FS links is currently deployed in the range 2025-2110 MHz and in just a few CEPT countries. Therefore, coexistence between FS in the band 2025-2110 MHz and MFCN (including AAS systems) in the 2110-2170 MHz can be addressed at national level.

4.3.4 Space Services

Recommendation ITU-R SA.1154 [22] provides a compatibility study of space services and high-density land mobile systems sharing the 2025-2110 MHz and 2200-2290 MHz bands. The conclusion of that study is that high density mobile systems should not be introduced in those bands. Thus, these bands cannot be identified as potential IMT bands. ERC Report 65 [4] provides adjacent channel compatibility studies between MFCN systems in the band 2110-2170 MHz and space services in the band 2025-2110 MHz. The conclusion of the study is that a carrier separation of 2.8 MHz is sufficient to protect narrow band receptions of the few systems (Earth-to-space links) operating near to 2110 MHz.

CEPT administrations developed common guidelines with respect to the compatibility between CGC operating in the band 2170-2200 MHz and EESS/SRS/SOS Earth stations operating in the frequency band 2200-2290 MHz given in ECC Recommendation (10)01 (rev.2010) [23]. It should be noted that the provisions (Considering-e)) of ECC Recommendation (10)01 considers “that compatibility between CGC base stations operating in the band 2170-2200 MHz and earth stations in the Earth Exploration Satellite Service, Space Research Service or Space Operation Service in the adjacent band 2200-2290 MHz, can be achieved through a coordinated process between affected operators and administrations”. Annex 2 to the ECC Recommendation (10)01 [23] lists the EESS/SRS/SOS Earth stations deployed in CEPT countries. The introduction of AAS systems in the 2110-2170 MHz frequency band does not affect the provisions given in ECC Recommendation 10(01) and the fact that coexistence with EESS/SRS/SOS Earth stations operating in the band 2200-2290 MHz is addressed at national level.

4.3.4.1 Compatibility with EESS/SRS/SOS (2025-2110°MHz)

Previous work in ERC Report 65 (Section 3.3.2) [4] calculated the aggregate interference to the space service satellite receiver from all visible UMTS base stations. The parameters assumed in ERC Report 65 as well as proposed required attenuation to meet the protection criteria given in Recommendation ITU-R S.1154 [22] are shown in Table 3.

Table 3: Interference scenario around 2110 MHz (From ERC Report 65 [4])

| Parameters | Values |
|--|---|
| Spacecraft height | 250 km (worst case) |
| Average transmission loss (average BS antenna gain in the satellite direction and free-space path loss from visible cells) | 154.2 dB |
| Polarisation loss | 2 dB |
| Maximum received interference at the spacecraft (note 1) | -217 dBW/Hz See Recommendation ITU-R SA.1154 [22] space-to-space case (worst case) |
| Average cell radius | 6.8 km |
| Visible earth | 9689313 km ² |
| Number of simultaneous transmitters | 66700 |
| BS power per channel | 41 dBm |
| Power control / remote areas | 6 dB |
| Channel bandwidth | 3.84 MHz (final results based on 5 MHz) |
| Down-tilt | 2.5 |
| Antenna height | 30 m |
| Antenna pattern | Recommendation ITU-R F.1336-4 [18] |

| Parameters | Values |
|---|--------------|
| Design Margin | 3 dB |
| Required attenuation | 43 dB |
| <i>Note 1: A For Earth-to-space links, the protection criterion is 4dB less stringent (-213 dBW/Hz)</i> | |

Interference Calculation Methodology

Similar methodology and parameters assumed in ERC Report 65 was followed for the comparison of Case 1 non-AAS system and Case 2 AAS system. The parameters to be used in the analysis are shown in Table 3 and Table 4. Furthermore, the interference calculation methodology follows ERC Report 65 Annex B where the centre of the terrestrial IMT cells are modelled as lying on concentric rings centred on the satellite point. This assumption simplifies the interference calculations since the elevation angle θ , the slant range and the free-space path loss to the satellite are constant for each ring of cells.

It should be noted that considering the size of the satellite footprint, free-space path loss is a conservative assumption for the rings closer to edge of the satellite footprint which are more likely to be in NLOS conditions due to the earth curvature. Also, for simplicity no-coverage areas such as seas, forest, etc. were disregarded. For modelling the AAS system behaviour, statistics over 1000 snapshots were taken where a single user is randomly deployed following a polar uniform distribution within the cell radius (urban and rural) and the AAS antenna beam is steered in elevation and azimuth towards the user position.

The average antenna gain across all azimuth angles for each elevation angle above the horizon was taken. Aggregated interference at the spacecraft is calculated by the following equation:

$$I_{agg}^{MFCN} (dBm/MHz) = \sum_N BS_{power} + G(\theta) - PL(d) - L$$

Where:

- N is the number of base station within the satellite footprint;
- PL (d) is the free-space path loss corresponding to the slant distance between BS and spacecraft;
- G(θ) is the antenna gain in the direction of the spacecraft and L the account for all other losses according to Table 3.

Finally, the required attenuation to meet the satellite protection criteria is calculated as follows:

$$Attenuation\ Needed\ (dB) = I_{max}^{sat} - I_{agg}^{MFCN}$$

Table 4 shows deployment parameters for non-AAS and AAS cases used in the compatibility analysis with EESS/SRS/SOS at 2110 MHz. It should be noted that the same losses and output power have been assumed in order to isolate the impact of the antenna behaviour in total aggregated interference at the spacecraft receiver.

Table 4: Deployment parameters

| Parameter | Case 1: Non-AAS | Case 2: AAS |
|---|---|---|
| Spacecraft height (km) | 250 km (worst case) | 250 km (worst case) |
| Maximum received interference at the spacecraft | -217 dBW/Hz See Recommendation ITU-R SA.1154 [22] space-to-space case (worst case) | -217 dBW/Hz See Recommendation ITU-R SA.1154 [22] space-to-space case (worst case) |

| | | |
|--|--|--|
| Visible earth (km ²) | 9689313 | 9689313 |
| Number of simultaneous transmitters | ~70000 | ~70000 |
| Power control/remote areas (dB) | 6 | 6 |
| Simulation grid distance (km) (Note 1) | 6 | 6 |
| Antenna height (m) | 30 | 30 |
| Downtilt (degrees) | 2.5 and 5 | 10 |
| Cell radius of service area (for user distribution) (m) | N/A | 300 (urban) 1500 (sub-urban/rural) |
| Antenna characteristics | Recommendation ITU-R F.1336-4 recommends 3.1 Maximum antenna gain of 18 dBi 3 dB beamwidth of 65 degrees | See Annex 1 |
| Losses (dB) | Polarisation loss: 2 dB Design margin: 3 dB | Polarisation loss: 2 dB Design margin: 3 dB |
| Output power | 41 dBm | 41 dBm |
| Channel bandwidth | 5 MHz | 5 MHz |
| Note 1: Simulation grid distance describes the distance between base stations in a grid to cover the satellite footprint. See ERC Report 065 [4] | | |

In ECC Decision 06(01), the BEM level for non-AAS base stations is defined as per antenna and it is applicable to base station configurations with up to four antennas per sector. Thus, the difference in required attenuation to protect the spacecraft based on the configuration of four non-AAS antennas and AAS antenna with 8TRx (64 beamforming elements) was compared, as shown in Table 5.

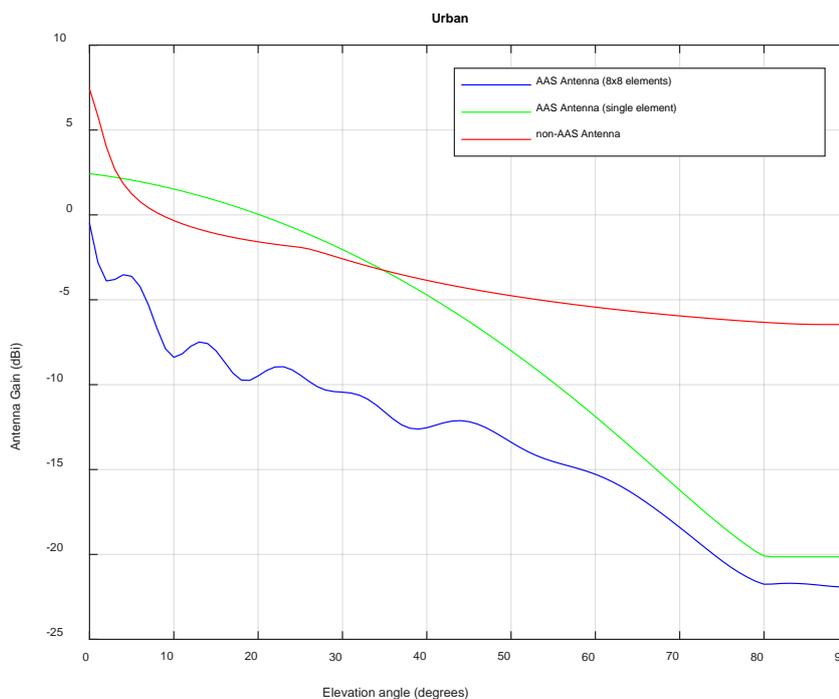


Figure 6: Antenna gains for different elevation angles above the horizon with a mechanical downtilt of 5 degrees for non-AAS and 10 degrees for AAS

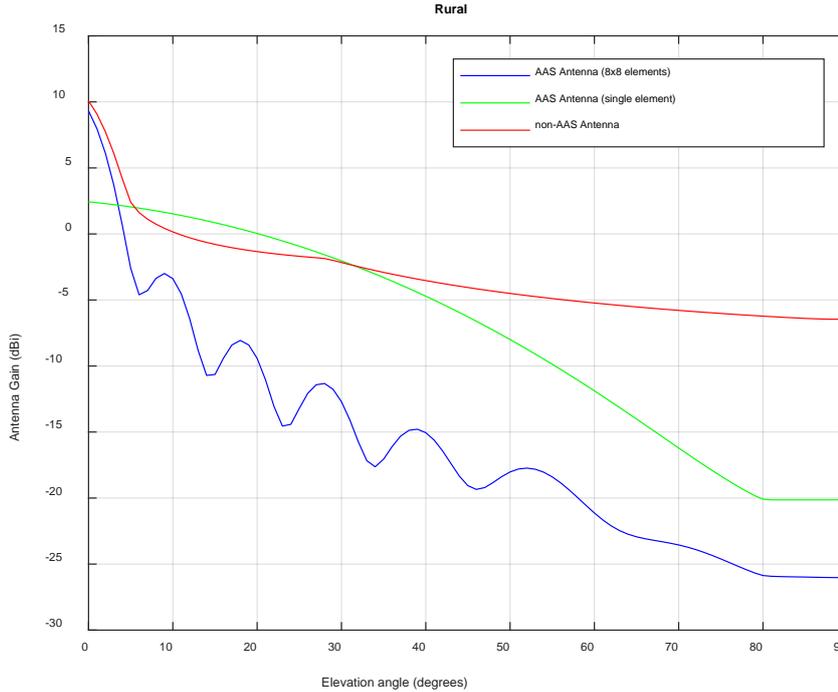


Figure 7: Antenna gains for different elevation angles above the horizon with a mechanical downtilt of 2.5 degrees for non-AAS and 10 degrees for AAS

Table 5: Required attenuation comparison between non-AAS and AAS case

| | Non-AAS Case | | AAS Case | Difference between non-AAS and AAS |
|--------------------------------------|---------------------------|-----------------------|-------------------------|------------------------------------|
| | Single Antenna per sector | 4 Antennas per sector | 8x8 Antennas per sector | |
| Downtilt 2.5 degrees non-AAS (rural) | 42.2 dB | 48.2 dB | 38.9 dB (correlated) | 9.3 dB |
| | | | 40.3 dB (uncorrelated) | 7.9 dB |
| Downtilt 5 degrees non-AAS (urban) | 40.2 dB | 46.2 dB | 33 dB (correlated) | 13.2 dB |
| | | | 40.3 dB (uncorrelated) | 5.9 dB |

Conclusion

Based on the results shown in Table 5, it can be concluded that the introduction of AAS will not worsen the interference situation with the adjacent service EESS/SRS/SOS (2025-2110°MHz), even if considering conservative assumptions in the deployment of the MFCN network within the satellite footprint following previous work in ERC Report 65 [4].

Furthermore, Table 5 shows the difference between non-AAS and AAS for correlated and non-correlated case. Given the small out-of-band region of 10MHz, it is considered that correlated assumption should hold. Under this assumption, it is found that the difference between non-AAS (4 antennas) and AAS case would be in the range of 9.3 and 13.2 dB. The latter value should be more representative given that majority of

base stations will be located in urban locations. Thus, out-of-band emissions from AAS systems will still meet the interference levels required to protect the EESS/SRS/SOS at 2110 MHz.

4.3.4.2 Compatibility with EESS/SRS/SOS at 2200 MHz

CEPT Report 39 [2] and ERC Report 65 [4] do not include compatibility studies between MFCN and EESS/SRS/SOS at 2200 MHz as these two services are not adjacent. EESS/SRS/SOS allocated at 2200°MHz falls within the spurious emission domain which starts 10°MHz from the band edge, i.e. 2180 MHz. The limits for spurious emissions are defined in ERC Recommendation 74-01 (for the coexistence studies in this ECC Report the value of -30 dBm/MHz was used) [3]². Also, it is worthwhile noticing that compatibility between CGC base stations operating in the band 2170-2200 MHz and earth stations in the EESS/SRS/SOS in the adjacent band 2200-2290 MHz is achieved through a coordinated process between affected operators and administrations, following the ECC Recommendation 10(01) [23].

In the comparison between the current interference situation with non-AAS systems and the future situation where a mixed deployment of AAS and non-AAS system will be introduced, the only difference will be the antenna gain for these two systems. The following plot shows the difference in antenna gain (at the boresight direction) for three cases:

- Single Non-AAS antenna: Recommendation ITU-R F.1336-4 [18];
- AAS antenna: 8x8 elements (fully correlated);
- AAS antenna: 8x8 elements (uncorrelated).

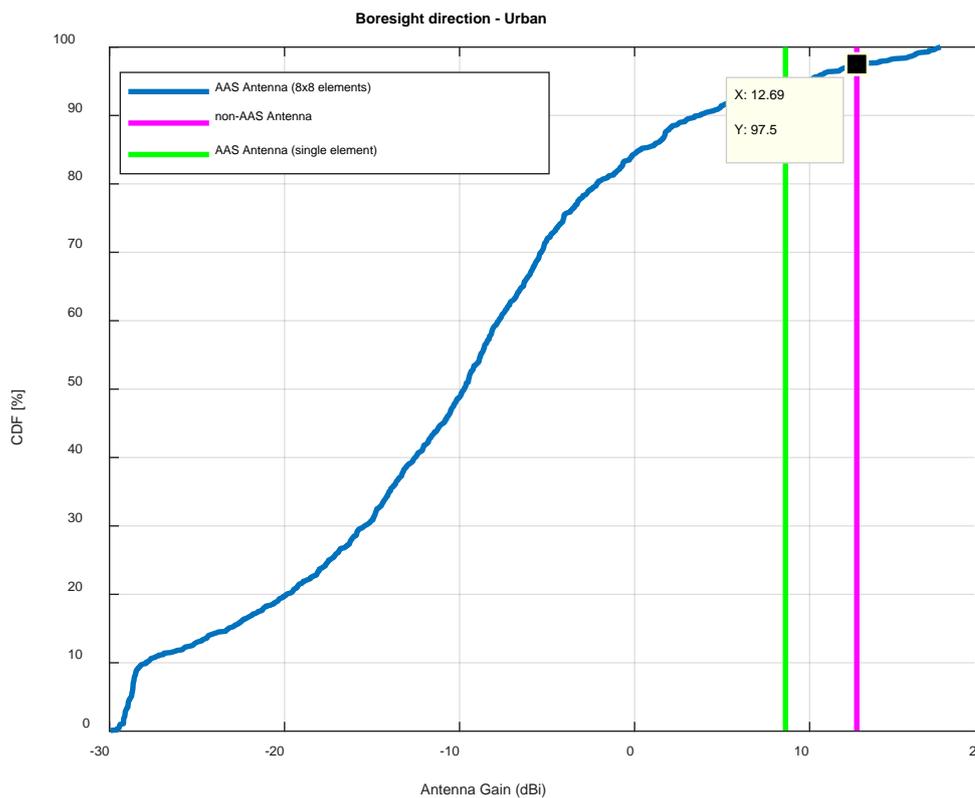


Figure 8: Comparison between antenna gain for AAS and non-AAS system in urban scenarios

Figure 8 shows the comparison between the three different cases in an urban scenario. It was noticed that the gain from the AAS antenna (correlated) exceeds the 2.5% of time; the maximum gain from single non-AAS antenna. Assuming that BS may have up to 4 non-AAS antennas, the maximum gain from the AAS

² It should be noted that at the moment of drafting this ECC Report, ERC Recommendation 74-01 was undergoing a revision of the spurious emissions limits for AAS systems.

antenna (correlated) will never exceed the combined gain from 4 non-AAS antennas. It was also noticed that the maximum gain from AAS antenna (non-correlated) is always lower than the gain for single non-AAS antenna.

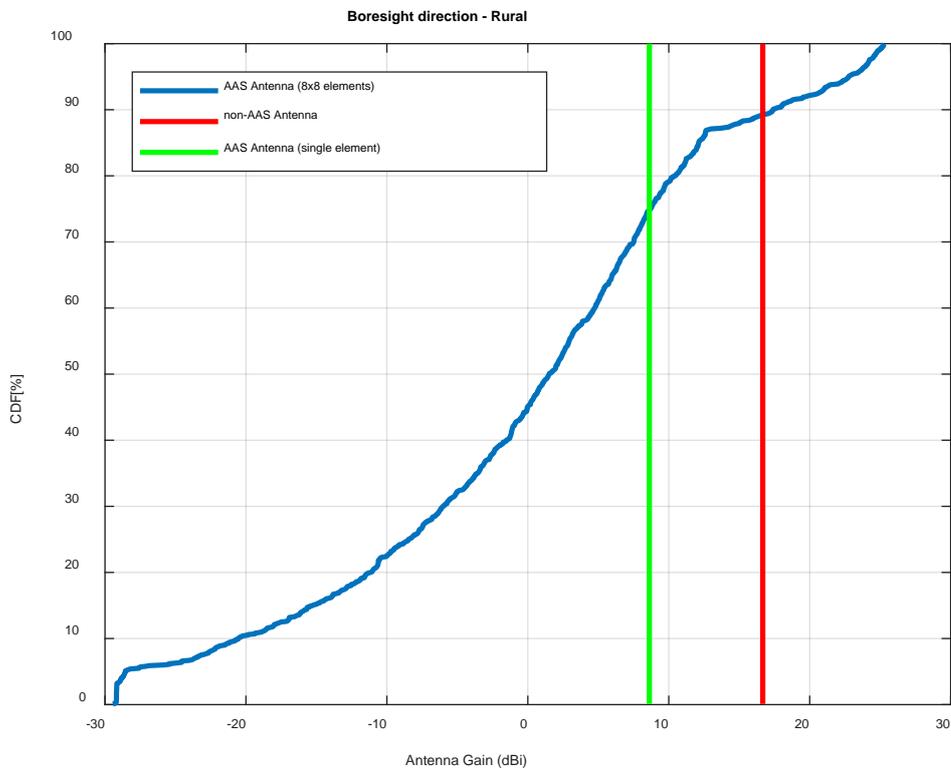


Figure 9: Comparison between antenna gain for AAS and non-AAS system in rural scenarios

Figure 9 shows the comparison between the three different cases in a rural scenario. It was noticed that the maximum gain from AAS antenna (non-correlated) is always lower than the gain for single non-AAS antenna. It was also noticed that the gain from the AAS antenna (correlated) exceeds the 11% of time the maximum gain from single non-AAS antenna. Assuming that BS may have up to 4 non-AAS antennas, the maximum gain from the AAS antenna (correlated) will be higher than the combined gain from 4 non-AAS antennas for 5% of the time. Table 6 shows the impact of AAS in the required separation distances to ensure protection of the EESS earth stations at 2200 MHz. Results show that the separation distances for the non-AAS cases with single and four antennas increases by a factor of 2.5 and 1.15, respectively, with the introduction of AAS considering the worst case of correlated case. The separation distance for AAS case would be in reality somewhere in between the values calculated for the correlated and those for the non-correlated case. Notice that results in Table 6 consider a protection criterion of -216 dBW/Hz for earth stations, 5-degree elevation angle and antenna pattern according to Recommendation ITU-R SA.1154 [22].

Table 6: Comparison between non-AAS and AAS case in terms of the required separation distances between MFCN and EESS earth stations (in km)

| | | Non-AAS (Single Tx) | Non-AAS (Four Tx) | AAS (non- correlated) | AAS (correlated) |
|---|--|------------------------|----------------------|--------------------------|---------------------|
| EESS ES Main Beam (P.452, [25], p=50%) | urban scenario (5-degree downtilt) | 7.8 | 15.5 | 6.9 | 18 |
| | rural scenario (2.5-degree downtilt) | 12.1 | 23.1 | 6.1 | 27.3 |
| EESS ES Main beam (P.452 [25], p=5%) | urban scenario (5-degree downtilt) | 9.3 | 19.7 | 8.1 | 22.4 |
| | rural scenario (2.5-degree downtilt) | 15.3 | 29.3 | 8.1 | 38.1 |

An alternative study has been provided using a different approach for the calculation of the separation distances between MFCN BS and EESS earth stations. The methodology follows the recommendation developed for coordination zones between IMT-2020 and EESS and SRS at 26 GHz (Annex 2) and is a time variable gain (TVG) methodology as per RR Appendix 7 [24] whereby the distribution of propagation loss and antenna gain are convoluted to get the distribution of interference. In the case of AAS systems, two parameters are varying with time: The propagation loss and the MFCN antenna gain towards the EESS earth station. The interference distribution will be a convolution between those 2 parameters and hence the percentage of time in the propagation model varies. In the case of non-AAS system, the MFCN antenna is fixed in boresight direction (worst case) and hence the only variable is the propagation loss. Hence, the percentage of time taken in the propagation model is the same as in the protection criterion.

Recommendation ITU-R P.452-16 [25] has been used for the propagation model, assuming a flat terrain. The reference location taken is Kiruna in Sweden.

The EESS ES has a maximum gain of 50 dBi and is pointing at an elevation angle of 5°, with an antenna pattern conforming with RR Appendix 8 [24]. The EESS antenna gain considered towards the MFCN station is therefore 14.5 dBi. The EESS antenna height is 10m. The protection criterion is -216 dBW/Hz not to be exceeded more than 0.1% of the time.

The parameters used for MFCN are the ones given in Annex 1.

Table 7: Comparison between non-AAS and AAS case in terms of the required separation distances between MFCN and EESS earth stations (in km) following TVG methodology

| | | Non-AAS | | AAS | |
|--|-------------------|-------------|-----------|------------------|--------------|
| | | (Single Tx) | (Four Tx) | (non-correlated) | (correlated) |
| EESS ES Main Beam (P.452 [25], p=0.1% for Non- AAS, and Variable for AAS) | urban scenario | 26.5 | 52.2 | ----- | 32.4 |
| | rural scenario | 35 | 67.6 | ----- | 56.1 |

Conclusion

Considering the above elements and the results showing that introduction of AAS may not degrade interference conditions with services in the spurious emission domain it can be concluded that no further studies are needed for the compatibility between IMT and EESS/SRS/SOS 2200 MHz within the scope of the work to review ECC Decision (06)01 [1] for the 2.1 GHz frequency band, on the assumption that the spurious emission limits follow ERC Recommendation 74-01 [3] levels (for the coexistence studies in this ECC Report the value of -30 dBm/MHz was used).

Coordination zones, where needed, will be in the same order of magnitude as for non-AAS case and they can be determined at a national level as previously done in ECC Recommendation 10(01) [23].

5 RECOMMENDED FRAMEWORK

5.1 BAND PLAN

The recommended band plan for the duplex direction for FDD carriers in the bands 1920-1980 MHz and 2110-2170 MHz, considers twelve paired blocks and the minimum block size should be ranging from 4.8 to 5.0 MHz. The sharing studies were performed with the assumption of this 300 kHz guard band according to the current band plan. Recent measurements of the OoB emissions of some real UMTS/LTE base stations (non-AAS) show a margin of up to 30 dB compared to the 3GPP mask, which was used in ERC Report 65 [4] (see Annex 2).

CEPT concluded on an updated band plan for the 1920-1980 MHz and 2110-2170 MHz band and it is up to each administration to decide, based on its requirements, and considering the impact on existing authorisations in its country within the band and services in adjacent bands, whether and how to migrate from the band plan in previous revisions of ECC Decision (06)01 [1] to the new band plan, and any associated conditions. It is noted that the UMTS channel raster is 200 kHz, which means that the centre frequency must be an integer multiple of 200 kHz. It is further noted that for the UE the lowest carrier is specified to be placed on 1922.4 MHz and the highest on 1977.6 MHz. This corresponds to 2112.4 MHz (lowest) and 2167.6 MHz (highest) for the base station respectively. This is a relevant consideration for some administrations who are considering migrating to the updated band plan.

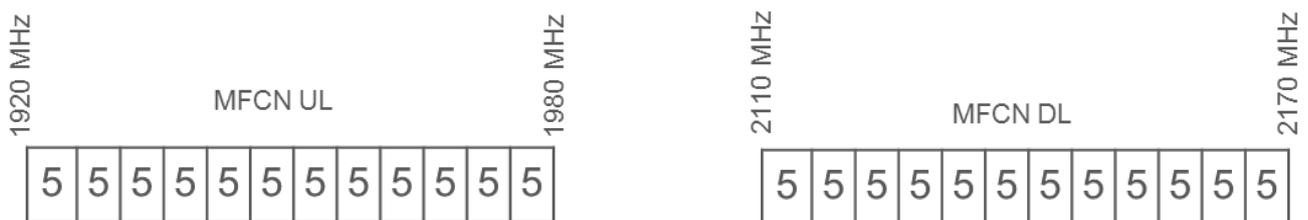


Figure 10: Updated band plan

Considering the current band plan, 5G NR systems in frequency bands 1920-1980 MHz may operate in Supplemental Uplink (SUL) mode, i.e. 5G NR uplink operation without paired downlink NR channel. The analysis conducted in this report confirmed the suitability of the current harmonised technical conditions for Supplemental Uplink (SUL) mode of operation.

This Report confirms that the current above band plan is suitable for 5G.

5.2 APPLICABLE TECHNICAL CONDITIONS

5.2.1 In-block power limits

As described in Section 2, no mandatory limit was defined in the existing regulatory framework. The same approach will be used also in the updated regulatory framework. For the case of AAS base stations, it is proposed to convert the existing not obligatory in-block e.i.r.p. limit specified in EC Decision 2012/688/EU [6] to TRP for consistency with the out-of-block limits. This implies the conversion of the existing non-mandatory e.i.r.p. limit of 65 dBm/(5 MHz) per antenna for the non-AAS base station to a corresponding TRP limit (assuming a 17 dBi antenna gain) following guidelines given in 3GPP TS 38.104 [26]. Also, it is proposed to specify the in-block TRP limits to a value that correspond to a total of eight beam forming antenna elements (scaling factor of 9 dB):

$$65 \text{ dBm}/(5 \text{ MHz}) - 17 \text{ dBi} + 9 \text{ dB} = 57 \text{ dBm}/(5 \text{ MHz}).$$

Table 8: Updated in-block power limit

| BEM element | Frequency range | Non-AAS e.i.r.p limit dBm/5 MHz | AAS TRP power limit dBm/(5 MHz) |
|-------------|--------------------------------|--|--|
| In-block | Block assigned to the operator | Not obligatory. In case an upper bound is desired by an administration, a value of 65 dBm/(5 MHz) per antenna may be applied. | Not obligatory. In case an upper bound is desired by an administration, a value of 57 dBm/(5 MHz) per cell/sector may be applied. |

UE In-block requirement

As for the technical condition for user equipment (UEs) it is recommended that the UE maximum mean in-block radiated power (e.i.r.p. for fixed UEs, and TRP for nomadic/mobile UEs) does not exceed 24 dBm [6].

5.2.2 Out-of-block power limits: Interference between FDD MFCNs

For AAS base stations, TRP is selected as the metric for specifying regulatory power limits. This corresponds to out-of-block power limits in the context of MFCN-to-MFCN interference in the case of FDD networks. In alignment with the specification of unwanted emission conducted power (TRP) for AAS base stations in 3GPP TS 38.104 [25] and the analysis made in ECC Report 281 [9], it is proposed to specify the out-of-block TRP limits to a value that correspond to a total of eight beam forming antenna elements. Table 9 shows the proposed out-of-block TRP limits for the update of ECC Decision (06)01[1].

Table 9: Proposed out-of-block TRP limits for AAS MFCN Base Stations

| Frequency range | AAS TRP power limit per cell ⁽¹⁾ |
|--|---|
| -5 to 0 MHz offset from lower block edge 0h to 5 MHz offset from upper block edge | 8 dBm/5 MHz |
| -10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge | 3 dBm/5 MHz |
| Other blocks | 1 dBm/5 MHz |

(1)) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.

Table 10 describes the relationship between the proposed out-of-block BEM limits and the corresponding 3GPP unwanted emission mask applicable for the 2110-2170 MHz band.

Table 10: ECC limits and the 3GPP unwanted emission mask

| Frequency offset (MHz) | 3GPP unwanted emission mask (TS 38.104) | Average Tx power | Units | 3GPP: Tx Power (dBm/(5 MHz)) | | 3GPP TRP power limits (dBm/(5 MHz)) | Proposed AAS TRP power limit dBm/5MHz per cell (1) |
|------------------------|---|------------------|--------------|------------------------------|------|-------------------------------------|--|
| 0 to 0.2 | -14 | -14.0 | dBm/(30 kHz) | 8.2 | -0.9 | 8.1 | 8 |
| 0.2 to 1 | -14 to -26 | -18.7 | dBm/(30 kHz) | 3.5 | | | |

| Frequency offset (MHz) | 3GPP unwanted emission mask (TS 38.104) | Average Tx power | Units | 3GPP: Tx Power (dBm/(5 MHz)) | | 3GPP TRP power limits (dBm/(5 MHz)) | Proposed AAS TRP power limit dBm/5MHz per cell (1) |
|--|---|------------------|---------|------------------------------|------|-------------------------------------|--|
| 1 to 5 | -13 | -13.0 | dBm/MHz | -6.0 | | | |
| 5 to 10 | -13 | -13.0 | dBm/MHz | -6.0 | -6.0 | 3 | 3 |
| 10 to 15 | -15 | -15.0 | dBm/MHz | -8.0 | -8.0 | 1 | 1 |
| (1) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors | | | | | | | |

6 CONCLUSIONS

This Report assessed the suitability of existing band plan and BEM for 5G in the 1920-1980 MHz and 2110-2170 MHz band and studied the coexistence of 5G with other services below 2110 MHz (space services in particular) and above 2170 MHz (MSS and space services).

The ECC Report concludes on:

- an updated band plan for the 1920-1980 MHz and 2110-2170 MHz band and that it is up to each administration to decide, based on its requirements, and considering the impact on existing authorizations in its country within the band and services in adjacent bands, whether and how to migrate from the band plan in previous revisions of ECC Decision (06)01 to the new band plan, and any associated conditions;
- the current BEM remains applicable for non-AAS systems;
- there is need for additional BEM for AAS systems.

It is noted that the spurious domain for the base station in this frequency band starts 10 MHz from the band edge and that the corresponding limits are defined in ERC Recommendation 74-01 [3] (for the coexistence studies in this ECC Report the value of -30 dBm/MHz was used).

This ECC Report provides the relevant required amendments to the ECC framework in order to include BEM for AAS MFCNs in Section 5 "Recommended Framework".

ANNEX 1: MFCN PARAMETER VALUES AND ASSUMPTIONS FOR SIMULATIONS

A1.1 NON-AAS MFCN

- Antenna height: 45 m (rural) and 30 m (urban) based on ECC Report 174 [27];
- Antenna gain: 18 dBi;
- Antenna tilt: 2.5° (rural) and 5° (urban);
- Antenna pattern: Recommendation ITU-R F.1336-4 [18] with 3dB beamwidth of 65 degrees;
- Feeder losses: 3 dB;
- Spurious emissions limit: -30 dBm in a reference bandwidth of 1 MHz.

A1.2 AAS MFCN

- Antenna height: 45 m (rural) and 30 m (urban) based on ECC Report 174 [27];
- Cell radius: 1500 m (rural) and 300 m (urban);
- Antenna tilt: 10° (mechanical);
- UE distribution: polar uniform;
- UE height: 1.5 m (outdoor);
- Spurious emissions limit: -30 dBm in a reference bandwidth of 1 MHz.

Table 11 Parameters for AAS system

| Parameter | Value |
|---|---|
| Antenna element directional pattern $a_{E \text{ dB}}(\theta, \varphi)$ | <p>According to 3GPP TR 37.840 [11](section 5.4.4.2) where:</p> <ul style="list-style-type: none"> ▪ 3 dB elevation beamwidth $\theta_{3 \text{ dB}} = 65^\circ$; ▪ 3 dB azimuth beamwidth $\varphi_{3 \text{ dB}} = 80^\circ$; ▪ Front-to-back ratio $A_m = 30 \text{ dB}$; ▪ Side-lobe ratio $SLAV = 30 \text{ dB}$. <p>NOTE: $a_E(\theta, \varphi) \leq 1$.</p> <p>NOTE: Each antenna element is larger in size in the vertical direction, and so $\theta_{3 \text{ dB}} < \varphi_{3 \text{ dB}}$. See 3GPP TR 37.840.</p> |
| Antenna element gain $G_{E \text{ dB}}$ | 8 dBi |
| Number of base station beamforming elements (N_V, N_H) | (8,8) |
| Element spacing | <p>0.9λ vertical separation 0.6λ horizontal separation</p> <p>NOTE: Larger vertical spacing provides narrower array beamwidth in elevation. See 3GPP TR 37.840 [11] (Table 5.4.4.2.1-1).</p> |

ANNEX 2: CONSIDERATIONS ON CHANGES TO THE NECESSITY OF GUARD BANDS IN THE 2 GHZ MFCN BANDS

A2.1 GUARD BANDS AT 2110 MHZ (SPACE SERVICES UPLINK)

OoB emissions from a UMTS base station

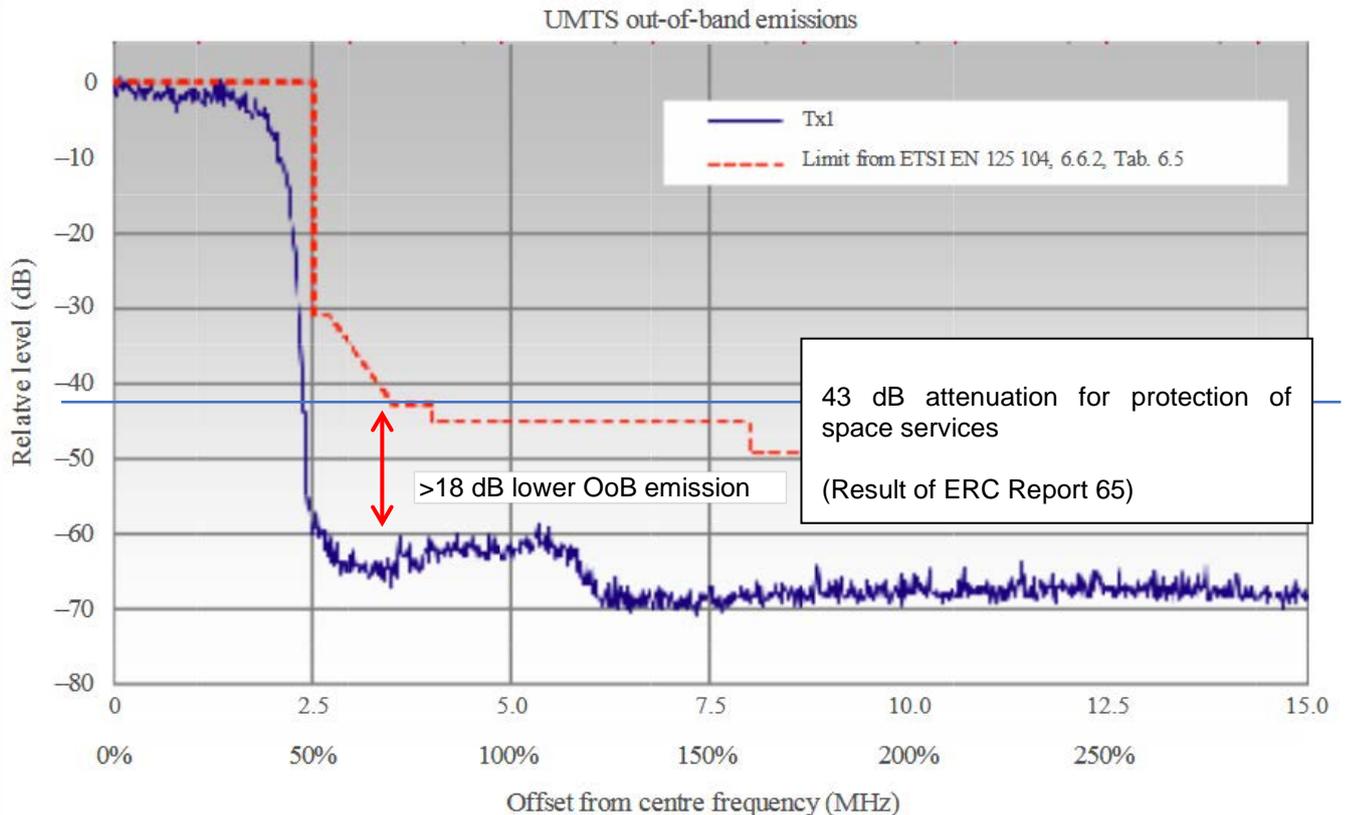


Figure 11: UMTS 2100 MHz base station

ERC Report 65 [4] concludes in Chapter 3.3.2, that an additional attenuation of 43 dB is needed for protection of space service satellites (at 250 km height -> worst case). As shown in ECC Report 249 [28] and Report ITU-R SM.2421-0 [29] the originally used 3GPP masks are much too pessimistic in comparison to real UMTS/LTE OoB emissions. The measured OoB emissions of UMTS/LTE base stations have shown up to 30 dB lower OoB emissions compared to the 3GPP mask in the first 300 kHz from band edge.

A2.2 GUARD BAND AT 1920 MHZ

Although some MFCN licenses are still in force, the band 1900-1920 MHz is no longer designated for MFCN (TDD) and currently no MFCN systems are deployed in Europe. While future usage possibilities are under discussion (e.g. FRMCS, DECT, UAS, etc.), it is currently not decided what services will be introduced into this band. Therefore, no guard band is needed at 1920 MHz.

A2.3 GUARD BAND AT 1980 MHZ (MSS UPLINK)

Unwanted emission measurements of 2 LTE 2.3 GHz UEs
(RMS power, resolution bandwidth = 10 kHz)

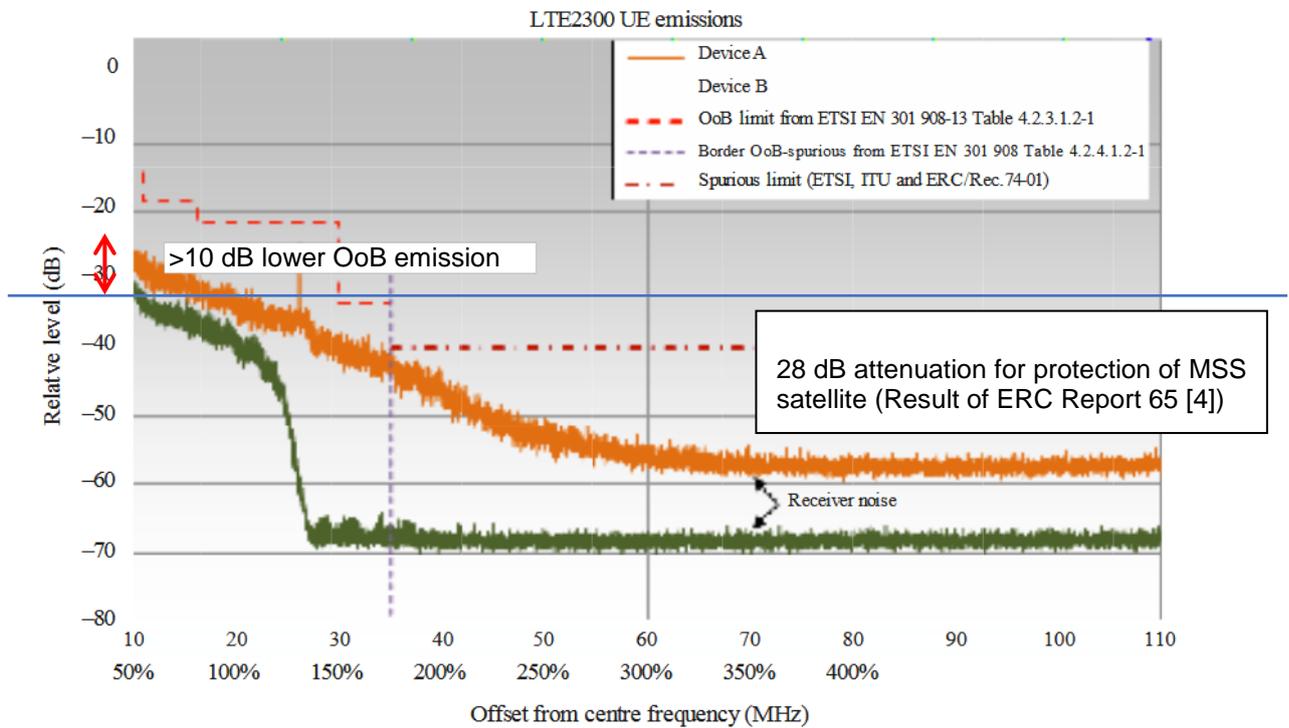


Figure 12: LTE 2300 MHz UE

ERC Report 65 [4] concludes in Chapter 3.2.1, that an additional attenuation of about 28 dB is needed for protection of MSS. As shown in ECC Report 249 [28] and Report ITU-R SM.2421-0 [29] the originally used 3GPP masks are too pessimistic in comparison to real UMTS/LTE OoB emissions. The real measured OoB emissions of a UMTS/LTE UE are almost 10 dB lower than suggested by the 3GPP mask in the first 300 kHz from band edge.

It is also worth mentioning that the MSS CGC (complementary ground component) terminals in the band 1980-2010 MHz use OFDM-technology and can therefore be deployed without interference.

A2.4 GUARD BAND AT 2170 MHZ (MSS DOWNLINK)

As shown before for the other bands, the guard band of 300 kHz is not necessary to protect the adjacent services due to the large margin in OoB emissions between the real measurement and the 3GPP mask.

The MSS allocation directly adjacent to MFCN above 2170 MHz is used for EAN applications. Therefore, the only possible interference from MFCN base stations may occur while the MSS receiver in an aeroplane is on the ground. If an additional protection is still needed, it can be granted by applying coordination procedures for MFCN base stations around airports, instead of a mandatory guard band for CEPT countries.

A2.5 SUMMARY

This investigation shows that the guard bands in the 2 GHz MFCN bands are not needed due to the measurements of real UMTS/LTE base stations. These BSs have up to 30 dB lower OoB emissions compared to the 3GPP mask, used in the compatibility analyse that resulted in the need of guard bands.

As there are no measurements yet available for AAS, this conclusion needs to be confirmed.

ANNEX 3: OVER-THE-AIR (OTA) UNWANTED EMISSION LIMITS FOR AAS MFCN

For lower bands AAS functionality is a feature that applied to the BS side only not to the UE. The NR and LTE UE requirements are defined in TS 38.101-1 [12] and TS 36.101 [30] respectively as conducted requirements they remain the same whether the BS is AAS or non-AAS.

LTE AAS BS requirements are defined in 3GPP TS 37.105 [31] Section-9 for the BS transmitter side and Section-10 for the Receiver side. LTE AAS system will be covered by the NR Harmonised Standards EN 301 908 part 23 (NR BS) [32]. The UE part of LTE is covered by ETSI EN 301 908-13 [33] which is the same as for non-AAS system.

NR AAS BS requirements are defined in 3GPP TS 38.104 [25] Section-9 for the BS transmitter side and Section-10 for the receiver side for the receiver side, starting from NR release 15. NR AAS system will be covered by the NR Harmonised Standards: EN 301 908 part 18 (MSR BS) [34], EN 301 908 part 24 (NR BS) [35] and EN 301 908 part 25 (NR UE) [36].

TS 37.105 provides the background for defining OTA AAS BS requirements. It states that for OTA AAS BS there are no conducted requirements. The radiated requirements have been derived in 3GPP based on the principle that they offer the same level of performance and protection as the hybrid AAS BS requirements.

3GPP defines in TS 37.105 (section 9.7.5.2.2) the OTA Operating band unwanted emission requirements for NR-AAS and LTE-AAS BS in band1 n1 (2100 MHz).

Table 12: Wide Area operating band unwanted emission mask (UEM) for BC1 for BS not supporting NR or BS supporting NR in Band n1 (Table 9.7.5.2.2-1 from 3GPP TS 37.105 [31])

| Frequency offset of measurement filter -3dB point, Δf | Frequency offset of measurement filter centre frequency, f_{offset} | Minimum requirement (NOTE 1, 2) | Measurement bandwidth (NOTE 4) |
|--|---|--|--------------------------------|
| $0 \text{ MHz} \leq \Delta f < 0.2 \text{ MHz}$ | $0.015 \text{ MHz} \leq f_{\text{offset}} < 0.215 \text{ MHz}$ | -5 dBm | 30 kHz |
| $0.2 \text{ MHz} \leq \Delta f < 1 \text{ MHz}$ | $0.215 \text{ MHz} \leq f_{\text{offset}} < 1.015 \text{ MHz}$ | $-5 \text{ dBm} - 15 \cdot \left(\frac{f_{\text{offset}}}{\text{MHz}} - 0.215 \right) \text{ dB}$ | 30 kHz |
| (NOTE 3) | $1.015 \text{ MHz} \leq f_{\text{offset}} < 1.5 \text{ MHz}$ | -17 dBm | 30 kHz |
| $1 \text{ MHz} \leq \Delta f \leq \min(\Delta f_{\text{max}}, 10 \text{ MHz})$ | $1.5 \text{ MHz} \leq f_{\text{offset}} < \min(f_{\text{offsetmax}}, 10.5 \text{ MHz})$ | -4 dBm | 1 MHz |
| $10 \text{ MHz} \leq \Delta f \leq \Delta f_{\text{max}}$ | $10.5 \text{ MHz} \leq f_{\text{offset}} < f_{\text{offsetmax}}$ | -6 dBm (NOTE 5) | 1 MHz |

NOTE 1: For MSR RIB supporting non-contiguous spectrum operation within any operating band the minimum requirement within sub-block gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the sub-block gap, where the contribution from the far-end sub-block shall be scaled according to the measurement bandwidth of the near-end sub-block. Exception is $\Delta f \geq 10 \text{ MHz}$ from both adjacent sub-blocks on each side of the sub-block gap, where the minimum requirement within sub-block gaps shall be -6 dBm/MHz.

NOTE 2: For MSR multi-band RIB with Inter RF Bandwidth gap $< 2 \times \Delta f_{\text{OBUE}}$ the minimum requirement within the Inter RF Bandwidth gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks or Base Station RF Bandwidth on each side of the Inter RF Bandwidth gap, where the contribution from the far-end sub-block or RF Bandwidth shall be scaled according to the measurement bandwidth of the near-end sub-block or RF Bandwidth.

NOTE 3: see Table 9.7.5.2.2-1 from 3GPP TS 37.105 [31]

NOTE 4: see Table 9.7.5.2.2-1 from 3GPP TS 37.105 [31]

NOTE 5: see Table 9.7.5.2.2-1 from 3GPP TS 37.105 [31]

TR 37.843 (Release 15) [37] provides explanation in section 5.6.1.2 on how the unwanted emissions for AAS BS were derived based on basic limits that are conducted requirements corresponding to non-AAS BS unwanted emissions and by applying a fixed scaling factor FSF that is based on minimum number of 8 transceiver units for E-UTRA.

The OTA AAS BS emissions limits for E-UTRA therefore are applied per cell and are based on the basic limits used in the Rel-13 AAS BS requirements multiplied by the FSF equal to 8 (or plus 9 dB). The radiated requirements therefore use the same equivalence as hybrid AAS BS to the non-AAS requirements assuming a scaling factor based on 8TRX compared to non-AAS BS.

Besides, TR 37.843 provides some elements on how the existing EIRP regulations were interpreted to TRP e.g.: E-UTRA: OTA AAS BS emissions limits = e.i.r.p. - [17] dBi + 9 dB

A fixed assumption was made of the gain of a passive antenna system [17] dBi in order that an OTA TRP requirement can be provided for AAS BS.

ANNEX 4: LIST OF REFERENCES

- [1] ECC Decision (06)01: "ECC Decision of 24 March 2006 on the harmonised utilisation of the bands 1920-1980 MHz and 2110-2170 MHz for mobile/fixed communications networks (MFCN) including terrestrial IMT", amended on 2 November 2012
- [2] CEPT Report 39: "Report from CEPT to the European Commission in response to the Mandate to develop least restrictive technical conditions for 2 GHz bands"
- [3] ERC Recommendation 74-01: "Unwanted Emissions in the Spurious Domain", amended in 2011
- [4] ERC Report 65: "Adjacent band compatibility between UMTS and other services in the 2 GHz band"
- [5] ERC Recommendation 01-01: "Cross-border coordination for mobile/fixed communications networks (MFCN) in the frequency bands: 1920-1980 MHz and 2110-2170 MHz"
- [6] EC Decision 2012/688/EU: "Commission Implementing Decision of 5 November 2012 on the harmonisation of the frequency bands 1920-1980 MHz and 2110-2170 MHz for terrestrial systems capable of providing electronic communications services in the Union"
- [7] 3GPP TS 36.104: "Technical Specification Group Radio Access Network - Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception"
- [8] Recommendation ITU-R M.2101 (02/2017): "Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies"
- [9] ECC Report 281: "Analysis of the suitability of the regulatory technical conditions for 5G MFCN operation in the 3400-3800 MHz band"
- [10] CEPT Report 67: "Report A from CEPT to the European Commission in response to the Mandate 'to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union' - Review of the harmonised technical conditions applicable to the 3.4-3.8 GHz ('3.6 GHz') frequency band"
- [11] 3GPP TR 37.840: "Study of Radio Frequency (RF) and Electromagnetic Compatibility (EMC) requirements for Active Antenna Array System (AAS) base station"
- [12] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".
- [13] ECC Decision (15)02: "ECC Decision of 3 July 2015 on the harmonised use of broadband Direct Air-to-Ground Communications (DA2GC) systems in the frequency band 1900-1920 MHz, withdrawn July 2018"
- [14] ECC Decision (18)01: "ECC Decision of 6 July 2018 on the withdrawal of ECC Decision (15)02 on 'The harmonised use of broadband Direct Air-to-Ground Communications (DA2GC) systems in the frequency band 1900-1920 MHz'"
- [15] ECC Decision (06)09: "ECC Decision of 1 December 2006 on the designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile-Satellite Service including those supplemented by a Complementary Ground Component (CGC)"
- [16] CEPT Report 13: "Harmonised technical conditions for the use of the 2 GHz bands for Mobile Satellite Services in the European Union", July 2006
- [17] ETSI EN 302 574-1 V2.1.1.: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Mobile Earth Stations (MES) operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to-earth) frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Complementary Ground Component (CGC) for wideband systems"
- [18] Recommendation ITU-R F.1336-4 (02/2014): "Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile services for use in sharing studies in the frequency range from 400 MHz to about 70 GHz"
- [19] Recommendation T/R 13-01: "Preferred channel arrangements for fixed service systems operating in the frequency range 1-2.3 GHz"
- [20] Recommendation ITU-R F.1098 (10/1995): "Radio-frequency channel arrangements for fixed wireless systems in the 1 900-2 300 MHz band"
- [21] ECC Report 173: "Fixed Service in Europe Current use and future trends post 2016"
- [22] Recommendation ITU-R SA.1154 (10/1995): "Provisions to protect the space research (SR), space operations (SO) and Earth exploration-satellite services (EES) and to facilitate sharing with the mobile service in the 2025-2110 MHz and 2200-2290 MHz bands"
- [23] ECC Recommendation 10(01): "Guidelines for compatibility between Complementary Ground Components (CGC) operating in the band 2170-2200 MHz and EESS/SOS/SRS earth stations operating in the band 2200-2290 MHz"
- [24] ITU Radio Regulations Edition of 2016
- [25] Recommendation ITU-R P.452-16 (07/2015): "Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz"

- [26] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception" (Release 15)
- [27] ECC Report 174: " Compatibility between the mobile service in the band 2500-2690 MHz and the radiodetermination service in the band 2700-2900 MHz", April 2012
- [28] ECC Report 249: "Unwanted emissions of common radio systems: measurements and use in sharing/compatibility studies", April 2016
- [29] Report ITU-R SM.2421-0: "Unwanted emissions of digital radio systems"
- [30] 3GPP TS 36.101: "Technical Specification Group Radio Access Network - Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception"
- [31] 3GPP TS 37.105: "Technical Specification Group Radio Access Network - Active Antenna System (AAS) Base Station (BS) transmission and reception (Release 14)"
- [32] ETSI EN 301 908-23 (NR BS): " IMT cellular networks; Harmonised Standard for access to radio spectrum; Part 23: Active Antenna System (AAS) Base Station (BS); Conducted conformance testing AAS BS V13.1.1"
- [33] ETSI EN 301 908-13: V11.1.2: "IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE)"
- [34] EN 301 908-18 V5.2.1: "IMT cellular networks; Harmonised EN covering the essential requirements of article 3.2 of the R&TTE Directive; Part 18: E-UTRA, UTRA and GSM/EDGE Multi-Standard Radio (MSR) Base Station (BS)"
- [35] EN 301 908-24: "IMT cellular networks; Harmonised Standard for access to radio spectrum Part 24: New Radio (NR) Base Stations (BS) NR BS V15.1.1"
- [36] EN 301 908-25: "IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of the Radio Equipment Directive 2014/53/EU; Part 25: New Radio (NR) User Equipments (UE)"
- [37] 3GPP TR 37.843 V15.2.0: Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS) radiated requirements