



# 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 6 July 2018 by the ECC**

## 0 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 enable 5G. Accounting for the need for large contiguous portions of spectrum to be made available for 5G, there may be a need to reorganise and defragment the band. CEPT is now developing guidelines / best practices for Administrations suggesting ways to facilitate availability of the 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.

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<sup>1</sup>;

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

CEPT confirms that BS in-block EIRP is not mandatory, therefore, there is no need to include a reference limit in the regulatory framework for either non-AAS or AAS systems. Member States wishing

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<sup>1</sup> National regulators typically specify maximum in-block EIRPs “per equipment/sector”, focusing on the total EIRP, and its potential to cause harmful interference.

to include a limit in their authorisation or to use a limit for coordination purpose may define such limits on a national basis.

## 2. 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<sup>2</sup>. 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.

## 3. 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.

For protection of FSS and FS above 3800 MHz in the context of non-AAS system, for consistency, the inclusion of emission limits above 3800 MHz for non-AAS is recommended, based on the baseline BEM, similarly to what has been done for AAS. It is noted that, even for existing WBB ECS authorisations, this does not bring any additional constraint since base stations are already complying with the baseline BEM. Coexistence above 3800 MHz could be managed on case by case basis as it is the case today (for example, by adding relevant filters to BS).

In the conclusion of the CEPT studies<sup>3</sup>, the following updates are proposed to the existing framework under the assumption of individual authorisation regime; the limits have been derived based on outdoor deployment scenarios:

- High throughput 5G use cases benefit from wide contiguous frequency allocations. Current 5G NR specifications support channel bandwidths up to 100 MHz. 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 applied for AAS base stations, specified as TRP limits per cell<sup>4</sup>;
- For unsynchronised and semi-synchronised operations, if no geographic or indoor/outdoor 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, relaxed baseline limit applying to specific implementation cases may be defined at national level. CEPT is developing a toolbox for the most appropriate synchronisation regulatory framework to help either network operators or Administrations to address relevant coexistence issues;
- An out-of-block restricted baseline power limit of -43 dBm/(5 MHz) TRP per cell applies for coexistence of unsynchronised and semi-synchronised WBB ECS BS in the same geographical area;
- An additional baseline is proposed for countries wishing to protect radar below 3400 MHz. Coordination may be required, for example a coordination distance of up to 12 km around fixed terrestrial radars, based on an AAS BS TRP limit of -52 dBm/MHz per cell. Such coordination is the responsibility of the relevant administration. It is noted that, for AAS base stations, manufacturers

<sup>2</sup> A nominal antenna gain is assumed in deriving out-of-block EIRP limits from the 3GPP spectrum emission masks (transmit powers).

<sup>3</sup> See ECC Report 281 [14]

<sup>4</sup> In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.

have indicated that the power limit of -52 dBm/MHz would imply, under current technology, about 20 MHz frequency separation between the block edge and 3400 MHz. Further details are provided in Table 5;

- For protection of FSS and FS above 3800 MHz, a set of additional baselines applies for AAS and non-AAS base stations to support the coordination process to be carried out at national level on a case-by-case basis with support from the operations guidelines from ECC Report 254 [2];
- The in-block e.i.r.p. limit for non-AAS base stations is not mandatory. Any in block limit for AAS or non-AAS BSs may be defined on a national basis;
- As for the technical condition for user equipment (UEs) it is recommended that the in-block TRP for mobile UEs does not exceed 28 dBm. The in-block radiated power limit for fixed/nomadic UEs may be agreed on a national basis provided that cross-border obligations are fulfilled.

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

- Each system respects the relevant applicable baseline level in case of synchronised operation for AAS or non-AAS systems; or
- Each system respects the relevant applicable restricted baseline level in case of unsynchronised operation for AAS or non-AAS systems.

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.

## TABLE OF CONTENTS

<b>0 EXECUTIVE SUMMARY .....</b>	<b>2</b>
<b>1 INTRODUCTION.....</b>	<b>9</b>
<b>2 FREQUENCY ARRANGEMENT .....</b>	<b>12</b>
2.1 Frequency arrangement in current framework.....	12
2.2 Proposed frequency arrangement.....	12
<b>3 EXISTING BEM REQUIREMENTS .....</b>	<b>14</b>
<b>4 ANALYSIS OF THE SUITABILITY OF THE CURRENT BEM REQUIREMENTS FOR 5G.....</b>	<b>15</b>
4.1 Method for assessing the suitability of existing BEM for 5G .....	15
4.2 Definitions.....	16
4.2.1 Non-AAS WBB ECS base stations.....	16
4.2.2 AAS WBB ECS base stations.....	16
4.2.3 Total Radiated Power (TRP) .....	17
4.2.4 Synchronisation in TDD WBB ECS .....	17
4.3 Suitability for non-AAS WBB ECS.....	18
4.4 Suitability for AAS WBB ECS.....	18
4.4.1 Implications from the AAS architecture .....	18
4.4.2 TRP metric vs. e.i.r.p. metric .....	19
4.4.3 Out-of-block power limits: Interference between synchronised WBB ECS.....	19
4.4.4 Out-of-block power limits: Interference between unsynchronised WBB ECS.....	20
4.4.5 Out-of-block power limits: Interference between LTE and 5G NR WBB ECS.....	20
4.4.6 Out-of-band power limits: Interference towards radars below 3400 MHz .....	20
4.4.7 Out-of-band power limits: coexistence with FSS/FS above 3800 MHz.....	21
4.4.8 Out-of-band power limits: coexistence with radio astronomy.....	21
4.4.9 In-block power limits.....	21
<b>5 PROPOSED BEM REQUIREMENTS FOR AAS WBB ECS BASE STATIONS.....</b>	<b>22</b>
5.1 Out-of-block power limits.....	22
5.1.1 Out-of-block power limits: Interference between synchronised WBB ECS.....	22
5.1.2 Out-of-block power limits: Interference between unsynchronised and semi-synchronised WBB ECS.....	22
5.2 Out-of-band power limits: Interference towards radars below 3400 MHz.....	23
5.3 Out-of-band power limits: Coexistence with FSS/FS .....	24
5.4 In-block power limit.....	25
5.5 UE In-block requirement.....	25
<b>6 CROSS-BORDER COORDINATION .....</b>	<b>26</b>
<b>7 CONCLUSIONS.....</b>	<b>27</b>
<b>ANNEX 1: CEPT MANDATE .....</b>	<b>29</b>
<b>1. POLICY CONTEXT AND INPUTS.....</b>	<b>30</b>
<b>2. JUSTIFICATION .....</b>	<b>33</b>
<b>3. TASK ORDER AND SCHEDULE .....</b>	<b>34</b>
<b>ANNEX 2: FREQUENCY ARRANGEMENT.....</b>	<b>37</b>

**ANNEX 3: PROPOSED UPDATES OF THE EC REGULATORY TECHNICAL CONDITIONS TO EC  
DECISION 2008/411/EU AND 2014/276/EU ..... 38**

**ANNEX 4: LIST OF REFERENCE..... 44**

## LIST OF ABBREVIATIONS

<b>Abbreviation</b>	<b>Explanation</b>
<b>3GPP</b>	3 <sup>rd</sup> Generation Partnership Project
<b>AAS</b>	Active Antenna System
<b>BEM</b>	Block Edge Mask
<b>BS</b>	Base Station
<b>CEPT</b>	European Conference of Postal and Telecommunications Administrations
<b>DL</b>	Downlink
<b>EC</b>	European Commission
<b>ECA</b>	European Common Allocation
<b>ECC</b>	Electronic Communications Committee
<b>ECS</b>	Electronic Communication Services
<b>e.i.r.p.</b>	Equivalent Isotropically Radiated Power
<b>E-UTRA</b>	Evolved Universal Terrestrial Radio Access
<b>FDD</b>	Frequency Division Duplex
<b>FS</b>	Fixed Service
<b>FSS</b>	Fixed Satellite Service
<b>IMT</b>	International Mobile Telecommunications
<b>ITU-R</b>	International Telecommunication Union - Radiocommunications
<b>LRTC</b>	Least Restrictive Technical Conditions
<b>LTE</b>	Long Term Evolution
<b>MSR</b>	Multi Standard Radio
<b>MCL</b>	Minimum Coupling Loss
<b>MFCN</b>	Mobile/Fixed Communications Network
<b>NR</b>	New Radio
<b>OOB</b>	Out of Band
<b>OTA</b>	Over The Air
<b>RAN</b>	Radio Access Network
<b>SDO</b>	Standards Developing Organisation
<b>SEM</b>	Spectrum Emission Mask
<b>TCP</b>	Transmission Control Protocol
<b>TDD</b>	Time Division Duplex
<b>TRP</b>	Total Radiated Power

<b>UE</b>	User Equipment
<b>UL</b>	Uplink
<b>UMTS</b>	Universal Mobile Telecommunications System
<b>WBB ECS</b>	Wireless Broadband Electronic Communication Services
<b>WRC</b>	World Radiocommunication Conference

## 1 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.

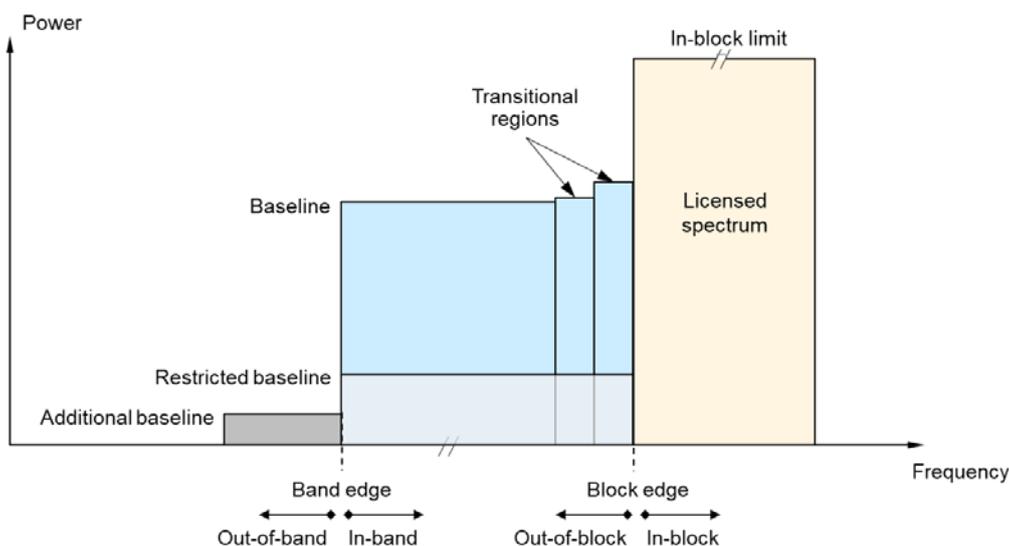
The development of new radio interfaces - 5G New Radio (NR) - that support the new capabilities of IMT-2020 is expected along with the enhancement of IMT-2000 and IMT-Advanced systems.

Due to its favourable properties, such as radio wave propagation and available bandwidth, the frequency band 3400-3800 MHz will be the primary frequency 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.
Restricted baseline	Spectrum used for WBB ECS by networks unsynchronised or semi-synchronised with the operator block in question

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

- 1. In-block power limit is used for the block assigned to the operator.
- 2. Baseline is used for synchronised WBB ECS networks except from the operator block in question and corresponding transitional regions
- 3. Transitional regions are determined, and corresponding power limits are used.
- 4. Restricted baseline is used for unsynchronised and semi-synchronised WBB ECS networks,
- 5. For spectrum below 3 400 MHz, one of the additional baseline power limits is used.
- 6. For coexistence with FSS/FS above 3800 MHz, the same baseline and transitional power limit for synchronised WBB ECS applies.

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 the coexistence scenario, such as frequency or distance separation, or specific site engineering.

The BEM is a ‘regulatory mask’ and should not be confused with Spectrum Emission Masks (SEM) for base stations and user equipment employed by Standards Developing Organisations (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<sup>5</sup> 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. In the context of evolution of WBB ECS, the 5G New Radio interface (5G NR) optimises wideband operation. This allows mobile operators to take full advantage of larger allocations of

<sup>5</sup> 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 [7] 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].

contiguous spectrum to increase peak rates and user experience. Standardisation has developed channel bandwidths support up to 100 MHz.

## 2 FREQUENCY ARRANGEMENT

### 2.1 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.

### 2.2 PROPOSED FREQUENCY ARRANGEMENT

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

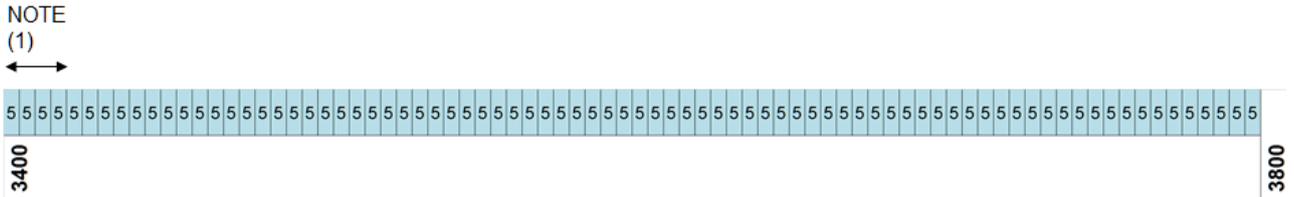
- The TDD mode exploits downlink/uplink flexibility to support increasing traffic asymmetry: today, with the rapid development of smartphones and their increasing usage, mobile applications are increasingly download-centric;
- The TDD mode exploits channel reciprocity for effective AAS implementation: 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 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;
- Relevant bandwidths for 5G NR in the 3400-3800 MHz range as developed by the standardisation: 10, 15, 20, 40, 50, 60, 80 and 100 MHz.
- High throughput 5G use cases benefit from wide contiguous frequency allocations. Current 5G NR specifications support channel bandwidths up to 100 MHz. Therefore, the spectrum should be provided in a manner allowing for at least 3x50 MHz of contiguous spectrum.
- Given the fragmented current use of 3400-3600 for FDD and/or TDD and 3600-3800 for TDD, ECC is developing guidance to Administrations in order to achieve a common TDD plan and facilitate the availability of suitable wide contiguous spectrum for 5G in 3400-3800 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 defined the whole 3400-3800 MHz as part of one single band (included in NR bands n77 and n78). 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 wide area outdoor AAS base stations in the lowest 5 MHz blocks taking into account the out-of-band unwanted emission limits to protect radars will require evolution of filtering capabilities for AAS. However, these lowest blocks would remain usable in some circumstances. See also section 5.2.

The proposed frequency arrangement will facilitate availability of wide 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<sup>6</sup>, the ECC is now developing guidelines/best practices for Administrations suggesting ways to facilitate availability of the largest possible contiguous portions of spectrum.

<sup>6</sup> 5G NR Standardisation channel bandwidth in the 3400-3800 MHz range: 10, 15, 20, 40, 50, 60, 80, 100 MHz (source 3GPP).

### 3 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.

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 co-existence 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.

## 4 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 unsynchronised or semi-synchronised, 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. CEPT is currently developing a toolbox for the most appropriate synchronisation regulatory framework to help either network operators or Administrations to address to coexistence issues. Such relaxed baseline limits will be defined as a result of negotiation between relevant networks operators or by a decision from Administrations.

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 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. Standardisation has developed 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).

### 4.1 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<sup>7</sup>:

- a maximum BS in-block EIRP of  $\leq 68$  dBm/(5 MHz) per antenna (non-mandatory);

<sup>7</sup> National regulators typically specify maximum in-block EIRPs per BS cell/sector, focusing on the total EIRP, and its potential to cause harmful interference.

- a maximum UE 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.

## 2. 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<sup>8</sup>. 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.

## 3. 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.

## 4.2 DEFINITIONS

### 4.2.1 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 or 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.

### 4.2.2 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

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<sup>8</sup> A nominal antenna gain is assumed in deriving out-of-block EIRP limits from the 3GPP spectrum emission masks (transmit powers).

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).

### 4.2.3 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.

$$TRP \stackrel{\text{def}}{=} \frac{1}{4\pi} \int_0^{2\pi} \int_0^\pi P(\theta, \varphi) \sin(\theta) d\theta d\varphi \quad (1)$$

where

- $TRP$  is equal to the total conducted power input into the antenna array system less any losses in the antenna array system;
- $P(\theta, \varphi)$ : power radiated by an antenna array system in direction  $(\theta, \varphi)$ .

$$P(\theta, \varphi) = P_{Tx} g(\theta, \varphi) \quad (2)$$

where

- $P_{Tx}$ : conducted power (Watts) input to the array system;
- $g(\theta, \varphi)$ : array systems directional gain along  $(\theta, \varphi)$  direction.

The maximum e.i.r.p. for an AAS base station can be written in log domain as follows:

$$\text{e.i.r.p.}_{max} = TRP + G_E + 10\log_{10} N \quad (3)$$

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

### 4.2.4 Synchronisation in TDD WBB ECS

The definitions below may not necessarily apply to an entire network. In particular, there are use cases where different base stations within a network may be unsynchronised or semi-synchronised.

#### 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 alignment of all DL and UL transmissions for all TDD networks involved as well as synchronising the beginning of the frame across all networks.

#### 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 at least one network transmits in DL while at least one network transmits in UL. This might happen if the TDD networks either do not align all DL and UL transmissions 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 where the UL/DL direction is not specified, as well as synchronising the beginning of the frame across all networks.

The semi-synchronised operation can be 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.

### 4.3 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.

### 4.4 SUITABILITY FOR AAS WBB ECS

#### 4.4.1 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. limits at the spectrum block edge. Some of these requirements (i.e. the restricted baseline power limit applying to the unsynchronised WBB ECSs and the additional baseline power limits 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 in non-AAS WBB ECS base stations, if needed, mobile operators have the possibility of installing additional external filters between the base station antenna connector and the antenna.

$$\text{e.i.r.p. BEM} = \text{SEM} - \text{Feeder\_Loss} + \text{Antenna\_Gain} - \text{Filter\_Rejection} \tag{4}$$

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 non-AAS base stations, it is not possible to meet the BEM regulatory limits through the installation of external filters anymore; the BEM regulatory requirements must therefore be met by product design.

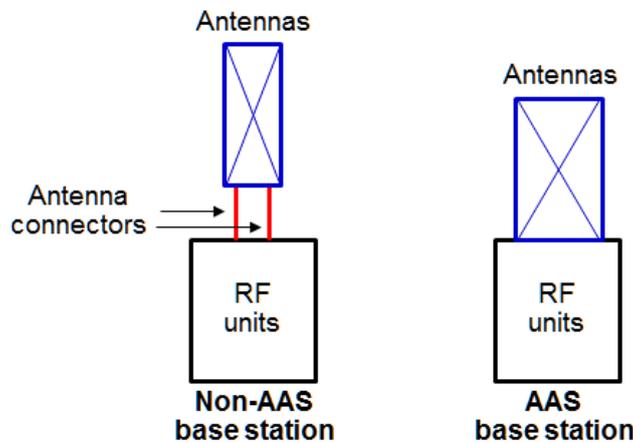


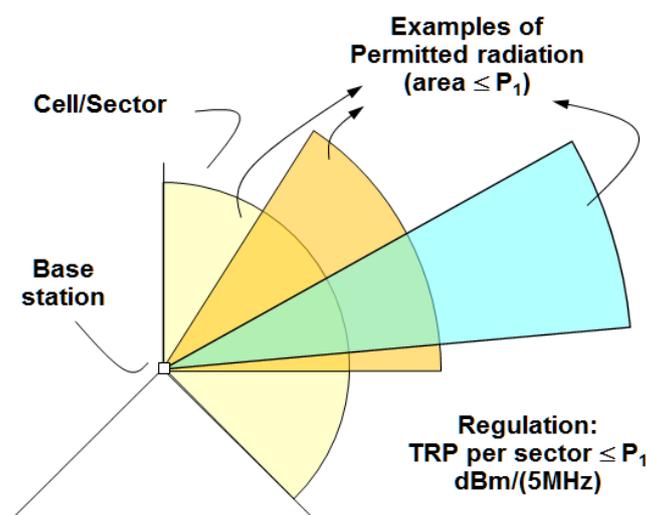
Figure 3: Reference point for non-AAS vs AAS base station

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.

#### 4.4.2 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.

ECC Report 281 [14] explains why, in the context of AAS base stations, it would be appropriate to specify any amended regulatory limits as TRP.

#### 4.4.3 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 unsynchronised 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.

#### 4.4.4 Out-of-block power limits: Interference between unsynchronised 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.

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

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

- Each system respects the relevant applicable baseline level in case of synchronised operation for AAS or non-AAS systems; or
- Each system respects the relevant applicable restricted baseline level in case of unsynchronised operation for AAS or non-AAS systems.

The two approaches are assessed in more details in ECC Report 281 leading to the following conclusions:

Synchronised operation between 5G NR and LTE is technically feasible but reduces flexibility. Although complete alignment of UL/DL transmissions between LTE and NR can be achieved, 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. This does not impact the technical conditions but degrades 5G QoS.

In case of unsynchronised operation of 5G NR and LTE networks, respecting the restricted baseline level for unsynchronised WBB ECS BSs coexistence would be challenging to implement as AAS systems cannot be fitted with additional external filters, unlike non-AAS BSs. The implementation of internal filters for AAS BSs 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. Assuming it would be economically feasible to implement the required additional filters, in addition, a frequency separation is likely to be required and studies should be conducted to confirm the need for such separation and to determine the width of such a frequency separation (simulations that were carried out [14] for the coexistence between unsynchronised MFCNs at 3400-3800 MHz may provide valuable reference about the ACIR/ACLR requirements). Relaxed restricted baseline limits can be defined at national level.

CEPT is developing a toolbox for the most appropriate synchronisation regulatory framework to help either network operators or Administrations to address relevant coexistence issues.

#### 4.4.6 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 AAS base stations.

Unlike the derivation of current additional baseline e.i.r.p. limits which relied on MCL, some of the studies in ECC Report 281 [14] took into account the time-varying directional antenna patterns at the mobile network base station transmitter.

ECC Report 281 describes five studies that looked at interference into ground based or airborne radars, including one study that focussed on the likelihood of blocking the radar receiver for a number 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.

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

ECC Decision (11)06 [1] states that coordination<sup>9</sup> 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. That 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 [2] 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. ECC report 254 does not address AAS systems.

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, Member States will carefully assess the usage of spectrum within 3400-3800 MHz with an option of clearing the band, as much as possible, from incumbent services. Where appropriate, Member States 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.

For protection of FSS and FS above 3800 MHz, a set of additional baselines is proposed for AAS and non-AAS base stations 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 [2].

#### **4.4.8 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 will be required, whose radii are to be determined based on coordination at national level on a case-by-case basis.

#### **4.4.9 In-block power limits**

The in-block e.i.r.p. limit for non-AAS base stations is not mandatory. Any in-block limit for AAS or non-AAS may be defined on national basis.

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## 5 PROPOSED BEM REQUIREMENTS FOR AAS WBB ECS

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

### 5.1 OUT-OF-BLOCK POWER LIMITS

In alignment with how unwanted emission conducted power (TRP) for AAS base stations is specified by 3GPP TS 38.104 [24], 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.

#### 5.1.1 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 [24], it is proposed to specify the out-of-block TRP limits to a value that corresponds 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 2 shows the proposed out-of-block TRP limits for the update of EC Decision 2014/276/EU [1].

**Table 2: Proposed updated baseline and transitional power limits for AAS base stations**

BEM element	Frequency range	AAS TRP limit dBm/(5MHz) per cell (1), (2)
Transitional region	-5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge	Min(PMax'-40, 16) (3)
Transitional region	-10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge	Min(PMax'-43, 12) (3)
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) (3)

(1) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.  
 (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) PMax' is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell.

#### 5.1.2 Out-of-block power limits: Interference between unsynchronised 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. ECC is developing a report further investigating the cases in which the restricted baseline applies.

**Table 3: Updated restricted baseline power limits for AAS base stations in the same geographical area for unsynchronised and semi-synchronised WBB ECS**

BEM element	Frequency range	AAS TRP limit dBm /(5MHz) per cell (1)
Restricted baseline	Unsynchronised and semi-synchronised blocks. Below the lower block edge Above the upper block edge Within 3400-3800 MHz	-43
(1) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.		

**5.2 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  $I_{agg}/N$  is not necessarily similar for both full correlation and 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 and 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 4: Updated base station additional baseline power limits below 3400 MHz for country specific cases for AAS base stations (1)**

Case		BEM element	Frequency range	AAS TRP limit dBm/MHz per cell (2)
A	CEPT countries with military radiolocation systems below 3400 MHz	Additional baseline	Below 3400 MHz (3)	-52
B	CEPT countries with military radiolocation systems below 3400 MHz			
C	CEPT countries without adjacent band usage or with usage that does not need extra protection		Below 3400 MHz	Not applicable

(1) Alternative measures may be required on a case by case basis for indoor AAS BSs on a national basis.  
 (2) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors  
 (3) In cases where Member States have already implemented a guard band when issuing licences for terrestrial systems capable of providing ECS before the adoption of this Implementing Decision and in accordance with Commission Decision 2008/411/EC as amended by Commission Implementing Decision 2014/276/EU [1], these Member States may apply the additional baseline only below such guard band, provided it complies with the protection of radars in the adjacent band and with cross-border obligations.

*Explanatory note to Table 4:* The additional baseline power limits given in Table 4 are applicable only to outdoor cells. In the case of an indoor cell, the power limits can be relaxed on a case by case basis.

The additional baseline limit can be applied per geographic 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.

A coordination zone of up to 12 km around fixed terrestrial radars, based on an AAS TRP limit of -52 dBm/MHz per cell, may be required. Such coordination is the responsibility of the relevant administration. Other mitigation measures like geographical separation, in-block power limit, or an additional guard band may be necessary.

For UEs other mitigation measures will be necessary, for example, geographical separation or an additional guard band.

Member States may decide to introduce at national level an in-band power limit to ensure protection of radar systems from AAS base stations.

**5.3 OUT-OF-BAND POWER LIMITS: COEXISTENCE WITH FSS/FS**

Accounting for the analysis in section 4.4.7, the baseline and transitional power limits defined in Table 5 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 [2].

**Table 5: Additional baseline limits for AAS base stations above 3800 MHz for the protection of FSS and FS**

BEM element	Frequency range	AAS TRP limit dBm/(5MHz) per cell (1)	
Additional baseline	3800-3805 MHz	Min(PMax'-40, 16)	(2)
	3805-3810 MHz	Min(PMax'-43, 12)	(2)
	3810-3840 MHz	Min(PMax'-43, 1)	(2)(3)
	Above 3840 MHz	-14	(4)

(1) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.  
(2) PMax' is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell  
(3) Additional limits may apply on a case by case basis at national level.  
(4) Derived from 3GPP TS 38.104 [24].

**5.4 IN-BLOCK POWER LIMIT**

CEPT confirms that BS in-block EIRP is not mandatory, therefore, there is no need to include a reference limit in the regulatory framework for either non-AAS or AAS systems. Administration wishing to include a limit in their authorisation or to use a limit for coordination purpose may define such limits on a national basis.

**5.5 UE IN-BLOCK REQUIREMENT**

As for the technical condition for user equipment (UEs), it is recommended that the in-block TRP for mobile UEs does not exceed 28 dBm. The in-block radiated power limit for fixed/nomadic UEs may be agreed on a national basis provided that cross-border obligations are fulfilled.

## 6 CROSS-BORDER COORDINATION

Cross-border coordination is managed on a bilateral and multilateral basis between Member States. Even in the context of the current fragmented usage in the 3400-3800 MHz band, Member States 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 Member States 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.

## 7 CONCLUSIONS

This report has assessed the existing regulatory framework for 3400-3800 MHz to assess its suitability for 5G, focusing in particular on the use of AAS base stations. The limits have been derived based on outdoor deployment scenarios.

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

- High throughput 5G use cases benefit from wide contiguous frequency allocations. Current 5G NR specifications support channel bandwidths up to 100 MHz. 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 cell<sup>10</sup>;
- 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 or indoor/outdoor 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, Member States 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.
- An additional baseline is proposed for countries wishing to protect radar below 3400 MHz. Coordination may be required, for example a coordination distance of up to 12 km around fixed terrestrial radars, based on a AAS BS TRP limit of -52 dBm/MHz per cell. Such coordination is the responsibility of the relevant administration. It is noted that, for AAS base stations, manufacturers have indicated that the power limit of -52 dBm/MHz would imply, under current technology, about 20 MHz frequency separation between the block edge and the additional baseline limit below 3400 MHz;
- For protection of FSS and FS above 3800 MHz, a set of additional baselines is proposed for AAS and non-AAS base stations to support the coordination process to be carried out at national level on case-by-case basis with support from the operational guidelines from ECC Report 254 [2];
- The in-block e.i.r.p. limit for non-AAS base stations is not mandatory. Any in block limit for AAS or non-AAS may be defined on a national basis;
- As for the technical condition for user equipment (UEs) it is recommended that the in-block TRP for mobile UEs does not exceed 28 dBm. The in-block radiated power limit for fixed/nomadic UEs may be agreed on a national basis provided that cross-border obligations are fulfilled.

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

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<sup>10</sup> In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.

- Each system respects the relevant applicable baseline level in case of synchronised operation for AAS or non-AAS systems; or
- Each system respects the relevant applicable restricted baseline level in case of unsynchronised operation for AAS or non-AAS systems.

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 ECS WBB coexistence would be challenging to implement as AAS systems cannot be fitted with additional external filters. Assuming it would be economically feasible to implement the required additional filters, in addition, a frequency separation is likely to be required, and studies should be conducted to confirm the need for such separation and to determine the width of such frequency separation (simulations that were carried out [14] for the coexistence between unsynchronised MFCNs at 3400-3800 MHz may provide valuable reference).

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.

**ANNEX 1: CEPT MANDATE**



**EUROPEAN COMMISSION**

Communications Networks Content & Technology Directorate-General

Electronic 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**

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## 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<sup>11</sup>. 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<sup>12</sup> 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<sup>13</sup>, 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)<sup>14</sup> 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<sup>15</sup> on a 5G vision as well as on the significance of novel use cases

<sup>11</sup> 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")

<sup>12</sup> 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!!PDF-E.pdf)

<sup>13</sup> ITU-R Resolution 238 (WRC-15)

<sup>14</sup> See <https://5g-ppp.eu/>

<sup>15</sup> 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](https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf)

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)<sup>16</sup> regarding pioneer frequency bands for the Union.

In April 2016, the Commission adopted a package on the "Digitisation of the European Industry"<sup>17</sup>, 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"<sup>18</sup>, 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"<sup>19</sup> – 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<sup>20</sup>: 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<sup>21</sup>: 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').

<sup>16</sup> 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)

<sup>17</sup> See <https://ec.europa.eu/digital-single-market/en/digitising-european-industry>

<sup>18</sup> See: <https://ec.europa.eu/digital-single-market/en/5g-europe-action-plan>

<sup>19</sup> Link: [http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc\\_id=16579](http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579)

<sup>20</sup> 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)

<sup>21</sup> 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)

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<sup>22</sup>.

In its "Strategic Roadmap towards 5G for Europe: Opinion on spectrum related aspects for next-generation wireless systems (5G)"<sup>23</sup>, 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<sup>24</sup>.
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**<sup>25</sup>, 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

<sup>22</sup> Commission Communication on European Strategy on Cooperative Intelligent Transport Systems (C-ITS) at: [http://ec.europa.eu/transport/sites/transport/files/com20160766\\_en.pdf](http://ec.europa.eu/transport/sites/transport/files/com20160766_en.pdf)

<sup>23</sup> Document RSPG16-032 FINAL of 9 November 2016

<sup>24</sup> Ensuring regulatory predictability is important for this band taking into account the ongoing implementation of Decision 2014/276/EU across the Union

<sup>25</sup> 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.

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<sup>26</sup> or the 37-40 GHz band<sup>27</sup>. 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<sup>28</sup> 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<sup>29</sup>. 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.

## 2. JUSTIFICATION

Pursuant to Article 4(2) of the Radio Spectrum Decision<sup>30</sup> 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

<sup>26</sup> 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](#)

<sup>27</sup> 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

<sup>28</sup> 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

<sup>29</sup> Linked to Article 1.3 of the Radio Spectrum Decision

<sup>30</sup> 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

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<sup>31</sup> (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<sup>32</sup>.

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.

### 3. 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<sup>33</sup> 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 recommendations<sup>23</sup> in respect to other radio services. More specifically, CEPT is mandated to perform the following

<sup>31</sup> Article of Decision 676/2002/EC (Radio Spectrum Decision)

<sup>32</sup> See Articles 6(1), 4(1) and 8(6) of the RSPP

<sup>33</sup> Enshrined in the RSPP and the Radio Spectrum Decision

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 opinion<sup>23</sup> 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.

3. Develop channelling arrangements and common and minimal (least restrictive) technical conditions<sup>34</sup> 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.

4. 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:

<b>Delivery date</b>	<b>Deliverable</b>	<b>Subject</b>
March 2018	Draft Report A from CEPT to the Commission <sup>35</sup>	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	Description of the work undertaken and the results on Task 1.

<sup>34</sup> Such as the definition of appropriate Block Edge Masks (BEMs)

<sup>35</sup> Subject to subsequent public consultation

	the public consultation	
March 2018	Draft Report B from CEPT to the Commission <sup>35</sup>	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.

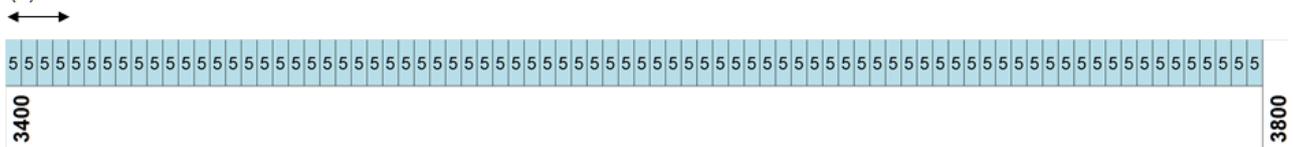
## ANNEX 2: FREQUENCY ARRANGEMENT

### A2.1 UPDATED FREQUENCY ARRANGEMENT

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 5 MHz, despite expected larger channel bandwidths for high throughput 5G uses. 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:

NOTE  
(1)



**Figure 5: Proposed updated harmonised frequency arrangement: 3400-3800 MHz band**

NOTE (1): The feasibility of implementation of wide area outdoor AAS base stations in the lowest 5 MHz blocks taking into account the out-of-band unwanted emission limits to protect radars will require evolution of filtering capabilities for AAS. However, these lowest blocks would remain usable in some circumstances.

## ANNEX 3: PROPOSED UPDATES OF THE EC REGULATORY TECHNICAL CONDITIONS TO EC DECISION 2008/411/EU AND 2014/276/EU

### ANNEX

#### **B. TECHNICAL CONDITIONS FOR BASE STATIONS — BLOCK EDGE MASK**

The following technical parameters for base stations called block edge mask (BEM) are an essential component of conditions necessary to ensure coexistence between neighbouring networks in the absence of bilateral or multilateral agreements between operators of such neighbouring networks. Less stringent technical parameters, if agreed among the operators of such networks, may also be used.

The BEM consists of several elements given in Table 1, for the 3 400-3 800 MHz. The baseline power limit, designed to protect the spectrum of other operators, and the transitional region power limits, enabling filter roll-off from the in-block to the baseline power limit represent out-of-block elements and the restricted baseline which applies. The BEM is applicable to base stations with different power levels.

Tables 2 to 7 contain the power limits for the different BEM elements. Power limits are provided for synchronised, unsynchronised and semi-synchronised MFCN networks, also for the protection of radar operation below 3400 MHz and for the protection of FSS/FS above 3800 MHz.

$P_{Max}$  is the maximum carrier power in dBm for the base station in question, measured as e.i.r.p. per antenna.  $P_{Max}'$  is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell.

The definitions below on synchronised, unsynchronised and semi-synchronised operation may not necessarily apply to an entire network. In particular, there are use cases where different base stations within a network may be unsynchronised or semi-synchronised.

Synchronised operation 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 alignment of all DL and UL transmissions for all TDD networks involved as well as synchronising the beginning of the frame across all networks.

Unsynchronised operation means operation of TDD in several different networks, where at any given moment in time at least one network transmits in DL while at least one network transmits in UL. This might happen if the TDD networks either do not align all DL and UL transmissions or do not synchronise at the beginning of the frame.

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 where the UL/DL direction is not specified, as well as synchronising the beginning of the frame across all networks.

To obtain a BEM for a specific block, the BEM elements that are defined in Table 1 are combined in the following steps:

1. In-block power limit is used for the block assigned to the operator.

2. Baseline is used for synchronised WBB ECS networks except from the operator block in question and corresponding transitional regions
3. Transitional regions are determined, and corresponding power limits are used.
4. Restricted baseline is used for unsynchronised and semi-synchronised WBB ECS networks,
5. For spectrum below 3 400 MHz, one of the additional baseline power limits is used.
6. For coexistence with FSS/FS above 3800 MHz, the same baseline and transitional power limit for synchronized WBB ECS applies

The Figure provides an example of the combination of different BEM elements.

*Table 1*

**Definition of BEM elements**

<b>BEM element</b>	<b>Definition</b>
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
Restricted baseline	Spectrum used for WBB ECS by networks unsynchronised or semi-synchronised with the operator block in question

*Table 2*

**In-block power limit for non-AAS and AAS base station**

<b>BEM element</b>	<b>Frequency range</b>	<b>Power limit for non-AAS and AAS base stations</b>
In-block	Block assigned to the operator	Not obligatory.

*Explanatory note to Table 2*

For femto base stations, power control should be applied to minimise interference to adjacent channels. The requirement on power control for femto base stations results from the need to reduce interference from equipment that may be deployed by consumers and may thus not be coordinated with surrounding networks.

Table 3

**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. limit	AAS TRP limit
Baseline	Below -10 MHz offset from lower block edge.  Above 10 MHz offset from upper block edge.  Within 3400 - 3800 MHz.	$\text{Min}(P_{\text{Max}} - 43, 13)$ dBm/(5 MHz) per antenna (1)	$\text{Min}(P_{\text{Max}}' - 43, 1)$ dBm/(5 MHz) TRP per cell (2) (3)

- (1) P<sub>Max</sub> is the maximum mean carrier power in dBm for the base station measured as e.i.r.p. per carrier per antenna
- (2) P<sub>Max</sub>' is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell
- (3) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.

*Explanatory note to Table 3*

The baseline for synchronised TDD is expressed by combining attenuation relative to the maximum carrier power with a fixed upper limit. The stricter of the two requirements applies. The fixed level provides an upper bound on the interference from a base station. When two TDD blocks are synchronised, there will be no interference between base stations.

Table 4

**Transitional region power limits for synchronised WBB ECS networks, for non-AAS and AAS base stations**

BEM element	Frequency range	Non-AAS e.i.r.p. limit	AAS TRP limit
Transitional region	- 5 to 0 MHz offset from lower block edge or  0 to 5 MHz offset from upper block edge	$\text{Min}(P_{\text{Max}} - 40, 21)$ dBm/(5 MHz) EIRP per antenna (1)	$\text{Min}(P_{\text{Max}}' - 40, 16)$ dBm/(5 MHz) TRP per cell (2) (3)
Transitional region	- 10 to - 5 MHz offset from lower block edge or  5 to 10 MHz offset from upper block edge	$\text{Min}(P_{\text{Max}} - 43, 15)$ dBm/(5 MHz) EIRP per antenna (1)	$\text{Min}(P_{\text{Max}}' - 43, 12)$ dBm/(5 MHz) TRP per cell (2) (3)

- (1) P<sub>Max</sub> is the maximum mean carrier power in dBm for the base station measured as e.i.r.p. per carrier per antenna
- (2) P<sub>Max</sub>' is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell
- (3) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.

*Explanatory note to Table 4*

The 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. The transitional region power limits are defined to enable the reduction of power from the in-block level to the baseline. The requirements are expressed as attenuation relative to the maximum carrier power, combined with a fixed upper limit. The stricter of the two requirements applies.

Table 5

**Restricted baseline power limits for unsynchronised and semi-synchronised WBB ECS networks, for non-AAS and AAS base stations**

BEM element	Frequency Range	Non-AAS e.i.r.p. limit	AAS TRP limit
Restricted baseline	Unsynchronised and semi synchronised blocks Below the lower block edge Above the upper block edge Within 3400-3800 MHz	-34 dBm/(5 MHz) per cell (1)	-43 dBm/(5 MHz) per cell (1)

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

*Explanatory note to Table 5*

Table 5 provides the restricted baseline power limit 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, EU Member States may define a relaxed alternative “restricted baseline power limit” applying to specific implementation cases to ensure a more efficient usage of spectrum.

Table 6

**Non-AAS and AAS Base station (1) additional baseline power limits below 3400 MHz for country specific cases**

Case	BEM element	Frequency range	Non AAS e.i.r.p. limit	AAS TRP limit	
A	Union countries with military radiolocation systems below 3400 MHz	Additional baseline	Below 3400 MHz (2)	- 59 dBm/MHz EIRP per antenna	-52 dBm/MHz TRP per cell (3)
B	Union countries with military radiolocation systems below 3400 MHz	Additional baseline	Below 3400 MHz (2)	- 50 dBm/MHz EIRP per antenna	-52 dBm/MHz TRP per cell (3)
C	Union countries without adjacent band usage or with usage that does not need extra protection	Additional baseline	Below 3400 MHz	Not applicable	Not applicable

(1) Alternative measures may be required on a case by case basis for indoor AAS BSs on a national basis.

(2) In cases where Member States have already implemented a guard band when issuing licences for terrestrial systems capable of providing ECS before the adoption of this Implementing Decision and in accordance with Commission Decision 2008/411/EC as amended by Commission Implementing Decision 2014/276/EU, these Member States may apply the additional baseline only below such guard band, provided it complies with the protection of radars in the adjacent band and with cross-border obligations.

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

The additional baseline limit reflects the need for protection for military radiolocation in some countries. EU Member States may select the limits from case A or B for non AAS depending on the level of protection required for the radar in the region in question.

A coordination zone of up to 12 km around fixed terrestrial radars, based on a AAS TRP limit of -52 dBm/MHz per cell, may be required. Such coordination is the responsibility of the relevant Member State. Other mitigation measures like geographical separation, in-block power limit, or an additional guard band may be necessary.

In case of indoor deployments, Member States may define a relaxed limit applying to specific implementation cases.

Table 7

**Base station additional baseline power limits above 3800 MHz for coexistence with FSS/FS**

<b>BEM element</b>	<b>Frequency range</b>	<b>Non-AAS e.i.r.p. limit per antenna</b>	<b>AAS TRP limit</b>
Additional baseline	3800-3805 MHz	Min( $P_{Max} - 40, 21$ ) dBm/(5 MHz) EIRP per antenna (1)	Min( $P_{Max}' - 40, 16$ ) dBm/(5MHz) TRP per cell (2) (3)
	3805-3810 MHz	Min( $P_{Max} - 43, 15$ ) dBm/(5 MHz) EIRP per antenna (1)	Min( $P_{Max}' - 43, 12$ ) dBm/(5MHz) TRP per cell (2) (3)
	3810-3840 MHz	Min( $P_{Max} - 43, 13$ ) dBm/(5 MHz) EIRP per antenna (1)	Min( $P_{Max}' - 43, 1$ )dBm/(5MHz) TRP per cell (2) (3)
	Above 3840 MHz	-2 dBm/(5MHz) EIRP per antenna (1)	-14 dBm/(5MHz) TRP per cell (3)

(1)  $P_{Max}$  is the maximum mean carrier power in dBm for the base station measured as e.i.r.p. per carrier per antenna

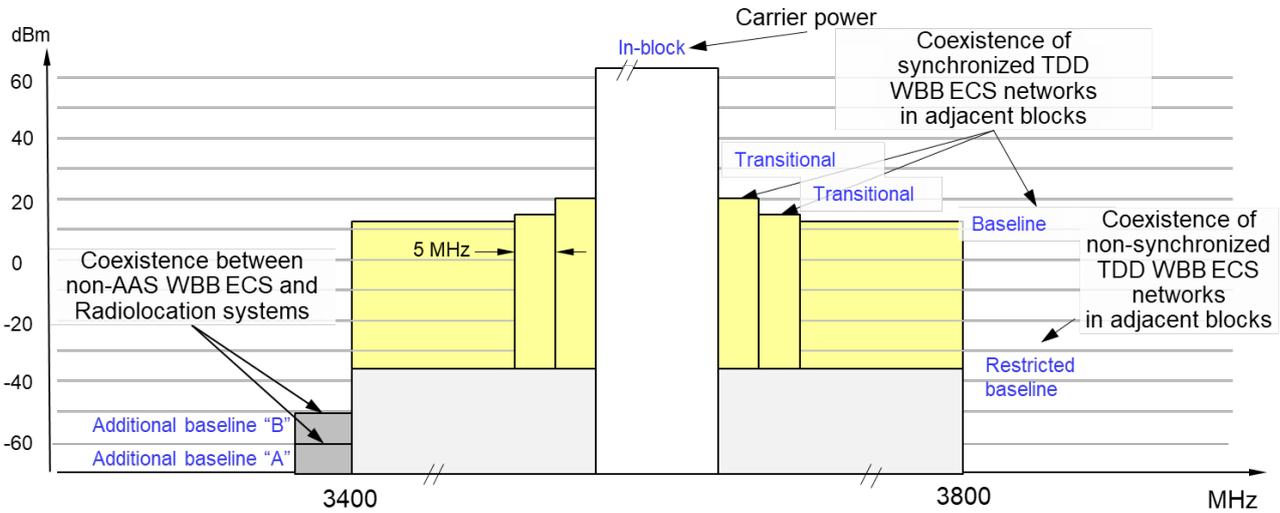
(2)  $P_{Max}'$  is the maximum mean carrier power in dBm for the base station measured as TRP per carrier in a given cell

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

*Explanatory note to Table 7*

The additional baselines defined in Table 7 for AAS and non-AAS base stations are applied at the 3800 MHz band edge to support the coordination process to be carried out at national level .

Figure  
**Example TDD Base station power limits BEM elements**



**C. TECHNICAL CONDITIONS FOR TERMINAL STATIONS**

Table 8

**In-block requirement — terminal station BEM in-block power limit**

Maximum in-block power	28 dBm TRP
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It is recommended that the in-block radiated power for mobile TS does not exceed 28 dBm. The in-block radiated power limit for fixed/nomadic TS may be agreed on a national basis, provided cross-border obligations are fulfilled.

Note that for TSs, mitigation measures to protect radar below 3400MHz may be necessary, for example, geographical separation or an additional guard band.

**ANNEX 4: LIST OF REFERENCE**

- [1] EC Decision 2014/276/EU: "Commission Implementing Decision of 2 May 2014 on amending Decision 2008/411/EC on the harmonisation of the 3400 - 3800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community"
- [2] ECC Decision (11)06: "Harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz" - Approved 09 December 2011, Amended 14 March 2014
- [3] ECC Report 254: "Operational guidelines for spectrum sharing to support the implementation of the current ECC framework in the 3600-3800 MHz range", November 2016
- [4] ITU Radio Regulations Edition of 2016
- [5] ERC Report 25: "The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz", updated October 2017
- [6] Resolution ITU-R 56: "Naming for International Mobile Telecommunications"
- [7] Recommendation ITU-R M.2083-0: "IMT Vision - "Framework and overall objectives of the future development of IMT for 2020 and beyond""
- [8] Recommendation ITU-R M.1457-13: "Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)"
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- [10] Recommendation ITU-R M.1645-0: "Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000"
- [11] 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", Corrected March 2014
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- [17] 3GPP R4-168430, "On NRb BS ACLR requirement," Huawei, 3GPP TSG-RAN WG4 Meeting #80bis, October 2016.
- [18] 3GPP R4-165896: "Metric for unwanted emissions and ACLR", Ericsson, 3GPP TSG-RAN WG4 #80, August 2016
- [19] 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)
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- [21] ECC Report 216 "Practical guidance for TDD networks synchronisation", August 2014
- [22] 3GPP R1-1611081: Final Report of 3GPP TSG RAN WG1 #86bis, November 2016
- [23] ECC PT1(17)070: "LS on Suitability of technical conditions of ECC/DEC/(11)06 for 5G", 3GPP TSG-RAN WG4, April 2017
- [24] 3GPP TS 38.104 V15.0.0 (2017-12), "NR; Base Station (BS) radio transmission and reception (Release 15)"