**Cover note for the Public Consultation on Draft CEPT Report 67**

**Cover note for the Public Consultation on draft CEPT Report A**

**Harmonised technical conditions for spectrum use in the 3400-3800 MHz band in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union**

This draft CEPT Report provides harmonised technical conditions for the use of 5G wireless broadband electronic communication services in the 3400-3800 MHz band.

During the development of these technical conditions, the following issues were highlighted:

**1 In-block power**

ECC considered proposals for revised values for the non-obligatory limits on the base station in-block power. The value initially considered was 47 dBm/5 MHz TRP, but industry requested to increase the value up to 56 dBm/5 MHz TRP. There were concerns that the higher value would have the consequence of unduly increasing the coordination distances. Since the current limit is not obligatory, there were different views on whether it was necessary to specify any in-block limit in the least restrictive technical conditions.

**2 Limit for protection of radars in the adjacent band**

ECC agreed to include the TRP limit of −52 dBm/MHz for protection of radars below 3400 MHz. It is noted that coordination areas may be needed for the protection of fixed radars in some countries, and that manufacturers have indicated that this would imply a need for a frequency separation of about 20 MHz, based on current AAS technology, to comply with the TRP limit where full power AAS is used.

**3 Alternative restricted baseline limit**

For unsynchronised and semi-synchronised operations, if no geographic separation is available, a restricted baseline limit applies outside the block. Administrations may have to specify at a national level some more relaxed “restricted baseline”. The text on this matter is in square brackets for further consideration during the public consultation.

**4 Limit above 3800 MHz for non-AAS base stations**

Emission limits above 3800 MHz have been defined for AAS, although they are not defined for non-AAS. These may need to be defined during the public consultation.

Views on the text of the CEPT Report, and in particular on these aspects are requested during the public consultation.

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

**Report approved on DD Month YYYY by the ECC**

**CEPT Report – subject to public consultation**

# Executive summary

Due to its favourable properties, such as radio wave propagation and available bandwidth, the frequency band 3400-3800 MHz will be the primary spectrum band for the introduction of 5G WBB ECS systems based on TDD mode in Europe.

The European Commission issued a mandate to the CEPT to review the harmonised technical conditions applicable to the **3400-3800 MHz frequency band, as a 5G pioneer band**, with a view to their suitability for 5G terrestrial wireless systems.

This report forms the response to this mandate and provides recommendations to update the existing regulatory framework in EC Decision 2014/276/EU [1] focussing on the use of Active Antenna Systems (AAS) envisaged for 5G.

When reviewing the applicability of the current regulatory framework for 5G, CEPT identified that:

* There is no need to maintain FDD frequency arrangement. Moreover, the frequency separation at 3.6 GHz for the TDD frequency arrangement is no longer needed;
* The proposed frequency arrangement will facilitate availability of larger contiguous frequency blocks to 5G operators. Accounting for the need for largest possible contiguous portions of spectrum to be made available for 5G, there is a need to reorganise and defragment the band. CEPT is now developing guidelines / best practices for administrations suggesting ways to facilitate availability of largest possible contiguous portions of spectrum.

Moreover,

* 5G is expected to be commonly deployed leveraging AAS;
* the current regulatory framework is not appropriate for AAS;
* there is a need for additional BEM: 4G and 5G AAS BSs are similar from a compatibility standpoint and can be accommodated by a single set of LRTCs appropriate for AAS BSs;
* 4G and 5G non-AAS BSs are similar from a compatibility standpoint and can be accommodated by a single set of LRTCs appropriate for non-AAS BSs and already in force.

Therefore, CEPT concluded that in order not to restrict 5G to only non-AAS deployment, it was necessary to extend the current regulatory framework with a set of LRTCs appropriate for AAS BSs as described in Annex 2.

The following considerations are taken into account in the assessment of the existing framework.

1. In-block radiated power limits

ECC Decision (11)06 [2] and EC Decision 2014/276/EU [1] specify[[1]](#footnote-1);

* a maximum BS in-block EIRP of ≤ 68 dBm/5 MHz per antenna (non-mandatory);
* a maximum TS in-block TRP of 25 dBm.

It is important to assess whether these types of requirements for in-block power are applicable for AAS base stations

1. Out-of-block power limits - Interference between operators in adjacent blocks

ECC Decision (11)06 [2] and EC Decision 2014/276/EU [1] specify out-of-block EIRP limits for “synchronous TDD” inside the band that are based on 3GPP spectrum emission masks (transmit powers), specified “per antenna”, and predicated on an assumed nominal antenna gain[[2]](#footnote-2). The Decisions specify more stringent out-of-block EIRP limits for unsynchronised TDD.

It is important to assess whether these types of specifications for out-of-block EIRP are applicable for AAS base stations

1. Out-of-band (OOB) power limits - Interference to other services in adjacent bands

In order to continue to ensure protection of radar below 3400 MHz. the existing OOB EIRP limit needs to be reviewed in the context of AAS base station deployments

The following updates are proposed to the existing framework:

* 5G use cases suggest the adoption of minimum contiguous frequency allocations of around 50/80 MHz per operator. Therefore the spectrum should be provided in a manner allowing for at least 3x50 MHz of contiguous spectrum;
* There is no need to consider separate frequency arrangements for 3400-3600 MHz and 3600-3800 MHz from a regulatory perspective. The unpaired arrangement is therefore selected as the only option for the 3400-3800 MHz band;
* The levels of existing out-of-block power limits for coexistence of synchronised WBB ECS BS are proposed to be used for AAS base stations, specified as TRP limits for the whole antenna panel;
* An out-of-block power limit of -43 dBm/5 MHz TRP for the whole antenna panel is proposed for coexistence of unsynchronised and semi-synchronised WBB ECS BS;
* For unsynchronised and semi-synchronised operations, if no geographic separation is available, the restricted baseline applies. Less stringent technical parameters, if agreed among the operators of such networks, may also be used. [In addition, depending on national circumstances, administrations may define relaxed baseline limit applying to specific implementation cases.];
* For protection of radars below 3400 MHz, limits for AAS base station of –52 dBm/MHz for the whole antenna panel TRP is proposed, which manufacturers have indicated would imply under current technology, about 20 MHz frequency separation between the block edge and 3400 MHz. Other mitigation measures such as geographical separation, coordination on a case by case basis or an additional frequency separation may be necessary for a TDD allocation. For countries with military radiolocation systems below 3400 MHz a coordination zone of up to 12 km around fixed terrestrial radars, based on a AAS TRP power limit of −52 dBm/MHz per antenna panel, may be needed. Such coordination is under responsibility of the relevant EU Member State;
* For protection of FSS and FS above 3800 MHz, the baseline and transitional power limits are additionally proposed to be applied for AAS base stations at the 3800 MHz band edge to support the coordination process to be carried out at national level on case by case basis with support from the operations guidelines from ECC Report 254 [3]**;**
* [The existing in-block e.i.r.p. limit for non-AAS base stations is proposed to be converted to 47 dBm/5 MHz TRP for the whole antenna panel for AAS base stations.];
* A UE in-block limit of 28 dBm TRP is proposed.

Coexistence between LTE network and 5G NR in adjacent frequencies is ensured when either:

* Respecting the baseline level in case of synchronised operation;
* Respecting the restricted baseline level in case of non-synchronised LTE and 5G NR networks.

Synchronised operation between 5G NR and LTE is technically feasible but may lead to higher latency and reduced flexibility in the UL/DL transmission ratio, although networks could be designed to overcome some of these drawbacks.

Cross-border co-ordination can be sufficiently addressed through existing bilateral and multi-lateral procedures, supported by ECC Recommendations. CEPT will work to ensure Recommendations are 5G compatible.

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**LIST OF ABBREVIATIONS**

|  |  |
| --- | --- |
| **Abbreviation** | **Explanation** |
| 3GPP | 3rd Generation Partnership Project |
| AAS | Active Antenna System |
| BEM | Block Edge Mask |
| BS | Base Station |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CSI | Channel State Information |
| DL | Downlink |
| EC | European Commission |
| ECA | European Common Allocation |
| ECC | Electronic Communications Committee |
| ECS | Electronic Communication Services |
| EFIS | European Frequency Information System |
| e.i.r.p. | Equivalent Isotropically Radiated Power |
| **E-UTRA** | Evolved Universal Terrestrial Radio Access |
| FDD | Frequency Division Duplex |
| FS | Fixed Service |
| FSS | Fixed Satellite Service |
| IMT | International Mobile Telecommunications |
| ITU-R | International Telecommunication Union - Radiocommunications |
| LRTC | Least Restrictive Technical Conditions |
| LTE | Long Term Evolution |
| MSR | Multi Standard Radio |
| MFCN | Mobile/Fixed Communications Network |
| NR | New Radio |
| OOB | Out of Band |
| OTA | Over The Air |
| RAN | Radio Access Network |
| SDL | Supplemental Downlink |
| SDO | Standards Developingt Organisation |
| SEM | Spectrum Emission Mask |
| TCP | Transmission Control Protocol |
| TDD | Time Division Duplex |
| TRP | Total Radiated Power |
| TS | Terminal Station |
| UE | User Equipment |
| UL | Uplink |
| UMTS | Universal Mobile Telecommunications System |
| WBB ECS | Wireless Broadband Electronic Communication Services |
| WRC | World Radiocommunication Conference |

# Introduction

This report addresses Task 1 of the EC Mandate to CEPT to develop harmonised technical conditions for 5G (see Annex 1):

“1. Review the harmonised technical conditions applicable to the **3.4-3.8 GHz ('3.6 GHz') frequency band, as a 5G pioneer band**, with view to their suitability for 5G terrestrial wireless systems and amend these, if necessary.”

The 3400-3800 MHz frequency band is already harmonised at EU level for terrestrial systems capable of providing wireless broadband electronic communications services (WBB ECS) and is already potentially available for future 5G use. In this regard, with the current framework, CEPT develop harmonised technical conditions to ensure spectrum usage on a shared basis, including protection conditions where necessary, pursuant to the sharing scenarios identified, in close cooperation with all concerned stakeholders. These conditions should be sufficient to mitigate interference and ensure coexistence with incumbent radio services/applications in the same band or in adjacent bands, in line with their regulatory status.

The development of new radio interfaces -5G New Radio (NR) - that support the new capabilities of IMT-2020 is expected along with the enhancement of IMT-2000 and IMT-Advanced systems.

Due to its favourable properties, such as radio wave propagation and available bandwidth, the frequency band 3400-3800 MHz will be the primary spectrum band for the introduction of 5G WBB ECS systems in Europe.

The BEM consists of several elements. The in-block power limit is applied to a block owned by an operator. The out-of-block elements consist of a baseline level, designed to protect the spectrum of other WBB ECS operators, and transitional levels enabling filter roll-off from in-block to baseline levels. Such limits may be relaxed whenever there are bilateral agreements between operators.

For the spectrum 3400-3800 MHz, the BEM has not been developed to protect other services or applications, and only applies in blocks that have been licensed to WBB ECS according to the new harmonised frequency arrangement. The BEM defines additional requirements outside the band for the protection of other services.

In the figure below, it is assumed for simplicity that all blocks have been licensed to WBB ECS. Figure 1 shows the combination of the different BEM elements.



Figure 1: Illustration of a general block edge mask

Table 1 below contains the different elements of the BEM for the 3400-3800 MHz bands.

Table 1: BEM elements

|  |  |
| --- | --- |
| BEM element  | Definition |
| In-block | Block for which the BEM is derived. |
| Baseline  | Spectrum used for WBB ECS, except from the operator block in question and corresponding transitional regions. |
| Transitional regions  | The transitional region applies 0 to 10 MHz below and above the block assigned to the operator. Transitional regions do not apply to TDD blocks allocated to other operators, unless networks are synchronised.The transitional regions do not apply below 3400 MHz or above 3800 MHz. |
| Additional baseline | Below 3400 MHz and above 3800 MHz. |

To obtain a BEM for a specific block, the BEM elements that are defined in Table 1 are used as follows:

* The in-block power limit is used for the block assigned to the operator;
* Transitional regions are determined, and corresponding power limits are used;
* For remaining spectrum assigned to WBB ECS, baseline power limits are used;
* For spectrum below 3400 MHz and above 3800 MHz, “additional baseline” power limits are used.

Co-existence with other services, co-channel or adjacent channel and applications is not necessarily guaranteed by the BEM for WBB ECS, as other methods may be more efficient depending on coexistence scenario, such as frequency or distance separation, or specific site engineering. It is noted that in the Radio Regulations [4], the mobile service has a secondary allocation in the frequency range 3600-3800 MHz, while in the ECA Table (ERC Report 25) [5] the mobile service has a primary allocation in this frequency range.

The BEM is a ‘regulatory mask’, and should not be confused with Spectrum Emission Masks (SEM) for base stations and user equipment employed by SDOs. The BEM concept does not in itself define the means by which the equipment in an operator’s network meets the BEM.

For user equipment, the BEM proposed by this CEPT Report is restricted to in-block power, which is in line with previous decisions of the European Commission on UE BEMs. UE aspects are taken into consideration however when deriving the BS BEM and in the analysis of interference to and from other services.

For the purposes of this report the term WBB ECS includes IMT and other communications networks in the mobile and fixed services and refers to radio communication systems which should comply with the BEM defined in this Report. IMT covers IMT-2000, IMT-Advanced and IMT-2020, as defined in Resolution ITU-R 6556 (naming for International Mobile Telecommunications) [6]; the development of new radio interfaces (5G) that support the new capabilities of IMT-2020 is expected along with the enhancement of IMT-2000 and IMT-Advanced systems. The IMT-2020 process is on-going in ITU-R, in cooperation with standardisation organisations. Recommendation ITU-R M.2083 [7] addresses the objectives of the future development of IMT for 2020 and beyond, which includes further enhancement of existing IMT and the development of IMT-2020.

In the context of evolution of WBB ECS, the 5G New Radio interface (5G NR) optimises wideband operation. This allows operators to take full advantage of larger allocations of contiguous spectrum to increase peak rates and user experience. Ongoing standardization is considering channel bandwidths up to 100 MHz.

The detailed specifications of IMT radio interfaces are described in Recommendation ITU-R M.1457 [8] for IMT-2000 and Recommendation ITU-R M. 2012 [9] for IMT-Advanced. Recommendation ITU-R M.2083-0 now defines the framework and overall objectives of the future development of IMT for 2020 and beyond. IMT-2020 systems, system components, and related aspects that support the provision of far more enhanced capabilities than those described in Recommendation ITU-R M.1645 [10].

# Frequency arrangement

## Frequency arrangement in current framework

The existing regulatory framework in EC Decision 2014/276/EU [1] includes two frequency arrangements for the 3400-3600 MHz block, one preferred based on TDD and an alternative arrangement based on FDD. It also includes a TDD harmonised frequency arrangement for 3600-3800 MHz.

5G use cases benefit from minimum contiguous frequency allocations of around 50/80 MHz per operator. Therefore the spectrum should be provided in a manner allowing for at least 3x50 MHz of contiguous spectrum.

## Proposed frequency arrangements

The unpaired (TDD) arrangement is selected as the only option for the 3400-3800 MHz range for the following reasons:

* The TDD mode exploits downlink/uplink flexibility to support increasing traffic asymmetry: today, with the rapid development of smartphones and their increasing usage, mobile applications are increasingly download-centric;
* The TDD mode exploits channel reciprocity for effective AAS implementation: relying on uplink and downlink channel reciprocity (when the same portion of spectrum is used in both link directions this is frequently the case), the base stations can in some cases quickly and accurately obtain the downlink Channel State Information (CSI) based on the uplink channel estimation. This can be advantageous for AAS implementation to enhance the downlink transmission capacity while minimising interference;
* The TDD mode adapts better to possible incumbent users: given the current fragmented utilization of the 3400-3800 MHz portions of 3400-3800 MHz may be used by incumbent systems. Unpaired spectrum arrangement clearly has the advantage over a process that would include re-farming and pairing of new spectrum;
* Furthermore, we note that 3GPP has agreed on TDD-only band plans in this band for its NR specification. 3GPP has defined the following bandwidths for 5G NR in the 3400-3800 MHz range: 10, 15, 20, 40, 50, 60, 80, 100 MHz.

EC Decision 2014/276/EU [1] considers 3400-3600 MHz and 3600-3800 MHz as separate bands and defines its preferred frequency arrangements accordingly. However, in case of 5G NR 3GPP will define the whole 3400-3800 MHz as part of one single band (in both its B77 and B78 specifications). This suggests that, in case of 5G NR, there is no need to consider separate frequency arrangements for 3400-3600 MHz and 3600-3800 MHz from a regulatory perspective.

Furthermore, if the 3400-3600 MHz and the 3600-3800 MHz are defined as separate bands, there could be complications at the time of licensing if assignments straddle over the 3600 MHz boundary. This is likely given that it is expected that assignments in the band will be large.

The 5 MHz block size is chosen despite expected larger channel bandwidths for 5G. The 5 MHz granularity will facilitate dealing with the existing assignments, and will make it easier for the market to decide on the required bandwidth per operator during the assignment procedures.

The considerations above lead to the following frequency arrangement:



Figure 2: Proposed harmonised frequency arrangement:
3400-3800 MHz band

NOTE (1): The feasibility of implementation of AAS base stations in the lowest 5 MHz blocks, taking into account the unwanted emission limits to protect radars will depend on the evolution of filtering capabilities for AAS. However these lowest blocks would remain usable by non-AAS base stations. See also section 5.3.

The proposed frequency arrangement will facilitate availability of larger contiguous frequency blocks to 5G operators. Accounting for the growing need for connectivity and for the fact that the ongoing 5G NR standardisation is considering channel bandwidths up to 100 MHz, the ECC is now developing guidelines/best practices for administrations suggesting ways to facilitate availability of the largest possible contiguous portions of spectrum.

# Existing BEM Requirements

The harmonised technical conditions for WBB ECS base stations (BSs) in 3400-3800 MHz as described in ECC Decision (11)06 (rev. 2014) [2] and EC Decision 2014/276/EU [1] consist of Block Edge Mask (BEM) requirements with both in-block power limits, out-of-block emission limits which apply outside an operator’s block as well as out-of-band emission limits (below 3400 MHz).

The current regulatory framework for 3400-3600 MHz and 3600-3800 MHz provide all technical conditions for the existing FDD/TDD systems operating using non-AAS base stations and provide BEM to ensure compatibility with other systems operating in adjacent bands.

Given the fragmented current use of 3400-3600 for FDD and 3600-3800 for TDD or FDD, ECC is developing guidance to administrations in order to achieve a common TDD plan in 3400-3800 MHz.

The existing harmonised technical conditions ensure spectrum usage on a shared basis, including protection conditions where necessary, pursuant to the sharing scenarios identified, in close cooperation with all concerned stakeholders. These conditions should be sufficient to mitigate interference and ensure co­existence with incumbent radio services/applications in the same band or in adjacent bands, in line with their regulatory status, including at the EU outer borders.

The launch of commercial 5G services will also require substantial investments, the availability of a suitable amount of spectrum, and close collaboration between telecom players and key user industries. Network operators will not invest in new infrastructure if they do not see clear prospects for a solid demand and regulatory conditions that make the investment worthwhile.

According to the EC 5G Action Plan [1], member states shall address priorities for a coordinated 5G deployment across all EU Member States, targeting early network introduction by 2018, and moving towards commercial large scale introduction by the end of 2020 at the latest.

# Analysis of the suitability of the current BEM requirements for 5G

In order to make efficient use of the spectrum, 5G NR will be implemented with TDD. The introduction of 5G in the band raises different issues regarding the synchronisation between systems with AAS and non AAS antennas, in order to ensure coexistence with other incumbent services in the band and in adjacent bands. There is a need for technology neutral regulations addressing, among others, 4G and 5G systems as well as AAS and non AAS base stations.

When more than one TDD network operates in the same geographic area, severe interference may occur if the networks are uncoordinated, i.e. if some equipment belonging to one network is transmitting while equipment belonging to another network is receiving in the same time-slots and in the same band (on the same channel or on adjacent channels) while having a poor isolation (e.g. because of geographical proximity such as in co-sited deployments in a multi-operator context, or due to line of sight propagation scenarios).In this situation, both out-of-band and spurious emissions on the transmitter side and imperfect adjacent channel selectivity on the receiver side can desensitise or block the neighbour receiver, preventing it from properly listening to desired signals.

Without inter-operator synchronisation, coexistence may require operator-specific filters at the base station, both at the transmitter and receiver, to avoid interference. This may prevent economies of scale. Furthermore, additional filtering at the UE side is usually not feasible. In the case of TDD-TDD coexistence, one way to avoid all BS-BS and UE-UE interference without using frequency separations and specific filtering is to synchronise base stations so that they align their downlink and uplink switching points, as described in further sections. Since synchronised operation reduces UE-UE and BS-BS interference compared to unsynchronised operation, different regulatory constraints (such as block edge masks) may apply to those two different situations. ECC Report 203 [11] gives an example of different block edge masks for synchronised and unsynchronised TDD operations.

Based on the assessment, the report identifies modifications to the existing least restrictive technical conditions in terms of frequency arrangement and Block Edge Mask.

The significant increase in the number of mobile devices and exponential growth in consumption of wireless data is at the basis for the adoption of active antenna systems (AAS) for WBB ECSs operating in the 3400-3800 MHz frequency range. The adoption of AAS for IMT will provide significant increases in the average cell throughput

In the context of evolution of WBB ECS, the 5G New Radio interface (5G NR) optimises wideband operation. This allows operators to take full advantage of larger allocations of contiguous spectrum to increase peak rates and user experience. Ongoing standardisation is considering channel bandwidths up to 100 MHz This section, provides the analysis on the suitability of existing BEM requirements of EC Decision 2014/276/EU [1] for 5G, and provides proposals for amendments where necessary, focussing on WBB ECSs which use time division duplex (TDD).

## Method for assessing the suitability of existing BEM for 5G

1. In-block radiated power limits

ECC/DEC/(11)06 [2] and EC Decision 2014/276/EU [1] specify[[3]](#footnote-3)::

* a maximum BS in-block EIRP of ≤ 68 dBm/(5 MHz) per antenna (non-mandatory);
* a maximum TS in-block TRP of 25 dBm.

It is important to assess whether these types of requirements for in-block power are applicable for AAS base stations

1. Out-of-block power limits - Interference between operators in adjacent blocks

ECC/DEC/(11)06 [2] and EC Decision 2014/276/EU [1] specify out-of-block EIRP limits for “synchronous TDD” inside the band that are based on 3GPP spectrum emission masks (transmit powers), specified “per antenna”, and predicated on an assumed nominal antenna gain[[4]](#footnote-4). The Decisions specify more stringent out-of-block EIRP limits for unsynchronised TDD.

It is important to assess whether these types of specifications for out-of-block EIRP are applicable for AAS base stations

1. Out-of-band (OOB) power limits - Interference to other services in adjacent bands

In order to continue to ensure protection of radar below 3400 MHz. the existing OOB EIRP limit needs to be reviewed in the context of AAS base station deployments

##  Definitions

### Non-AAS WBB ECS base stations

For the purposes of this document, the term non-AAS (short for non-active antenna systems) refers to WBB ECS base station transmitters which are manufactured and supplied separately to antenna systems. Non-AAS base stations will provide one or more antenna connectors, which are connected to one or more separately supplied passive antenna elements or arrays to radiate radio waves.

The existing regulatory power limits apply to non-AAS WBB ECS base stations, in the sense that they are derived from the analysis of the sum of the radiated powers across multiple antenna connectors, and in some cases accounting for the anticipated antenna directional pattern, and the contribution of these to harmful interference at a victim receiver.

### AAS WBB ECS base stations

AAS (short for active antenna systems) is one of the key features for 5G NR and LTE evolution products.

According to Recommendation ITU-R M.2101 [13] , 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.

For the purposes of this document, the term AAS refers to a base station and antenna system where the amplitude and / or phase between antenna elements is continually adjusted 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.

In AAS base stations the antenna system is integrated as part of the base station system/product. Due to the higher frequencies of the 3400-3800 MHz band compared to those of existing bands harmonised for WBB ECS, and therefore smaller wavelengths and antenna dimensions/spacing, it is feasible to perform beam forming with large numbers (tens) of antenna elements and to benefit from the resulting narrow beamwidths. Performing beam forming with a large number of elements in general requires the antenna array to be supplied and integrated with the base station.

For instance, this can be realised by mapping a set of antenna ports into a physical antenna, where each antenna port consists of a certain number of antenna elements. Consequently, signals from the different antenna ports are added coherently at the receiver side to form a beam pointing in the direction of the receiver. The antenna diagram and beam characteristics will be dependent on the chosen antenna implementation, number of antenna ports, antenna elements, etc. The transmitter will in turn be able to direct the energy to different directions (i.e. following the positions of the served receivers).

### **Total Radiated Power (TRP)**

TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere as shown in the expression below.

 (1)

where

* is equal to the total conducted power input into the antenna array system less any losses in the antenna array system;
* : power radiated by an antenna array system in direction

 (2)

where

* : conducted power (Watts) input to the array system;
* : array systems directional gain along direction.

The maximum EIRP for an AAS base station can be written in log domain as follows:

 (3)

Where is the antenna element gain in dBi, and is the number of beam forming elements.

### **Synchronisation in TDD WBB ECS**

Synchronised operation

The synchronised operation in the context of this Report means operation of TDD in several different networks, where [no simultaneous UL and DL transmissions occur, i.e. at any given moment in time either all networks transmit in DL or all networks transmit in UL. This requires the adoption of a single frame structure for all TDD networks involved as well as synchronising the beginning of the frame across all networks.

See also ECC Report 281 [14].

Unsynchronised operation

The unsynchronised operation in the context of this Report means operation of TDD in several different networks, where at any given moment in time some network transmit in DL and some networks transmit in UL. This might happen if the TDD networks either do not operate with the same TDD frame structure or do not synchronise at the beginning of the frame.

Semi-synchronised operation

The semi-synchronised operation corresponds to the case where part of the frame is consistent with synchronised operation as described above, while the remaining portion of the frame is consistent with unsynchronised operation as described above. This requires the adoption of a frame structure for all TDD networks involved, including slots were the UL/DL direction is not specified, as well as synchronising the beginning of the frame across all networks.

The semi-synchronised operation is only beneficial for small-cells. The interference mitigation techniques necessary for semi-synchronisation would be studied at the earliest in 3GPP Release 16. It is expected that not all User Equipment will be able to support this type of operation.

## Suitability for non AAS WBB ECS

As described in ECC Report 281 [14], the existing baseline and transitional out-of-block power limits in the context of interference between adjacent WBB ECS networks are derived from 3GPP specification TS 37.104 [15], where unwanted emission requirements are applied per antenna connector. 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). Hence, using e.i.r.p. as a metric for setting requirements was considered to be suitable, given the passive nature of the antenna array.

Based on the need to avoid disrupting the usage rights that have been already assigned for non-AAS WBB ECS in the 3400-3800 MHz range, it is proposed to maintain the existing in-block and out of block e.i.r.p. limits as specified in EC Decision 2014/276/EU [1]. Therefore all the existing base station requirements are proposed to continue to apply for non-AAS WBB ECS:

## Suitability for AAS WBB ECS

### Implications from the AAS architecture

The existing BEM requirements for WBB ECS, including IMT-2000 and IMT-advanced technologies, are described in terms of e.i.r.p. power limits at the spectrum block edge. Some of these requirements (i.e. the restricted power limit applying to the non-synchronised WBB ECSs and the additional power limit defined to protect radar systems below 3400 MHz) are not specified in the equipment standard, and are used by national regulators as part of WBB ECS license condition therefore representing a regulatory obligation for mobile operators. To respect such regulatory limits, if needed, in case of non AAS WBB ECS base stations the mobile operators have the possibility to install additional external filter between the base station antenna connector and the antenna.

 (4)

In case of AAS base stations, as illustrated below, the antenna arrays are included in the base station without an accessible interface between the AAS system and the base station. Differently from the case of non AAS base stations, mobile operators do not have the possibility to meet the BEM regulatory limits through the installation of external filters anymore; the BEM regulatory requirements must therefore be met by product design.


Figure 3: Reference point for non AAS vs AAS base station

Given the need to implement any additional filtering inside the AAS base station itself the additional baseline power limits need to be harmonised across Member States as much as possible in order to avoid country-specific or even operator-specific implementations which would not be able to rely on significant economies of scale and would therefore not be commercially viable.

### Out-of-block power limits: Interference between synchronised WBB ECS

EC Decision 2014/276/EU [1] proposes two different BEMs for coexistence of WBB ECS network in adjacent blocks:

One power limit (the "baseline" power limit) applies to the coexistence of networks in synchronised operation, while a more stringent power limit (the "restricted baseline" power limit) is defined for non-synchronised and semi-synchronised networks coexistence (see definition in section 4.2.4).

In this section, we address the suitability of the two “transitional region” power limits and the “baseline” power limit, which apply to synchronised TDD base stations.

ECC Report 281 [14] described the relationship between the 3GPP MSR E-UTRA wide area base station unwanted emission mask and the baseline and transitional regulatory limits in EC Decision 2014/276/EU [1]. 3GPP TS 37.104 [15] specified the relevant unwanted emission mask in the form of conducted power limits measured at the antenna connector.

#### TRP metric vs. e.i.r.p. metric

A second item to be addressed is related to the most appropriate metric to characterise the unwanted emissions from AAS.

The use of TRP for specification of emission limits is illustrated in Figure 4 below. Each of the depicted examples of radiation patterns correspond to the same TRP (i.e. each example is associated with the same area in the two-dimensional diagram).



Figure 4: An illustration of the use of TRP for specification of emission limits

As illustrated above, in terms of impact to adjacent systems (base station downlink direction), for the same total maximum conducted power, adopting a larger number of base station antennas may lead to high values of peak e.i.r.p., although the total radiated power (TRP) will remain unchanged. Least restrictive regulatory technical conditions for AAS WBB ECS base stations should account for this behaviour.

The following text explains why, in the context of AAS base stations, it would be appropriate to specify any amended regulatory limits as TRP.

1. Editor’s Note 1: The section below on 3GPP could be considered during public consultation.

Consistency with the 3GPP approach

Considerable effort has been made by 3GPP to assess the effects of the AAS unwanted emissions on other mobile networks and to identify the appropriate metric for their characterisation. The different characteristics of the AAS systems in comparison with traditional sector or omni-directional antennas were analysed in detail. 3GPP RAN4 technical group has therefore been considering the following approaches for AAS:

* In case of AAS In the context of E-UTRA, the existing conducted unwanted emission masks in TS 37.104 [15] are scaled in accordance with a value N, where N is a function of the number of active transmitter units per cell/sector and is capped at the value of 8 . This approach is described in Section 6.6.5 of TS 37.105 [16].
* In case of AAS in the context of 5G-New Radio and LTE evolution, the unwanted emission masks will be specified as over-the-air (OTA) rather than conducted power limits. Furthermore, the OTA emission limits will be specified as TRP, rather than e.i.r.p. This is because 3GPP studies have indicated that harmful interference to adjacent mobile systems is primarily dictated by the TRP (rather than the e.i.r.p.) of a base station in any given cell or sector.

The 3GPP approaches are illustrated in Figure 5 below. It is important that any amendments to the transitional and baseline limits in the context of 5G account for the above developments at 3GPP.

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Figure 5: Developments at 3GPP for active antenna systems and 5G

3GPP studies [17] have shown that the impact in terms of throughput degradation of the unwanted emissions on the adjacent mobile systems (i.e. inter-WBB ECS interference) depends on the total amount of interference which is injected into the network. Such total amount of interference is well represented by the TRP. Setting the requirements in terms of TRP would limit the level of throughput degradation in the victim network to a desired level. The total emissions power and not the spatial pattern impacts the victim network.

Even for the same antenna implementation, the wanted signal and the unwanted signal may have different beam shapes. The correlation properties of the unwanted emissions coming from the different AAS transmitters will be implementation dependent and may differ between different BS implementations. If the unwanted emissions at each transmitter would be fully correlated, then the unwanted emissions would form the same spatial pattern as the wanted signal (i.e. a narrow, moving beam). If on the other hand the unwanted emissions from each transmitter would be uncorrelated, then there would be no beam forming and the unwanted emissions can be expected to form the same spatial pattern as that of the individual radiating antenna elements (i.e. a wide beam).

The relationship between the TRP and e.i.r.p. is therefore not known, as it is directly related to the number of radiating antennas, specific base station implementation (e.g. geometry of the antenna array: elements spacing, linear array of elements) and correlation between unwanted emission signals from different antenna ports[[5]](#footnote-5). In other words, specifying an e.i.r.p. limit could result in different levels of TRP depending on implementations. This would in turn cause different implementations that would meet an e.i.r.p. requirement to cause different levels of degradation in a victim network. Thus e.i.r.p. would be an inappropriate metric.

The definition of an e.i.r.p. limit, can lead to the situation for which the system with lower antenna gain could meet the emission requirements by injecting higher level of interference into the network (the exaggerated example depicted on the right hand side in Figure 6. Therefore, specifying an e.i.r.p. requirement will not allow guaranteed control of the total amount of interference in the network.



Figure 6: Example spatial patterns of unwanted emissions from two AAS base stations, both meeting the same e.i.r.p. limit but radiating different TRPs corresponding to different conducted unwanted emissions power levels

On the other hand, a TRP requirement will limit the total amount of interference injected in the network regardless the specific BS implementation. For the same level of TRP, BS with higher antenna gains will have higher directivity, thus higher spatial control of the radiating interference, while the total amount of injected interference will be the same compared to a BS deploying lower number of antenna elements.

In other words, different BS implementations may lead to the same impact on a given victim system, meaning that limiting the BS implementation would not bring any benefit to the victim system and would only lead to less flexible and less efficient antenna solutions. Hence, the requirements should be independent of the correlation level of the unwanted emissions.

Setting the requirements for AAS in terms of e.i.r.p. would lead to misleading results and potentially reduced protection [18] or overprotection for coexisting systems.

It is worth noticing that a TRP requirement would also correspond to the conducted requirement in case of an ideal system with perfect matching and no antenna losses.

The throughput impact of emissions from an AAS network to a legacy (non-AAS) victim network was analysed using simulations for the specific class of antenna arrays with specific elements spacing (that is described in section 5.4 of 3GPP TR 37.840 [19], [20]). Different correlation properties between transmitters were simulated and the level of the AAS unwanted emissions were varied in order to observe the effect of correlation and emissions level of an AAS on a legacy (non-AAS) victim network. With the simulation assumptions used for the studies, 100% correlation implies that the unwanted emissions are beam-formed in the same manner as the wanted signal. Such correlation is very unlikely, but was included in the study for completeness. 0% correlation implies that the unwanted emissions are not beam-formed but are radiated with the individual antenna element pattern. It was found that the aggressor (AAS BS) total radiated unwanted emissions power was directly proportional to the victim network throughput degradation, independently of the correlation and hence the spatial pattern of the unwanted emissions. The results of these studies showed that, the level of correlation (and hence the spatial pattern of the emissions) does not impact the coexistence performance. Simulations have shown, for the specific antenna configuration used, that the TRP would be an appropriate metric in assessing harmful interference since it would be independent of the effect of correlation level.

In other words, different BS implementations may lead to the same impact on a given victim system, meaning that limiting the BS implementation would not bring any benefit to the victim system and would only lead to less flexible and less efficient antenna solutions. Hence, the requirements should be independent of the correlation level of the unwanted emissions.

Finally, another relevant element behind 3GPP choice of defining unwanted emission with a TRP metric is the different behaviour between passive and active antenna systems. In case of passive systems, the antenna gain does not vary much between the wanted signal and unwanted emissions. Thus e.i.r.p. is directly proportional to TRP and can be used as a substitute. For active systems, the e.i.r.p. could vary wildly between wanted signal and emissions and between implementations, so e.i.r.p. is not proportional to TRP and using e.i.r.p. to substitute TRP would be incorrect.

Based on the above, if the OTA unwanted emissions are based on total radiated emissions around the base station, the coexistence performance provided by the OTA unwanted emissions requirements will be the same as with the requirements of today. On the other hand, if the requirements are based on directional emissions power (e.i.r.p.), the level of coexistence protection would be variable depending on the spatial pattern of the unwanted emissions and the amount of correlation in unwanted emissions between transmitters, which would be variable and probably implementation dependent.

As a minor note, it is worth noticing that a TRP requirement would also correspond to the conducted requirement in case of an ideal system with perfect matching and no antenna losses.

Based on the above observations, 3GPP has concluded that TRP is the appropriate metric for specifying the ACLR and out-of-block emission limits, in the context of interference between adjacent channel mobile networks.

Implications from the AAS architecture

As described in section 4.4, in case of AAS base stations, the antenna arrays are included in the base station without an accessible interface between the AAS system and the base station.

In addition, the AAS antenna main beam moves while following the UE positions, the base station BEM compliance measurement procedure proposed in the ECC Decision (11)06 [2] may not be applicable anymore. The AAS base station unwanted emission mask including out of band emissions and spurious emissions needs to be specified and tested in lab as TRP levels, the conducted power test does not apply to AAS base stations.

Therefore:

* The current regulatory technical conditions (e.i.r.p. BEM) studied in the ECC Report 203 [11] are applicable for 3G/4G WBB ECS and fixed wireless access networks which do not use AAS antennas, but they are not suitable and cannot be applied to 4G and 5G WBB ECS AAS base stations with integrated antenna arrays;
* The unwanted emissions are to be specified as over-the-air (OTA), rather than as conducted requirement, since the conducted power cannot be measured due to the fact that the amplifier is an integral part of the antenna element. In particular, the OTA emission limits will be expressed in terms of TRP rather than e.i.r.p.;
* TRP-based BEM for AAS base stations may need to be included in the BS standard, e.g. European Harmonised Standard due to the fact that operators will not be able to improve the product performance as specified in the standard since external filters cannot by applied to AAS base stations and due to the fact that TRP limits can be measured in laboratories but not in the field.

#### Synchronisation in 5G NR

Several LTE-TDD networks are currently providing services to millions of end users with hundreds of thousands of base stations deployed in the field adopting synchronisation and alignment of uplink and downlink transmissions between operators using adjacent frequency blocks: such networks provide proven experience in the field that should be considered as the starting point for the definition of the regulatory framework for 5G NR.

With particular reference to the aspect of interference between WBB ECS networks, the updated CEPT regulatory framework should account for the following principles:

* Leverage on proven technologies and best practices in the field by accounting for them in the framework baseline[[6]](#footnote-6);
* The framework should remain open towards technology evolutions such as those that are being discussed in 3GPP defining new schemes that will ensure more flexibility in UL and DL transmissions between 5G NR networks operating in adjacent frequency blocks. The specifications for such schemes are currently being discussed and will be finalised within Release 16 of the 5G NR specifications;
* The framework baseline should be applicable to all UEs.

One of the most important features of NR is the ability to choose the transmission direction of any portion of the slot and the ability to use any portion of the slot for control or data. This ability allows flexibility in adapting to the traffic pattern as well as latency reduction, improved capacity, robust mobility. Interference management would be simplified in case of alignment of the transmission directions at least for some portions of the slot (e.g. portions used for control plane).

NR is also defining the framework for the network to evaluate the interference conditions and dynamically adjust the transmission direction based on traffic demand, especially in small cell deployment topologies. This possibility of dynamically adjusting the transmission direction based on traffic demand is not defined today for Macro cells deployment topology, and therefore this capability cannot be assumed as a baseline for all possible deployment scenarios in particular the very important case of Macro cells.

Different examples of slot configuration are being discussed in 3GPP as presented below.

Figure 7 below shows an example of NR-NR coexistence with UL and DL control transmission in every slot. In this case, each slot has both DL and UL control regions at the edges, whereas the middle is occupied with UL or DL data. The position of the DL and UL control blocks in this special case are fixed regardless of whether this is an UL-centric or DL-centric slot. The critical control regions are therefore protected from cross-link interference even when adjacent channel deployment chooses to utilise the same slot for data in the opposite direction (as seen in the middle slot in Figure 7).

 Figure 7: Example of NR-NR coexistence with UL and DL control transmissions in every slot

This configuration is defined in 3GPP as a UE capability that only capable UEs support. Not all UEs from the market are mandated to support it. Therefore it cannot be considered as the baseline assumption for 5G WBB ECS synchronisation.

Other possible scenarios exist as shown in Figure 8 below where the DL and UL control regions are not present in all slots, some portions of the slots are reserved for aligned UL or DL transmissions either for data or control plane between adjacent networks.

Figure 8: Example of NR-NR coexistence with portions of the slot dedicated to UL or DL transmissions [either for control or data plane]

Interference caused by non-aligned UL-DL data transmissions between adjacent networks are expected to be managed through:

* Introducing a frequency separation (not using certain radio resource at the edge of the channel);
* Reducing the DL data transmit power in the DL/UL misaligned subframes, together with some advanced scheduling and receiving solutions such as cross-link interference mitigation mechanisms.

### Out-of-block power limits: Interference between non-synchronised WBB ECS

Simulations were carried out in ECC Report 281 [14] for the coexistence between unsynchronised WBB ECS at 3400-3800 MHz, leading to the definition of restricted power limits which would apply to AAS base stations. Specifically, the following two scenarios have been considered:

* Interference from AAS base stations to non-AAS base stations;
* Interference from AAS base stations to AAS base stations.

The impact of interference was assessed by evaluating the degradation in the mean uplink throughput of the victim WBB ECS.

### Out-of-block power limits: Interference between LTE and 5G NR WBB ECS

Coexistence between LTE network and 5G NR in adjacent frequencies is ensured when either:

* Respecting the baseline level in case of synchronised operation;
* Respecting the restricted baseline level in case of non-synchronised LTE and 5G NR networks.

The two approaches are assessed in more details in the following sections leading to the following conclusions:

Synchronised operation between 5G NR and LTE is technically feasible but may lead to higher latency and reduced flexibility in the UL/DL transmission ratio, although networks could be designed to overcome some of these drawbacks.

In case of unsynchronised operation of 5G NR and LTE networks, respecting the restricted baseline level for unsynchronised WBB ECS networks coexistence would be challenging to implement as AAS systems cannot be fitted with additional external filters. Assuming it would be economically feasible to comply with such baseline a frequency separation is likely to be required and studies should be conducted to determine the width of such a frequency separation.

#### Common synchronisation between LTE and 5G NR

This section provides an analysis on the possibility to synchronise and align LTE and 5G NR transmissions from a technical perspective and the associated implications.

As first step, the following section provides the necessary technical background related to 5G NR subcarrier spacing and symbol alignment. This background is based on 3GPP agreements.

5G NR subcarrier spacing

3GPP RAN1 has agreed on an LTE-based 5G NR subcarrier spacing (and cyclic prefix length) for 5G NR based on 2^n×15 "kHz" subcarrier spacing as illustrated in the example table below.

The value of the parameter n depends on the intended frequency band. For instance, n = 0, 1 and 2, corresponding to 15, 30 and 60 kHz subcarrier spacing, are considered by 3GPP RAN4 for frequencies below 6 GHz. On the other hand, larger subcarrier spacing is considered for frequencies above 6 GHz, e.g. 120 kHz, in addition to 15, 30 and 60 kHz.

Table 2: Subcarrier spacing for 5G NR for frequencies below 6 GHz

|  |  |  |
| --- | --- | --- |
| Subcarrier spacing | Slot duration(assuming 7 OFDM symbols per slot) | Slot duration(assuming 14 OFDM symbols per slot) |
| 15 kHz | 500 µs | 1000 µs |
| 30 kHz (2 x 15 kHz) | 250 µs | 500 µs |
| 60 kHz (4 x 15 kHz) | 125 µs | 250 µs |

The corresponding 3GPP agreement is captured in [22].

Symbol alignment

The Symbol alignment is a 5G NR property, allowing a long OFDM symbol (i.e. with narrow subcarrier spacing) to exactly cover an integer number of shorter OFDM symbols (i.e. with wider subcarrier spacing). Figure 9 is an illustration of the symbol alignment property of 5G NR.

The darker symbols in Figure 9 are symbols with longer Cycle Prefix (CP), as the cyclic prefix of the first OFDM symbol in every 0.5 ms interval is 16 x longer than the cyclic prefix of the remaining symbols in the time interval ( is the 30.72 MHz chip duration).

As Figure 9 shows, a 15 kHz NR symbol exactly covers four 60 kHz NR symbols. Similarly, considering an LTE sub-frame of 1 ms, the latter would exactly overlap with four 14-symbols 60 kHz NR slots.

Figure 9: Symbol alignment in 5G NR

5G NR slot structure can therefore be utilised in a manner such that the direction of transmission is fully aligned with the LTE TDD Configuration.

Considering that symbol alignment is a fundamental property of 5G NR, and that it ensures alignment between LTE and 5G NR as described in the previous sections, it can be concluded that synchronisation and alignment of UL/DL transmissions between LTE and 5G NR base stations is technically feasible.

Implications

Although complete alignment of UL/DL transmissions between LTE and NR can be achieved as described above, this would have implications on the minimum latency achievable by 5G NR. Full synchronisation of the NR slot structure and LTE TDD Configuration brings significant drawback to the NR implementation. Many of the benefits of NR are linked precisely to the frame structure. Reverting to the LTE structure would imply higher latency, higher UE memory cost, TCP performance loss, mobility performance loss and spectral efficiency loss, although networks could be designed to overcome some of these drawbacks.

#### No common synchronisation between LTE and 5G NR

A possible alternative to the synchronised approach implies respecting the restricted baseline level for non-synchronised WBB ECS coexistence.

Differently from the case of non-AAS base stations, respecting the restricted baseline limit would imply the introduction of an additional internal filter within the AAS bases station. Since the implementation of such filters would depend on the operator's spectrum specific assignment, the filter (and the AAS base stations) would become operator-specific which would not be sustainable in terms of effort.

### Out-of-band power limits: Interference towards radars below 3400 MHz

The existing regulatory requirements for the protection of radiolocation systems below 3400 MHz from WBB ECS non-AAS base stations (-50 dBm/MHz or -59 dBm/MHz e.i.r.p. applied below 3400 MHz) introduce implementation challenges in WBB ECS base stations.

Adjacent band protection requirements for radiolocation systems below 3400 MHz were therefore carefully studied for both non-AAS and AAS base stations, especially as the latter may not allow the installation of additional external filters.

Differently from the MCL studies carried out for the derivation of current additional baseline e.i.r.p. limits, the studies supporting this report took into account the directional antenna patterns at the mobile network base station transmitter.

ECC Report 281 [14] described two studies where the probability of the interference at a terrestrial radar receiver exceeding a target level of -118 dBm/MHz (corresponding to I/N of -6dB) has been calculated via Monte Carlo simulations and as a function of WBB ECS base station out-of-block radiations for a number of scenarios.

Considering the outcomes from the studies in ECC Report 281, a value of −52 dBm/MHz is considered as an appropriate TRP value to be adopted to ensure protection of radiolocation systems below 3400 MHz.

Several observations can be made based on the results of the studies in described in ECC Report 281:

* The probability of exceeding any given interference threshold (exceedance probability) increases monotonically with the WBB ECS base station out-of-block e.i.r.p. and TRP;
* The out-of-block TRP required for a given exceedance probability is more stringent for WBB ECS macro base station deployments than for WBB ECS micro base station deployments;
* The statistics of interference at the radar receiver as a function of TRP are far less sensitive to the correlation level (extent of beam forming) than is the case for e.i.r.p. In case of AAS base stations, the use of the e.i.r.p. metric would imply widely different levels of interference to radar systems below 3400 MHz, depending on the extent of signal correlation across the base station’s antennas;
* The impact of the correlation of out-of-block signals across the antenna elements of an AAS WBB ECS base station on the exceedance probability varies according to the value of out-of-block TRP considered;
* The regulatory out-of-block power limits below 3400 MHz should be specified as TRP;
* For the protection of a terrestrial radar receiver, a study was performed for an out-of-block TRP limits below 3400 MHz, corresponding to a 0.1% probability that the I/N at the terrestrial radar receiver would exceed -6 dB.

### Out-of-band power limits: coexistence with FSS/FS above 3800 MHz

ECC Decision (11)06 [2] states that coordination[[7]](#footnote-7) between WBB ECS and FSS or FS should be carried out on a case-by-case basis, since no single separation distance, frequency separation or signal strength limit can be provided. The Decision (in its Annex 5) provides the key principles the Administrations should implement in relation to the coexistence with other services than WBB ECS in the 3400-3800 MHz range.

More recently, the ECC published ECC Report 254 [3] containing operational guidelines to support the implementation of the current ECC framework for Mobile/Fixed Communications Networks (MFCN) in the 3600-3800 MHz range. The Report outlines optional procedures to enable administrations to allow sharing between MFCN (WBB ECS) and Fixed Satellite Service and Fixed Service in this band. Based on national circumstances an administration might apply the most suitable procedures to set up its national sharing framework.

Given the fact that the 3400-3800 MHz range is considered as a 5G primary band suitable for the introduction of 5G-based services in Europe even before 2020, Administrations will carefully assess the usage of spectrum within 3400-3600 MHz with an option of clearing the band, as much as possible, from incumbent services. Where appropriate, CEPT administrations will need to specify the provisions necessary to enable and facilitate the clearing or coexistence between 5G-based services and the existing incumbent services (FSS/FS) in the 3400-3800 MHz band. Decisions will be taken based on impact assessments to determine the preferred approach with respect to incumbent services. Such assessments will be carried out at national level accounting for the overall social and economic benefits.

In addition, with specific reference to AAS base stations, the definition of a harmonised out-of-band power limit at the 3800 MHz edge can represent a valid support to the coordination procedures to be implemented at national level on a case-by-case basis to facilitate coexistence with FSS Earth stations and fixed links operating in the 3800-4200 MHz range. Compared to the existing framework that remains valid for non-AAS base stations, the addition of such provision is justified by the need to ensure that any additional regulatory limit is harmonised across CEPT countries in order to avoid country specific or even operator specific implementations for AAS base stations (see ECC Report 281 [14]).

### Out-of-band power limits: coexistence with radio astronomy

For the protection of RAS observations from possible detrimental interference by AAS WBB ECS, exclusion zones around RAS stations may be required based on coordination at national level on a case-by-case basis.

### In-block power limits

No mandatory limit was defined in the existing regulatory framework. The same approach is proposed in the updated regulatory framework.

# Proposed BEM requirements for AAS WBB ECS Base Stations

Based on the analysis presented in the previous section, the following sections propose updates to the some of the BEM elements.

## Out-of-block power limits: Interference between synchronised WBB ECS

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 WBB ECS-to-WBB ECS interference in the case of synchronised networks and time aligned UL/DL transmissions.

In alignment with how unwanted emission conducted power (TRP) for AAS base stations is specified by 3GPP TS 38.104 [26], 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.

For the case of synchronised WBB ECS with time aligned UL/DL transmissions, the following Table 3 shows the proposed out-of-block TRP limits for the update of EC Decision 2014/276/EU [1].

Table 3: Proposed updated baseline and transitional power limits for AAS base stations

|  |  |  |
| --- | --- | --- |
| BEM element | Frequency range | AAS TRP power limitdBm / 5MHz |
| Transitional region | -5 to 0 MHz offset from lower block edge 0h to 5 MHz offset from upper block edge  | Min(PMax'-40, 16) |
| Transitional region | -10 to -5 MHz offset from lower block edge5 to 10 MHz offset from upper block edge | Min(PMax'-43, 12) |
| baseline | Below -10 MHz offset from lower block edge.Above 10 MHz offset from upper block edge.Within 3400-3800 MHz | Min(PMax'-43, 1)  |
| Notes (1) PMax' is the maximum mean carrier power for the base station measured as TRP per carrier(2) The transitional regions and the baseline power limit apply to the synchronised operation of WBB ECS networks as defined in section 4.2.4(3) TRP for Pmax’, for baseline and for transitional apply to the whole antenna panel |

## Out-of-block power limits: Interference between non-synchronised and semi synchronised WBB ECS

EC Decision 2014/276/EU [1] provides power limits for coexistence between unsynchronised WBB ECS networks through the definition of a single baseline level.

It is proposed to update the existing baseline limit in line with the simulation results provided in ECC Report 281 [14], and to express this in terms of TRP as indicated below.

Table 4: Updated restricted baseline power limits for AAS base stations
 for unsynchronised WBB ECS networks

|  |  |  |
| --- | --- | --- |
| BEM element | Frequency range | AAS TRP power limitdBm / 5MHz |
| Restricted baseline | Below the lower block edgeAbove the upper block edgeWithin 3400-3800 MHz | -43 |
| Note (1) TRP for restricted baseline applies to the whole antenna pane |

## Out-of-band power limits: Interference towards radars below 3400 MHz

Based on the coexistence analysis in ECC Report 281 [14]:

* The cumulative effect of interference (due to a set of BSs in the vicinity of the radar) case onto radiolocation system involves different situations of interfering and receiving antennas pointing (because of the moving nature of radar antenna and IMT-2020 AAS) which requires to use a metric accounting the interference in all directions like TRP;
* it shows that the single entry worst case scenario would more rely on an e.i.r.p. metric to set the unwanted emission limits but at the same time may be not applicable in practice since statistical and aggregated study of interference is needed to address any future deployment of 5G in 3400-3800 MHz;
* it raises a question about the correlation level (between elements of the antenna arrays) issue by observing that the distribution of *Iagg/N* isn’t necessarily similar for both full correlation & uncorrelated elements of the antenna panel and that the gap between the results may be high. It shows that this dependence may be linked with the statistical pointing of the IMT-2020 BS beam which differ for small cell & macro BSs. Further investigation on that issue is needed.

In line with the simulation results from ECC Report 281 the following power limits are proposed for countries wishing to protect radar below 3400 MHz. It is noted that, for AAS base stations, manufacturers have indicated that the power limit of -52 dBm/MHz would imply, under current technology, approximately 20 MHz frequency separation between the block edge and 3400 MHz.

Table 5: Updated base station additional baseline power limits below 3400 MHz for country specific cases for AAS and non-AAS base stations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case | BEM element | Frequency range | Non AAS e.i.r.p. power limitdBm/MHz per cell(1) | AAS TRP(2) power limitdBm/MHz |
| A | CEPT countries with military radiolocation systems below 3400 MHz | Additional Baseline | Below 3400 MHz | -59 | -52 |
| B | CEPT countries with military radiolocation systems below 3400 MHz | Additional baseline | Below 3400 MHz | -50 |
| C | CEPT countries without adjacent band usage or with usage that does not need extra protection | Additional baseline | Below 3400 MHz | Not applicable | Not applicable |
| (1) In a multi-sector site, the value per ‘cell’ corresponds to the value for one of the sectors.(2) TRP for additional baseline applies to the whole antenna panel |

EU Member States may select the limits from case A or B depending on the level of protection required for the radar in the region in question.

The additional baseline limit can be applied per region or country so that the adjacent band may have different levels of protection in different geographical areas or countries, depending on the deployment of the adjacent band systems.

In addition, the levels given in Table 5 are only applicable to outdoor cells. In case of indoor deployments, the levels can be relaxed on a case by case basis[[8]](#footnote-8).

Other mitigation measures such as geographical separation, coordination on a case by case basis or an additional frequency separation may be necessary for a TDD allocation. For countries with military radiolocation systems below 3400 MHz a required coordination zone of up to 12 km around fixed terrestrial radars, based on a AAS TRP power limit of -52 dBm/MHz per antenna panel, may be needed. Such coordination is under responsibility of the relevant EU Member State.

For UEs other mitigation measures will be necessary such as e.g. geographical separation or an additional frequency separation.

## **Out-of-band power limits: Coexistence with FSS/FS**

Accounting for the analysis in section 4.4.6, the baseline and transitional power limits defined in Table 6 are applied at the 3800 MHz band edge to support the coordination process to be carried out at national level on case by case basis with support from the operations guidelines from ECC Report 254 [3].

Table 6: Additional baseline limits for AAS base stations above 3800 MHz for the protection of FSS and FS

|  |  |  |
| --- | --- | --- |
| BEM element | Frequency range | Power limit forAASTRP (dBm/5MHz) |
| Additional baseline  | 3800-3805 MHz | Min(PMax'-40, 16)  |
| 3805-3810 MHz | Min(PMax'-43, 12) |
| Above 3810 MHz  | Min(PMax'-43, 1) |

## **In-block power limit**

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 2014/276/EU [1] to TRP for consistency with the out-of-block limits .

This implies the conversion of the existing e.i.r.p. limit of 68 dBm/5MHz per antenna for the non-AAS base station to a corresponding TRP limit (assuming, , a 21 dBi antenna gain). In alignment with how unwanted emission conducted power (TRP) for AAS base stations is specified by 3GPP TS 38.104 [26], 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.

Proposed not obligatory in-block power limit for AAS base stations

Table 7: Proposed in-block power limit for AAS base stations

|  |  |  |
| --- | --- | --- |
| BEM element | Frequency range | AAS TRP power limitdBm/5MHz |
| In-block | Block assigned to the operator | Not obligatory.[In case an upper bound is desired by an administration, a value of 47 dBm/5 MHz for the whole antenna panel may be applied.]For femto base stations, the use of power control is mandatory in order to minimize interference to adjacent channels. |

As for the technical condition for user equipment (UEs) it is recommended that the UE in-block radiated power does not exceed 28 dBm.

# Cross-border coordination

Cross-border coordination is managed on a bilateral and multilateral basis between CEPT administrations. Even in the context of the current fragmented usage in the 3400-3800 MHz band, CEPT administrations do not currently experience unmanageable cross-border coordination issues. It should be noted that cross-border coordination parameters differ from the harmonised technical conditions proposed in this CEPT report

Initiatives from CEPT administrations to deploy 5G in this band and ongoing work to re-organise the band to provide contiguous blocks of spectrum should make bilateral and multilateral negotiations less complex. CEPT is developing recommendations to support the bilateral/multilateral negotiation and will ensure 5G is addressed in these recommendations.

It is noted that in the Radio Regulations [4], the mobile service has a secondary allocation in the frequency range 3600-3800 MHz, while in the ECA Table (ERC Report 25) [5] the mobile service has a primary allocation in this frequency range.

# Conclusions

This report has assessed the existing regulatory framework for 3400-3800 MHz to assess its suitability for 5G, focussing in particular on the use of AAS base stations.

The following changes are proposed to the existing framework as a result of this analysis:

* 5G use cases suggest the adoption of minimum contiguous frequency allocations of around 50/80 MHz per operator. Therefore the spectrum should be provided in a manner allowing for at least 3x50 MHz of contiguous spectrum;
* There is no need to consider separate frequency arrangements for 3400-3600 MHz and 3600-3800 MHz from a regulatory perspective. The unpaired arrangement is therefore selected as the only option for the 3400-3800 MHz band;
* The levels of existing out-of-block power limits for coexistence of synchronised WBB ECS BS are proposed to be used for AAS base stations, specified as TRP limits for the whole antenna panel;
* An out-of-block power limit of -43 dBm/(5 MHz) TRP is proposed as the restricted baseline for coexistence of unsynchronised and semi-synchronised WBB ECS BS if no geographic separation is available. Less stringent technical parameters, if agreed among the operators of such networks, may also be used. [In addition, depending on national circumstances, administrations may define relaxed baseline limit applying to specific implementation cases to ensure a more efficient usage of spectrum.] Specific measures to facilitate unsynchronised operation include:
	+ Frequency separations and/or restricted blocks;
	+ Additional filter to be applied at the WBB ECS base station transmitters and receivers;
	+ Site coordination between operators: inter-site distance separation (for non co-located sites), antenna separation distances and site engineering (for co-located sites);
	+ Reduction of the base station output power.
* For protection of radars below 3400 MHz, limits for AAS base station of -52 dBm/MHz per cell/sector TRP are proposed, which manufacturers have indicated would imply, under current technology, approximately 20 MHz frequency separation between the block edge and 3400 MHz. Other mitigation measures such as geographical separation, coordination on a case by case basis or an additional frequency separation may be necessary for a TDD allocation. For countries with military radiolocation systems below 3400 MHz a coordination zone of up to 12 km around fixed terrestrial radars, based on a AAS TRP power limit of −52 dBm/MHz per antenna panel, may be needed. Such coordination is under responsibility of the relevant EU Member State;
* For protection of FSS and FS above 3800 MHz, the baseline for synchronised operations and transitional power limits are additionally proposed to be applied for AAS base stations at the 3800 MHz band edge to support the coordination process to be carried out at national level on case by case basis with support from the operations guidelines from ECC Report 254 [3]**;**
* the existing in-block e.i.r.p. limit for non-AAS base stations is proposed to be converted to [47 dBm/5 MHz] TRP per antenna panel for AAS base stations;
* A UE in-block limit of 28 dBm TRP is proposed.

Coexistence between LTE network and 5G NR in adjacent frequencies is ensured when either:

* Respecting the baseline level in case of synchronised operation, or;
* Respecting the restricted baseline level in case of non-synchronised LTE and 5G NR networks

Synchronised operation between 5G NR and LTE is technically feasible but may lead to higher latency and reduced flexibility in the UL/DL transmission ratio, although networks could be designed to overcome some of these drawbacks.

In case of unsynchronised operation of 5G NR and LTE networks, respecting the restricted baseline level for non-synchronised ECS WBB coexistence would be challenging to implement as AAS systems cannot be fitted with additional external filters. A frequency separation is likely to be required and studies should be conducted to determine the width of such frequency separation.

Cross-border co-ordination can be sufficiently addressed through existing bilateral and multi-lateral procedures, supported by ECC Recommendations. CEPT will work to ensure Recommendations are 5G compatible.

1. cept mandate

|  |  |
| --- | --- |
|  | EUROPEAN COMMISSIONCommunications Networks Content & Technology Directorate-GeneralElectronic Communications Networks & Services**Spectrum**  |

Brussels, 7 December 2016

DG CONNECT/B4

**RSCOM16-40rev3**

 **PUBLIC**

**RADIO SPECTRUM COMMITTEE**

**Working Document**

**Opinion of the RSC
pursuant to Advisory Procedure under Article 4 of Regulation 182/2011/EU and Article 4.2 of Radio Spectrum Decision 676/2002/EC**

**Subject: Mandate to CEPT to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union**

*This is a Committee working document which does not necessarily reflect the official position of the Commission. No inferences should be drawn from this document as to the precise form or content of future measures to be submitted by the Commission. The Commission accepts no responsibility or liability whatsoever with regard to any information or data referred to in this document.*

**Mandate to CEPT**

 **to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union**

Purpose

This Mandate should deliver harmonised technical conditions, including sharing conditions wherever needed, which are suitable for the initial launch (by the year 2020) of next-generation (5G) terrestrial wireless systems in the Union, in selected frequency bands. These conditions should comply with the overarching Union spectrum policy principles of technology and service neutrality and efficient use. In particular, they should ensure the (continued) provision of wireless broadband electronic communications services including relevant 5G usage scenarios such as wireless broadband or the Internet of Things. 5G terrestrial wireless systems are likely to operate both, in existing EU-harmonised frequency bands below 6 GHz and in pioneer frequency bands above 24 GHz.

Timely availability of spectrum designated to 5G in the Union is key for keeping up with the pace of global 5G developments and early infrastructure deployment[[9]](#footnote-9). Therefore, timely deliverables under this Mandate are needed with focus on early available ('pioneer') frequency bands, in order to enable their harmonisation and use for 5G terrestrial wireless systems in the Union. Depending on the evolving assessment of 5G spectrum needs at Union level as well as international developments, the Commission may consider one or more follow-up mandates to CEPT.

1. **Policy context and inputs**

The ITU-R vision for the next-generation mobile telecommunications[[10]](#footnote-10) outlines three major 5G usage scenarios for the time frame of 2020 and beyond – enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable and low latency communications (URLLC). Furthermore, WRC-15 initiated studies on a list of potential additional frequency bands for next-generation (5G) terrestrial wireless systems within the 24.25-86 GHz frequency range[[11]](#footnote-11), which should provide deliverables to enable WRC-19 to take a decision under agenda item 1.13 with a focus on global harmonisation.

The 5G Infrastructure Public Private Partnership (5G-PPP)[[12]](#footnote-12) was launched by the European Commission in 2013 with the goal to develop 5G communication systems and services for the provision of ubiquitous super-fast connectivity and seamless service delivery and thus to foster European leadership in technology and standardisation. The 5G-PPP Infrastructure Association (IA) has delivered concept papers[[13]](#footnote-13) on a 5G vision as well as on the significance of novel use cases originating from connectivity to specific vertical sectors (such as transport, healthcare or media). In terms of spectrum, the 5G-PPP IA emphasizes the need for very wide contiguous carrier bandwidths (e.g. hundreds of MHz up to several GHz) to be provided at a very high overall system capacity with focus on carrier frequencies above 6 GHz. Furthermore, vertical sectors are considered drivers of 5G requirements from the outset with high priority, in particular within frequency bands below 6 GHz. It is also recommended to consider any new bands for 5G use based on assessment and recognition of other services using, or planning to use, these bands. The 5G-PPP IA has liaised with the Radio Spectrum Policy Group (RSPG)[[14]](#footnote-14) regarding pioneer frequency bands for the Union.

In April 2016, the Commission adopted a package on the "Digitisation of the European Industry"[[15]](#footnote-15), which identified as a political priority for the Union use cases for next-generation wireless services in the context of the Internet of Things but also stressed the need to prepare the introduction of next-generation wireless broadband services. In September 2016, the Commission adopted its Communication to the Council and the European Parliament "5G for Europe: An Action Plan"[[16]](#footnote-16), which inter alia puts forward proposed actions on the EU-level identification and harmonisation of spectrum for 5G – pioneer frequency bands as well as additional bands – based on the opinion of the RSPG. The preparatory work for the 5G Action Plan drew on a major input from industry in the telecom and vertical sectors – the "5G Manifesto for timely deployment of 5G in Europe"[[17]](#footnote-17) – which includes recommendations on pioneer frequency bands for 5G use in consistency with the views of the 5G-PPP.

Therefore, next-generation (5G) terrestrial wireless systems should operate both, in existing EU-harmonised frequency bands below 6 GHz and in new frequency bands above 24 GHz. Potential hybrid business models using fixed or mobile terrestrial network infrastructure and satellite platforms may impact on spectrum use in 5G frequency bands above 24 GHz in the context of providing complementary or convergent services.

The following EU-harmonised frequency bands for terrestrial systems capable of providing wireless broadband electronic communications services are already potentially available for future 5G use:

* Below 1 GHz[[18]](#footnote-18): 694-790 MHz ('700 MHz band'), 790-862 MHz ('800 MHz band'), 880-915 MHz and 925-960 MHz ('900 MHz band').
* Above 1 GHz[[19]](#footnote-19): 1452-1492 MHz ('1.5 GHz band'), 1710-1785 MHz and 1805-1880 MHz ('1800 MHz band'), 1920-1980 MHz and 2110-2170 MHz ('paired terrestrial 2 GHz band'), 2500-2690 MHz ('2.6 GHz band'), 3400-3800 MHz ('3.6 GHz band').

It should be noted that in all these frequency bands, with the exception of the 900 MHz and 1800 MHz bands, the harmonised technical conditions are based on the concept of block edge masks, in order to facilitate a technologically neutral approach and least restrictive conditions, which allows for the use of any technology that complies with the block edge mask. For the 900 MHz and 1800 MHz frequency bands, the harmonised technical conditions are based on specific technologies referenced through ETSI standards, which are evolving to enable 5G use.

EU-harmonised bands for wireless broadband electronic communications services are potentially to be used for providing amongst other services vehicle-to-anything (V2X) connectivity, machine-to-machine or other IoT applications, e.g. by means of cellular networks. In this regard, the Commission has adopted a Communication on European Strategy on Cooperative Intelligent Transport Systems[[20]](#footnote-20).

In its "Strategic Roadmap towards 5G for Europe: Opinion on spectrum related aspects for next-generation wireless systems (5G)"[[21]](#footnote-21), the RSPG sets out its priorities and recommendations for pioneer frequency bands for the introduction of 5G terrestrial wireless systems in Europe as follows:

1. The RSPG considers the frequency band **3400-3800 MHz** to be the **primary band** suitable for the introduction of 5G-based services in Europe even **before 2020** given that it is already harmonised for mobile networks and offers wide channel bandwidth[[22]](#footnote-22).
2. The RSPG is of the opinion that 5G will need to be deployed also in bands already **harmonised below 1 GHz**, including particularly **the 700 MHz band[[23]](#footnote-23)**, in order to enable nation-wide and indoor 5G coverage.
3. The RSPG recognises the need to ensure that technical and regulatory conditions for **all bands already harmonised** for mobile networks are **fit for 5G use**.
4. The RSPG recommends the **24.25-27.5 GHz** (hereinafter '26 GHz') band as a **pioneer band** for Europe to be harmonised before 2020.

Furthermore, the RSPG considers the 31.8-33.4 GHz band as a promising band, and the 40.5-43.5 GHz band as a viable option in the longer term, for 5G use.

The RSPG expresses a vision that 5G will drive industrial and societal transformation and economic growth in Europe from 2020 and beyond. The strategic roadmap aims to facilitate the launch of 5G on a large scale by 2020, thereby ensuring that the benefits of 5G-based services are available to all European citizens in a timely manner. The RSPG expects that the first major commercial deployments will be based on lower frequencies. One of the reasons is the possibility to reach rapidly a sufficient coverage for addressing enhanced broadband communications and, above all, the machine-type communications market, which may require ubiquity, low latency and low complexity. As regards candidate bands for 5G use above 6 GHz, the RSPG has limited its consideration to the bands listed by WRC-15, focussing on the frequency bands proposed by Europe at WRC-15, in order to strengthen the global harmonisation opportunities. Therefore, enabling early availability of different pioneer frequency bands under harmonised technical conditions is of strategic importance for the Union for the introduction of commercial 5G services in Europe, possibly preceded by relevant trials and pilots.

The status of ITU-level spectrum allocations and the current use of potential frequency bands for 5G, in particular above 24 GHz, necessitate studies to assess **shared spectrum use** between 5G terrestrial wireless systems and existing or prospective incumbent use as well as compatibility studies with respect to adjacent bands. Sharing studies are of high relevance with respect to terrestrial backhaul or fixed satellite links, in particular with view to existing and future earth stations in the earth exploration satellite service (EESS), space research service (SRS), the fixed satellite service (FSS), and on-board receivers of data relay satellite systems (DRSS). In this regard, the RSPG provides recommendations on spectrum coexistence within the 26 GHz pioneer band, which are relevant for the development of technical conditions for shared spectrum use.

It should be noted that certain non-European countries have identified spectrum for 5G services on a national basis in frequency bands, which are adjacent to priority bands according to the RSPG opinion, most notably within the 27.5-29.5 GHz ('28 GHz') band[[24]](#footnote-24) or the 37-40 GHz band[[25]](#footnote-25). These developments should be taken into account in order to facilitate global interoperability and economies of scale of equipment based on the implementation of a common tuning range.

Therefore, comprehensive studies on the technical conditions for spectrum use in existing EU-harmonised frequency bands below 6 GHz and the pioneer band above 24 GHz[[26]](#footnote-26) for the introduction of 5G terrestrial wireless systems are necessary to enable deployment of evolving and new services and applications (under licensed or licence-exempt operation). These studies should be framed by the Union's policy strategy so as to provide an appropriate spectrum mix for various usage scenarios, to study coexistence scenarios with other radio services and to develop a European approach benefiting to the extent possible from global harmonisation. It is likely that results from the work at ITU level will deliver inputs to the studies under this Mandate[[27]](#footnote-27). In this regard, CEPT is already conducting studies on the pioneer 3.6 GHz and 26 GHz bands to assess harmonised technical conditions for 5G terrestrial wireless systems, as well as on potential extensions of the 1.5 GHz band.

1. **Justification**

Pursuant to Article 4(2) of the Radio Spectrum Decision[[28]](#footnote-28) the Commission may issue mandates to the CEPT for the development of technical implementing measures with a view to ensuring harmonised conditions for the availability and efficient use of radio spectrum necessary for the functioning of the internal market. Such mandates shall set the tasks to be performed and their timetable. Pursuant to the Radio Spectrum Decision, activities under the Decision must facilitate policy making with regard to the strategic planning and harmonisation of radio spectrum use as well as ensure the effective implementation of radio spectrum policy in the EU while serving the aim of coordination of policy approaches. Furthermore, they shall take due account of the work of international organisations related to radio spectrum management[[29]](#footnote-29) (such as ITU).

The Radio Spectrum Policy Programme (RSPP) requires Member States, in cooperation with the Commission, to take all steps necessary to ensure that sufficient spectrum for coverage and capacity purposes is available within the Union, in order to enable the Union to have the fastest broadband speeds in the world, thereby making it possible for wireless applications and European leadership in new services to contribute effectively to economic growth, and to achieving the target for all citizens to have access to broadband speeds of not less than 30 Mbps by 2020. Furthermore, the RSPP calls on Member States and the Commission to ensure spectrum availability for the Internet of Things (IoT). The RSPP also stipulates that Member States, in cooperation with the Commission, shall, where appropriate, foster shared use of spectrum[[30]](#footnote-30).

Advances in international standardisation as well as rapid international developments regarding 5G trials and spectrum use until 2020 call for a swift and coordinated EU-level process on delivering sufficient and appropriate spectrum for 5G use in the Union according to anticipated deployment of 5G usage scenarios. Therefore, urgent action is needed in line with Union policy priorities and taking due account of relevant progress in international spectrum management to perform technical studies in order to develop harmonised technical conditions for spectrum use for the introduction of 5G terrestrial wireless systems.

1. **Task order and schedule**

CEPT is herewith mandated to develop harmonised technical conditions for spectrum use of selected frequency bands, which is suitable for 5G terrestrial wireless systems, in compliance with the policy priorities set out in this Mandate. These conditions should allow the provisions of wireless broadband electronic communications services including 5G usage scenarios and take into account needs for shared spectrum use with existing or prospective incumbent uses. CEPT should give utmost consideration to overarching Union-level spectrum policy objectives[[31]](#footnote-31) such as efficient spectrum use and take utmost account of applicable principles of Union law such as technological and service neutrality, non-discrimination and proportionality insofar as technically possible.

CEPT is requested to collaborate actively with the European Telecommunications Standardisation Institute (ETSI) which develops harmonised standards for conformity under the Radio Equipment Directive. In particular, CEPT should take into consideration emerging technologies and ETSI (harmonised) standards, which define 5G systems and facilitate shared spectrum use or foster economies of scale. Furthermore, CEPT is requested to take into account relevant developments at international level and to consider possible synergies.

When developing harmonised technical conditions, CEPT shall focus its efforts on the pioneer bands as identified in this Mandate and take due account of the relevant RSPG recommendations21 in respect to other radio services. More specifically, CEPT is mandated to perform the following tasks with view to creating sufficiently precise harmonised technical conditions for the development of EU-wide equipment for the introduction of 5G terrestrial wireless systems in the Union:

1. Review the harmonised technical conditions applicable to the **3.4-3.8 GHz ('3.6 GHz') frequency band, as a 5G pioneer band**, with view to their suitability for 5G terrestrial wireless systems and amend these, if necessary.
2. Study and assess the **24.25-27.5 GHz ('26 GHz') frequency band** **as a 5G pioneer band** for use under relevant 5G usage scenarios taking into account the coexistence issues highlighted in the RSPG opinion21 with respect to fixed links, earth exploration satellite and space research services, fixed satellite services, data relay satellite systems and passive services in the frequency band 23.6-24 GHz. In this regard, identify and study common *sharing scenarios* with incumbent radio services and applications, for which future demand has been identified.

Opportunities for interoperability and economies of scale of equipment such as a common tuning range, including the 26 GHz band, with possible 5G use outside Europe shall be taken into account. The impact of activities outside Europe in the adjacent frequency band for 5G use shall be considered, including a broad range of sharing scenarios that protect existing and future satellite services in the band.

1. Develop channelling arrangements and common and minimal (least restrictive) technical conditions[[32]](#footnote-32) for spectrum use in the **26 GHz frequency band**, which are suitable for 5G terrestrial wireless systems, in conjunction with relevant usage and sharing scenarios.

In this regard, develop harmonised technical conditions to ensure spectrum usage *on a shared basis,* including *protection conditions* where necessary, pursuant to the sharing scenarios identified under Task 2, in close cooperation with all concerned stakeholders. These conditions should be sufficient to mitigate interference and ensure coexistence with incumbent radio services/applications in the same band or in adjacent bands, in line with their regulatory status, including at the EU outer borders.

1. Assess requirements for cross-border coordination, wherever relevant, including at the EU outer borders.

Overall, the CEPT should provide deliverables under this Mandate according to the following schedule:

|  |  |  |
| --- | --- | --- |
| **Delivery date** | **Deliverable** | **Subject** |
| March 2018  | Draft Report A from CEPT to the Commission[[33]](#footnote-33) | Description of the work undertaken and the results on Task 1. |
| June 2018 | Final Report A from CEPT to the Commission taking into account the outcome of the public consultation | Description of the work undertaken and the results on Task 1. |
| March 2018  | Draft Report B from CEPT to the Commission33 | Description of the work undertaken and the results on Tasks 2 and 3. |
| June 2018 | Final Report B from CEPT to the Commission taking into account the outcome of the public consultation | Description of the work undertaken and the results on Tasks 2 and 3. |

The relevant results under Task 4 should be included in the deliverables above regarding different frequency bands.

CEPT is requested to report on the progress of its work pursuant to this Mandate to all meetings of the Radio Spectrum Committee taking place during the course of the Mandate.

The Commission, with the assistance of the Radio Spectrum Committee and pursuant to the Radio Spectrum Decision, may consider applying the results of this mandate in the Union, pursuant to Article 4 of the Radio Spectrum Decision and subject to international developments regarding 5G standardisation and spectrum management, and any relevant guidance of the RSPG.

1. Proposed updates to the LRTC set out in ec dECISION 2014/276/eu [1]
	1. Updated frequency arrangements

The unpaired arrangement is selected as the only option for the 3400-3800 MHz band.

There is no need to consider separate frequency arrangements for 3400-3600 MHz and 3600-3800 MHz

The block size is 5MHz, despite expected 5G larger channel bandwidths. The 5 MHz granularity will facilitate dealing with the existing assignments, and will make it easier for the market to decide on the required bandwidth per operator during the assignment procedures.

The considerations above lead to the following frequency arrangement:



Figure 10: Proposed updated harmonised frequency arrangement

3400-3800 MHz band

NOTE (1): The feasibility of implementation of AAS base stations in the lowest 5 MHz blocks, taking into account the unwanted emission limits to protect radars will depend on the evolution of filtering capabilities for AAS. However these lowest blocks would remain usable by non-AAS base stations.

* 1. updated regulatory bem

CEPT confirms that the current BEM remains applicable for non AAS systems and shall be retained. There is need for additional BEM for AAS systems.

* + 1. Out-of-block power limits: Interference between synchronised WBB ECS

The following out-of-block power limits are proposed for coexistence of synchronised WBB ECS BSs. Less stringent technical parameters, if agreed among the operators of such networks, may also be used.

Table 8: Proposed updated baseline power limits for synchronised WBB ECS networks,

for non AAS and AAS base stations

|  |  |  |  |
| --- | --- | --- | --- |
| BEM element | Frequency range | Non AAS e.i.r.p. power limitdBm/5MHz per antenna | AAS TRP power limitdBm/5MHz |
| Transitional region | -5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge  | Min(PMax−40, 21) | Min(PMax'-40, 16)  |
| Transitional region | -10 to -5 MHz offset from lower block edge5 to 10 MHz offset from upper block edge | Min(PMax−43, 15) | Min(PMax'-43, 12) |
| Baseline  | Synchronised operation | Min(PMax−43, 13) | Min(PMax'-43, 1)  |
| PMax is the maximum mean carrier power for the base station measured as e.i.r.p. per carrier per antennaPMax' is the maximum mean carrier power for the base station measured as TRP per carrier TRP for Pmax’, for baseline and for transitional apply to the whole antenna panel[[34]](#footnote-34) |

* + 1. Out-of-block power limits: Interference between non-synchronised or semi-synchronised WBB ECS

The following out-of-block power limit is proposed for coexistence of unsynchronised and semi-synchronised WBB ECS BS, if no geographic separation is available, the restricted baseline applies. Less stringent technical parameters, if agreed among the operators of such networks, may also be used. [In addition, depending on national circumstances, EU Member States may define a relaxed alternative “restricted baseline limit” applying to specific implementation cases to ensure a more efficient usage of spectrum.]

Table 9: Proposed updated restricted baseline power limits for unsynchronised and semi-synchronised WBB ECS, for non AAS and AAS base stations

|  |  |  |
| --- | --- | --- |
| BEM element | Non AAS e.i.r.p. power limit dBm / 5MHz per cell(1) | AAS TRP(2) power limit dBm / 5MHz  |
| Restricted baseline | -34 | -43 |
| (1) In a multi-sector site, the value per ‘cell’ corresponds to the value for one of the sectors. (2) TRP for restricted baseline applies to the whole antenna panel. |

* + 1. Out-of-band power limits: Interference towards radars below 3400 MHz

Table 10: Proposed updated base station additional baseline power limits below 3400 MHz for country specific cases, for non AAS and AAS base stations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case | BEM element | Frequency range | Non AAS e.i.r.p. power limit dBm/MHz per cell(1) | AAS TRP(2) power limit dBm/MHz  |
| A | CEPT countries with military radiolocation systems below 3400 MHz | Additional Baseline | Below 3400 MHz | -59 |  -52 |
| B | CEPT countries with military radiolocation systems below 3400 MHz | Additional baseline | Below 3400 MHz | -50 |
| C | CEPT countries without adjacent band usage or with usage that does not need extra protection | Additional baseline | Below 3400 MHz | Not applicable | Not applicable |
| (1) In a multi-sector site, the value per ‘cell’ corresponds to the value for one of the sectors. (2) TRP for additional baseline applies to the whole antenna panel. |

EU Member States may select the limits from case A or B depending on the level of protection required for the radar in the region in question.

Other mitigation measures such as geographical separation, coordination on a case by case basis or an additional frequency separation may be necessary for a TDD allocation. For countries with military radiolocation systems below 3400 MHz a required coordination zone of up to 12 km around fixed terrestrial radars, based on a AAS TRP power limit of -52 dBm/MHz per antenna panel, may be needed. Such coordination is under responsibility of the relevant EU Member State.

* + 1. Out-of-band power limits: coexistence with FSS / FS

Accounting for the analysis in section 4.4.6, the baseline and transitional power limits defined in Table 3 are applied at the 3800 MHz band edge to support the coordination process to be carried out at national level on case by case basis with support from the operations guidelines from ECC Report 254 [3].

Table 11: Proposed additional baseline to be applied at the 3800 MHz for AAS base stations

|  |  |  |
| --- | --- | --- |
| BEM element | Frequency range | Power limit for AASTRP (dBm/5MHz) |
| Additional baseline  | 3800-3805 MHz | Min(PMax'−40, 16)  |
| 3805-3810 MHz | Min(PMax'−43, 12) |
| Above 3810 MHz  | Min(PMax'−43, 1) |
| PMax' is the maximum mean carrier power for the base station measured as TRP per carrier irrespective of the number of antennasTRP for additional baseline applies to the whole antenna panel |

* + 1. In-block power limit

With reference to the in-block power limits: for the case of non-AAS base stations, the existing in-block e.i.r.p. limit is proposed to be maintained.

For the case of AAS base stations, it is proposed to convert the said e.i.r.p. limit to TRP for consistency with the out-of-block limits.

Table 12: Proposed in-block power limits for non-AAS and AAS base stations

|  |  |  |  |
| --- | --- | --- | --- |
| BEM element | Frequency range | Non AAS e.i.r.p. power limit dBm/5MHz per antenna | AAS TRP power limit dBm / 5MHz  |
| In-block | Block assigned to the operator | Not obligatory.[In case an upper bound is desired by an administration, a value of 68 dBm/5 MHz per antenna may be applied.]For femto base stations, the use of power control is mandatory in order to minimise interference to adjacent channels. | Not obligatory.[In case an upper bound is desired by an administration, a value of 47 dBm/5 MHz may be applied.] For femto base stations, the use of power control is mandatory in order to minimize interference to adjacent channels. |

* + 1. UE In-block requirement

As for the technical condition for user equipment (UEs), it is recommended that the UE in-block TRP does not exceed 28 dBm.

1. List of reference
2. EC Decision 2014/276/EU “Harmonised frequency arrangements for mobile/fixed communications networks (WBB ECS) operating in the bands 3400-3600 MHz and 3600-3800 MHz"
3. ECC Decision (11)06 of 9 December 2011 on harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz.
4. ECC Report 254: "Operational guidelines for spectrum sharing to support the implementation of the current ECC framework in the 3600-3800 MHz range"
5. ITU Radio Regulations Edition of 2016
6. ERC Report 25 “The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz”, updated October 2017
7. Resolution ITU-R 6556 “Naming for International Mobile Telecommunications”
8. Recommendation ITU-R M.2083-0 “IMT Vision - "Framework and overall objectives of the future development of IMT for 2020 and beyond"”
9. Recommendation ITU-R M.1457-13 “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)”
10. Recommendation ITU-R M.2012-2: “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced) ”’
11. Recommendation ITU-R M.1645-0 “Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000”
12. ECC Report 203: "Least Restrictive Technical Conditions suitable for Mobile/Fixed Communication Networks (MFCN), including IMT, in the frequency bands 3400-3600 MHz and 3600-3800 MHz"
13. EC 5G Action Plan
14. Recommendation ITU-R M.2101-0 (02/2017): "Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies"
15. ECC Report 281: Analysis of the suitability of the regulatory technical conditions for 5G MFCN operation in the 3400-3800 MHz band, March 2018
16. 3GPP TS 37.104 Technical Specification Group Radio Access Network: "E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception (Release 15)"
17. 3GPP TS 37.105 Technical Specification Group Radio Access Network: "Active Antenna System (AAS) Base Station (BS) transmission and reception (Release 14)"
18. 3GPP R4-168430, “On NRb BS ACLR requirement,” Huawei, 3GPP TSG-RAN WG4 Meeting #80bis, Oct. 2016.
19. 3GPP R4-165896, “Metric for unwanted emissions and ACLR”, Ericsson, 3GPP TSG-RAN WG4 #80
20. 3GPP TR 37.840 Technical Specification Group Radio Access Network "Study of Radio Frequency (RF) and Electromagnetic Compatibility (EMC) requirements for Active Antenna Array System (AAS) base station (Release 12)
21. 3GPP R4-165899, “On modelling the spatial shape of ACLR”, Ericsson, 3GPP TSG-RAN WG4 #80
22. ECC Report 216 "Practical guidance for TDD networks synchronisation"
23. “RAN1 Chairman’s Notes”, 3GPP TSG RAN WG1 Meeting #86bis, Lisbon, Portugal 10-14 October 2016
24. R4-1704402, “LS on Suitability of technical conditions of EC Decision 2014/276/EU for 5G”
25. R4-165899, “On modelling the spatial shape of ACLR”, Ericsson, 3GPP TSG-RAN WG4 #80
26. R4-165896, “Metric for unwanted emissions and ACLR”, Ericsson, 3GPP TSG-RAN WG4 #80
27. 3GPP TS 38.104 V15.0.0 (2017-12), “NR; Base Station (BS) radio transmission and reception (Release 15)”
1. National regulators typically specify maximum in-block EIRPs “per equipment/sector”, focusing on the total EIRP, and its potential to cause harmful interference. [↑](#footnote-ref-1)
2. A nominal antenna gain is assumed in deriving out-of-block EIRP limits from the 3GPP spectrum emission masks (transmit powers). [↑](#footnote-ref-2)
3. National regulators typically specify maximum in-block EIRPs “per equipment/sector”, focusing on the total EIRP, and its potential to cause harmful interference. [↑](#footnote-ref-3)
4. A nominal antenna gain is assumed in deriving out-of-block EIRP limits from the 3GPP spectrum emission masks (transmit powers). [↑](#footnote-ref-4)
5. In case of passive systems, the antenna gain does not vary much between the wanted signal and unwanted emissions. Thus, e.i.r.p. is directly proportional to TRP and can be used as a substitute. [↑](#footnote-ref-5)
6. ECC Report 216 "Practical guidance for TDD networks synchronisation" [19] contains some of the considerations that might be relevant for the definition of the regulatory framework" [↑](#footnote-ref-6)
7. EC Decision 11(06) specifies block edge mask elements that fall within the 3400-3800 MHz range with an additional baseline level below 3400 MHz. No level specified above 3800 MHz. [↑](#footnote-ref-7)
8. For example, for one specific case of small cells deployment below the clutter a study in Annex 4 of ECC Report 281 [12] indicate potential for relaxation [↑](#footnote-ref-8)
9. For example, Korea, Japan or the USA. In this regard, the US regulator (FCC) adopted on 14 July 2016 a Report and Order on 5G spectrum above 24 GHz ("Spectrum Frontiers") [↑](#footnote-ref-9)
10. In the ITU context of "International Mobile Telecommunications for 2020 (IMT-2020)", s. ITU Recommendation: [https://www.itu.int/dms\_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I%21%21PDF-E.pdf) [↑](#footnote-ref-10)
11. ITU-R Resolution 238 (WRC-15) [↑](#footnote-ref-11)
12. See <https://5g-ppp.eu/> [↑](#footnote-ref-12)
13. See the 5G-PPP brochures: "5G vision" at <https://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf>, and "5G empowering vertical industries" at: <https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf> [↑](#footnote-ref-13)
14. Document "Initiative on pioneer 5G bands" (8 July 2016) from the 5G-PPP to the RSPG public consultation on the Draft RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G) [↑](#footnote-ref-14)
15. See <https://ec.europa.eu/digital-single-market/en/digitising-european-industry> [↑](#footnote-ref-15)
16. See: <https://ec.europa.eu/digital-single-market/en/5g-europe-action-plan> [↑](#footnote-ref-16)
17. Link: <http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579> [↑](#footnote-ref-17)
18. Subject to Commission Decisions (EU)2016/687 (700 MHz band), 2010/267/EU (800 MHz band), 2009/766/EC amended by 2011/251/EC (900 MHz band), 2014/641/EU (PMSE in the 800 MHz band) [↑](#footnote-ref-18)
19. Subject to Commission Decisions (EU)2015/750 (1.5 GHz band), 2009/766/EC amended by 2011/251/EC (1800 MHz band), 2012/688/EU (paired terrestrial 2 GHz band), 2008/477/EC (2.6 GHz band), 2008/411/EC amended by 2014/276/EU (3.6 GHz band) [↑](#footnote-ref-19)
20. Commission Communication on European Strategy on Cooperative Intelligent Transport Systems (C-ITS) at: <http://ec.europa.eu/transport/sites/transport/files/com20160766_en.pdf> [↑](#footnote-ref-20)
21. Document RSPG16-032 FINAL of 9 November 2016 [↑](#footnote-ref-21)
22. Ensuring regulatory predictability is important for this band taking into account the ongoing implementation of Decision 2014/276/EU across the Union [↑](#footnote-ref-22)
23. It should be noted that the 700 MHz band has been recently harmonised (Commission Decision 2016/687/EU of April 2016) and should remain stable in light of ongoing national award procedures between now and 2020. [↑](#footnote-ref-23)
24. A regulatory decision in the USA, according to the FCC's Spectrum Frontier Report and Order and Further Notice of Proposed Rulemaking of 14 July 2016 available at: <https://www.fcc.gov/document/spectrum-frontiers-ro-and-fnprm>; Korea plans to use the 26.5-29.5 GHz band for early 5G trials in 2018 [↑](#footnote-ref-24)
25. A regulatory decision in the USA, according to the FCC's Spectrum Frontier Report and Order and Further Notice of Proposed Rulemaking of 14 July 2016; this band is also for study towards WRC-19 [↑](#footnote-ref-25)
26. Ensuring regulatory predictability is important for the bands within the scope of the tasks of this mandate taking into account ongoing national award procedures until 2020 [↑](#footnote-ref-26)
27. Linked to Article 1.3 of the Radio Spectrum Decision [↑](#footnote-ref-27)
28. Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002 [↑](#footnote-ref-28)
29. Article of Decision 676/2002/EC (Radio Spectrum Decision) [↑](#footnote-ref-29)
30. See Articles 6(1), 4(1) and 8(6) of the RSPP [↑](#footnote-ref-30)
31. Enshrined in the RSPP and the Radio Spectrum Decision [↑](#footnote-ref-31)
32. Such as the definition of appropriate Block Edge Masks (BEMs) [↑](#footnote-ref-32)
33. Subject to subsequent public consultation [↑](#footnote-ref-33)
34. [↑](#footnote-ref-34)