CEPT
ECC
Electronic Communications Committee

CEPT Report 81

Report from CEPT to the European Commission in response to Task 1 of the Mandate "*Study and assess conditions to operate 5G non-AAS connectivity for MCA in the 1800 MHz (1710-1785 MHz and 1805-1880 MHz) frequency band*" and Task 2 of the Mandate "*Study and assess whether, and under what conditions, the usage of an NCU in MCA operations could be made optional*"

Report approved on 05 November 2021 by the ECC

0 EXECUTIVE SUMMARY

This Report has been prepared in response to Task 1 of the Mandate from the European Commission to "*Study and assess conditions to operate 5G non-AAS connectivity for MCA in the 1800 MHz (1710-1785 MHz and 1805-1880 MHz) frequency band and develop harmonised technical conditions for the consequential revision of Commission Implementing Decision 2008/294/EC (as amended)*" and Task 2 to *"Study and assess whether, and under what conditions the usage of an NCU in MCA operations could be made optional."*

0.1 5G NON-AAS SYSTEMS ON BOARD AIRCRAFT AT 1800 MHZ

Minimum coupling loss analysis was used to determine the compatibility of 5G non-AAS systems on board aircraft at 1800 MHz with terrestrial GSM, LTE, 5G NR systems. It also considered possible usage of AAS systems in the ground networks in that band. The criterion of interference over noise ratio (I/N) equals to -6 dB, which is equivalent to an increase of 1 dB over the thermal noise floor, and was used for victim terrestrial user equipment and base stations caused by the external interference from either 5G aircraft user equipment and aircraft base stations. The analysis shows that the harmful interference is below an acceptable level of 1 dB desensitisation (noise rise below 1 dB) if the technical conditions set in Table 1 and Table 2 below are met for 5G non-AAS systems.

It should be pointed out that the impact on the terrestrial MFCN networks when a possible aerial user equipment ("UE") (e.g. drone) operation in 1800 MHz terrestrial MFCN network with both non-AAS and AAS BS was not studied. Further study on this aspect may be required in the future.

Table 1 and Table 2 provide the maximum e.i.r.p., defined outside and inside the aircraft, of the MCA 5G non-AAS BS and on board 5G UE. For channel bandwidths other than 5 MHz, a correction is calculated by adding 10 × $\log_{10}$ (channel bandwidth/5 MHz) dB to the aircraft base station (ac-BS) e.i.r.p. values. For a mobile terminal on board an aircraft (ac-UE), the calculated results are per channel regardless of which channel bandwidth is used.

Table 1: Maximum e.i.r.p. of 5G non-AAS on board ac-BS in 1800 MHz band

Height above ground (km)	3	4	5	6	7	8	9	10
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6
ac-BS e.i.r.p. inside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	15.2	17.7	19.6	21.2	22.5	23.7	24.7	25.6

Table 2: Maximum e.i.r.p. of 5G on board ac-UE in 1800 MHz band

Height above ground (km)	3	4	5	6	7	8	9	10
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	-0.4	2.2	4.1	5.7	7.0	8.1	9.2	10.1
ac-UE e.i.r.p. inside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	4.6	7.2	9.1	10.7	12.0	13.1	14.2	15.1

0.2 NCU IN MCA OPERATION

MCA systems are currently authorised to operate with GSM, UMTS and LTE technologies. For protecting ground GSM and LTE terrestrial networks at all frequencies, previous studies have shown that there is no need to have an NCU for MCA operation. However, for MCA systems, either a Network Control Unit (NCU) or aircraft fuselage shielding to further attenuate the signal is required to protect UMTS ground networks. The NCU increases the noise floor of the aircraft cabin. It is designed to ensure that signals transmitted by ground-based mobile systems are not detectable by the user equipment within the aircraft cabin. This is to ensure that MCA user terminals can only attempt to connect to the on board MCA base station.

Nonetheless, MCA licensed service providers reported at the time of writing this Report that only approximately 3%[1] of European commercial aircraft are equipped with MCA systems and have an NCU on board. For non-MCA equipped aircraft it is up to airline companies whether to require the passengers to switch off their mobile devices or not, in accordance with current EASA regulation 2014/029/R [13] for civil aviation safety and security. However, the MCA framework has been developed to allow the wireless communication technologies to be used by passengers on board aircraft in order to ensure coexistence of these services with other radio communications services including mobile networks on the ground.

CEPT is not aware of any complains or reports of interference from mobile network operators regarding possible adverse impacts (e.g. increased signalling load, capacity degradation) on terrestrial 900 MHz or 2 GHz UMTS networks from electronic devices on board European commercial aircraft (regardless of whether an MCA system and NCU were installed). However it should be stressed that due to the complexity of such impacts it is difficult to identify the source of interference which may be the reason why operators do not report/complain.

CEPT Report 63 [5] covers MFCN networks with non-AAS and was developed in 2016. It made the assumption concerning 5G "*future technologies related to 5G would likely involve frequency and time multiplexing access schemes for the transmission and the reception of UE and BS, similarly to GSM and LTE, unlike UMTS. Without precluding the frame structure, the waveform, the signalling procedures applicable to 5G systems, it can be expected, therefore, that the results of the studies for future 5G technologies would be similar to the LTE case".* Since then, the CEPT regulatory framework has been updated for MFCN terrestrial networks with AAS operating in the frequency band above 1 GHz (1.8 GHz, 2 GHz, 2.6 GHz and 3.4-3.8 GHz).

CEPT informs also the European Commission that AAS base stations have different antenna gain and patterns (SSB multi-beams antenna pattern and data beam-forming antenna pattern) compared to non-AAS antenna and may create a beam pointing towards a direction above the horizon to serve aerial UEs. The impact of MCA on MFCN with AAS has not been analysed in previous CEPT Reports in response to EC Mandates on MCA. CEPT is currently developing a relevant framework for harmonised operational and technical conditions for the usage of aerial UE in MFCN harmonised bands.

This Report confirms that an update of terrestrial mobile networks with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to AAS terrestrial networks.

Furthermore the future limited usages of aerial UEs (drones) with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to this AAS terrestrial networks .

By considering that:

- The discussion of technological neutrality, non-discrimination, and proportionality is separate from the technical question about whether there is still a need for an NCU to prevent connection from user terminals on board MCA-equipped aircraft to ground-based UMTS networks;
- CEPT Report 63 concluded that NCU is only required when UMTS terrestrial network is in operation;
- UMTS networks in the 2 GHz band could be refarmed to 4G LTE or 5G NR in near future to employ up-to-date technology where possible, as well as to increase spectrum efficiency in respond to market demand in a competitive environment;

[1] see CEPT Report 63

- UMTS networks in the 900 MHz band will remain in operation still for a very long time in some EU Member States. CEPT is not able to confirm that UMTS will be switched off in 900 MHz band in the near future;
- Development of AAS usage in terrestrial mobile networks including possible limited usages of aerial UEs (drones) with AAS bases stations does not require the need for NCU.
- The MCA framework has been developed to allow the wireless communication technologies (GSM, UMTS, LTE) to be used by passengers on board aircraft and that this report proposes also harmonised technical conditions for 5G non-AAS technology to be used by passengers on board aircraft;
- Airline companies can allow (and for some are already allowing) their passengers to use their mobile phones on board during all phases of a flight on non-MCA aircraft while respecting current EASA regulation 2014/029/R which does not address coexistence with ground mobile networks and adjacent services. Additionally, independently from the airline’s rules, some passengers might leave on their phones unintentionally during a flight.

It can be concluded that:

- The usage of NCU in MCA operations in 900 MHz band to prevent connection to ground-based UMTS networks should remain mandatory.
- The usage of NCU in MCA operations in 2 GHz band may be made optional in the near future.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
AAS	Active Antenna System
ac-BS	Aircraft base station
ac-UE	Mobile terminal on board an aircraft
BTS	Base Transceiver Station
BS	Base station
CEPT	European Conference of Postal and Telecommunications Administrations
EASA	European Aviation Safety Agency
EC	European Commission
ECC	Electronic Communications Committee
e.i.r.p.	Equivalent isotropic radiated power
g-BS	Ground base station
g-UE	Ground mobile terminal
GSM	Global System for Mobile communication
ITU-R	International Telecommunication Union – Radiocommunication sector
LTE	Long Term Evolution
MCA	Mobile communication services on board aircraft
MCL	Minimum Coupling Loss
NCU	Network Control Unit
PED	Personal Electronic Device
SSB	Synchronisation Signal Block
UAS	Unmanned Aerial Systems
UE	User equipment
UMTS	Universal Mobile Telecommunications System

1 INTRODUCTION

An MCA system is composed of two pieces of equipment: one or more aircraft base stations and a Network Control Unit (NCU). The NCU is designed to ensure that signals transmitted by terrestrial mobile networks are not detectable by the User Equipment within the aircraft cabin. This ensures that user terminals can only register to the on board base station. The on board base station will set the transmit power level of the device according to the current relevant MCA framework which has been developed progressively on the basis of the following CEPT Reports:

- **CEPT Report 16** [1] investigated the operation of GSM MCA systems at a height of at least 3000 m above ground level in the 1800 MHz frequency band (1710-1785 MHz uplink (terminal transmit, base station receive) / 1805-1880 MHz downlink (base station transmit, terminal receive)). This report led to the adoption of EC Decision 2008/294/EC [2];
- **CEPT Report 48** [3] investigated the technical impact on terrestrial mobile networks of introducing UMTS and LTE MCA systems, operating at height of at least 3000 metres above ground in the 1800 MHz frequency band (1710-1785 MHz uplink and 1805-1880 MHz downlink) for LTE and in the 2100 MHz frequency band (1920-1980 MHz uplink and 2110-2170 MHz downlink) for UMTS. This report was followed by the adoption of the EC Decision 2013/654/EC [4];
- **CEPT Report 63** [5] investigated the possibility of making the NCU optional on MCA enabled aircraft. This report was followed by the adoption of EC Decision 2016/2317/EC [6].

1.1 NCU IN MCA OPERATION

The existing regulatory framework consists of a connectivity part - 1800 MHz for GSM & LTE and 2100 MHz for UMTS - and a NCU part, which ensures that UMTS ground networks in the 900 MHz and 2100 MHz bands are not visible to user equipment on board the aircraft. CEPT Report 63 concluded that a NCU was not required for the protection of ground GSM and LTE networks.

CEPT Report 63 also made the following assumption: '*Future technologies related to 5G would likely involve frequency and time multiplexing access schemes for the transmission and the reception of UE and BS, similar to GSM and LTE. In consequence, no NCU would be needed when such 5G terrestrial networks operate*'. This assumption has been confirmed by the current 5G NR standards. Those CEPT Reports have only considered non-AAS terrestrial usages on the ground.

This Report assesses on the one hand conditions to operate 5G non-AAS connectivity for MCA in the 1800 MHz (1710-1785 MHz and 1805-1880 MHz) frequency band (task 1 of the EC mandate) and on the other hand the possibility for making the NCU optional (task 2 of the EC mandate). CEPT discussions focused on the technical question about whether there is still a need for a NCU to prevent connection from user terminals on board MCA-equipped aircraft to ground-based UMTS networks, which may be separate from any discussion whether the regulatory framework is disproportional or discriminatory.

The EC Mandate to CEPT recognises the cost burdens by operators of MCA systems and airlines of the requirement of NCU.

1.2 5G NON-AAS CONNECTIVITY FOR MCA IN 1800 MHZ

The availability of 5G networks and user equipment in Europe has led to the opportunity to provide 5G non-AAS connectivity on board aircraft. In addition to improved broadband speeds, 5G non-AAS MCA connectivity is anticipated to improve airline operational efficiencies through the availability of new applications and improve the passenger experience. The widespread adoption of 5G non-AAS MCA services would align with '*Commission Communication on the Gigabit Society*'[2] which sets the goal of having ubiquitous access to broadband connectivity.

In consequence, this CEPT Report studied and assessed the conditions to operate 5G non-AAS connectivity for MCA in 1800 MHz (1710-1785 MHz uplink and 1805-1880 MHz downlink) frequency band. Relevant harmonised technical conditions are also proposed.

[2] Commission Communication on the Gigabit Society

2 CURRENT MCA REGULATORY FRAMEWORK

The current MCA regulatory framework refers to consistent ECC and EC Decisions (ECC Decision (06)07 [7], EC Decision 2008/294/EC [2] amended by EC Decision 2013/654/EU [8] and EC Decision (EU) 2016/2317 [6]). Consistent ECC and EC frameworks should be preserved in future update.

The current regulatory framework allows for MCA connectivity in the frequency bands identified in Table 3:

Table 3: Current MCA bands

Mobile technology	Uplink frequency band	Downlink frequency band
GSM (GSM1800)	1710-1785 MHz	1805-1880 MHz
UMTS (UMTS2100)	1920-1980 MHz	2110-2170 MHz
LTE (LTE1800)	1710-1785 MHz	1805-1880 MHz

The current MCA regulatory framework provides in addition to frequency bands allowed for MCA services a reference to the system and relevant ETSI standards to be complied to. It also provides measures to prevent connection of mobile terminals to the ground networks, and technical parameters applicable to NCU (NCU bands: 925-960 MHz and 2110-2170 MHz to avoid tentative connection from on board terminals to ground UMTS networks). This also includes operational requirements applicable to aircraft BTS or Node B.

3 5G NON-AAS MCA CONNECTIVITY

3.1 BACKGROUND

ECC Report 93 [9] (for GSM) and ECC Report 187 [10] (for UMTS and LTE) considered the technical compatibility between MCA systems (non-AAS) and terrestrial mobile networks (non-AAS) in the following frequency bands:

- **1710-1785 MHz** for uplink (terminal transmit, base station receive) and **1805-1880 MHz** for downlink (base station transmit, terminal receive) in the case of **GSM** and **LTE**;
- **1920-1980 MHz** for uplink (terminal transmit, base station receive) and **2110-2170 MHz** for downlink (base station transmit, terminal receive) in case of **UMTS**.

This Report addresses the technical compatibility of the introduction of new MCA systems based on 5G non-AAS connectivity operating in the 1800 MHz band, with respect to terrestrial non-AAS and AAS mobile networks, noting AAS does not apply to user terminals in the 1800 MHz frequency band.

It should be noted that previous analysis described in CEPT Report 63 showed that LTE non-AAS and 5G NR non-AAS are equivalent. In consequence, there is no need to address coexistence with adjacent services which have been addressed by CEPT Report 48 and CEPT Report 63.

3.2 FREQUENCY BANDS

The analysis considers 5G non-AAS MCA systems operating at the frequency bands listed in Table 4 below.

Table 4: Frequency band of 5G non-AAS MCA

Direction	Frequency bands
Uplink	1710-1785 MHz
Downlink	1805-1880 MHz

3.3 IDENTIFICATION OF SCENARIOS

The following two scenarios for 5G non-AAS MCA connectivity are studied in this Report:

a) ac-UE impact on the ground-based communications link (g-UE to g-BS (uplink)) from a single aircraft (corresponding to scenario #5 in ECC Report 187 [10]). This scenario assesses the impact of on board ac-UE emissions on the ground-based BS receiver, by using MCL calculations.

b) ac-BS impact on the ground-based communication link (g-BS to g-UE (downlink)) from a single aircraft (corresponding to scenario #3 in ECC Report 187 [10]). This scenario assesses the impact of ac-BS emissions on the ground-based UE receivers, by using MCL calculations.

These scenarios are illustrated in the following figure.

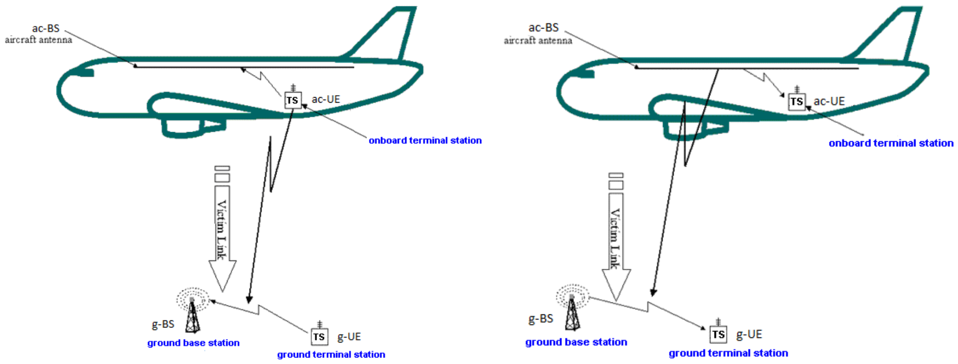

Figure 1: scenario a) (left) and b) (right)

3.3.1 Propagation model for the pathloss between aircraft and victim receivers on the ground

The propagation model used for the pathloss between the aircraft and the victim receivers on the ground is the free space loss (FSL) model and is given by:

$$FSL = 92.4 + 20 \times \log_{10} d + 20 \times \log_{10} f \quad (1)$$

Where:

- *d* (km) is the distance;
- *f* (GHz) the frequency (1850 MHz frequency is used in this Report).

3.4 GROUND-BASED PUBLIC MOBILE NETWORK PARAMETERS USED FOR MODELLING

3.4.1 Non-AAS ground-based public mobile network parameters

Table 5, Table 6 and Table 7 provide the parameters of the various user equipment and base stations, operating in the 1800 MHz band, that were used in the analysis.

Table 5: 1800 MHz 5G non-AAS parameters

Parameter	Unit	5G non-AAS	
		UE	BS
Antenna input power	dBm/channel	23	43 in 5 MHz 46 in 10, 15, 20, 30 MHz
Occupied bandwidth	MHz	4.5, 9.36, 14.22, 19.08, 23.94, 28.8	4.5, 9.36, 14.22, 19.08, 23.94, 28.8
Channel bandwidth	MHz	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30
Reference system noise figure (taken from values quoted in standards)	dB	9	5 (Note)
Reference noise level (thermal noise floor)	dBm/channel	-98.5 in 5 MHz channel -95.3 in 10 MHz channel -93.5 in 15 MHz channel -92.2 in 20 MHz channel -91.2 in 25 MHz channel -90.4 in 30 MHz channel	-102.5 in 5 MHz channel -99.3 in 10 MHz channel -97.5 in 15 MHz channel -96.2 in 20 MHz channel -95.2 in 25 MHz channel -94.4 in 30 MHz channel
Maximum antenna gain	dBi	-3	18
Antenna downtilt	degrees	N/A	3
Interference protection criterion (I/N)	dB	-6	
Note: Although the noise figure of deployed base station is around 3 dB, the feeder loss was not taken into account in the calculation. Therefore the 5 dB noise figure was used.			

Table 6: 1800 MHz LTE parameters

Parameter	Unit	LTE1800	
		UE	BS
Antenna input power	dBm/channel	23	43 in 5 MHz 46 in 10, 15, 20 MHz
Occupied bandwidth	MHz	4.5, 9, 13.5, 18	4.5, 9, 13.5, 18
Channel bandwidth	MHz	5, 10, 15, 20	5, 10, 15, 20
Reference system noise figure (taken from values quoted in standards)	dB	9	5 (Note)
Reference noise level (thermal noise floor)	dBm/channel	-98.5 in 5 MHz channel -95.5 in 10 MHz channel -93.7 in 15 MHz channel -92.4 in 20 MHz	-102.5 in 5 MHz channel -99.5 in 10 MHz channel -97.7 in 15 MHz channel -96.4 in 20 MHz channel
Maximum antenna gain	dBi	-3	18
Antenna downtilt	degrees	N/A	3
Interference protection criterion (I/N)	dB	-6	
Note: Although the noise figure of deployed base station is around 3 dB, the feeder loss was not taken into account in the calculation. Therefore the 5 dB noise figure was used.			

Table 7: 1800 MHz GSM parameters

Parameter	Unit	GSM1800	
		UE	BS
Antenna input power	dBm/channel	30	43
Occupied bandwidth	kHz	200	200
Reference system noise figure	dB	12	8 (Note 1)
Reference noise level (thermal noise floor)	dBm/channel	-109	-113
Maximum antenna gain	dBi	0 (Note 2)	18
Antenna downtilt	degrees	N/A	3
Interference protection criterion (I/N)	dB	-6	
Note 1: Although the noise figure of deployed base station is around 3 dB, the feeder loss was not taken into account in the calculation. Therefore, the 8 dB noise figure was used. Note 2: This is consistent with parameters in CEPT Report 63			

3.4.1.1 Antenna model

Recommendation ITU-R F.1336-4 [11] (recommends 3.1) is used to model all base station antennas with the following assumptions:

- Improved peak sidelobe pattern;
- Parameters k_a, k_p, k_h are set to 0.7 and the parameter k_v is set to 0.3;
- 65 degrees sector antenna with 3 dB horizontal beamwidth.

An omni-directional antenna is used to model all user equipment antennas.

3.4.2 AAS ground-based public mobile network parameters

Parameters for BS and UE are the same as in Table 5 except for antenna characteristics for BS. Parameters of AAS BS are given in ANNEX 3. An omni-directional antenna is used to model user equipment antenna.

4 COMPATIBILITY ANALYSES RELATED TO ON BOARD 5G NR NON-AAS CONNECTIVITY AT 1800 MHZ

The compatibility studies performed in this Report address the impact on ground-based public mobile networks by introducing an MCA system based on the 5G-NR technology operating at a height of at least 3000 metres above ground level in the following frequency band:

- 1710-1785 MHz for uplink (terminal transmit, base station receive)/1805-1880 MHz for downlink (base station transmit, terminal receive).

4.1 COMPATIBILITY ANALYSIS BETWEEN 5G NON-AAS MCA AND 5G NON-AAS GROUND-BASED PUBLIC MOBILE NETWORKS

4.1.1 Determination of the maximum e.i.r.p. of MCA 5G non-AAS stations

Within CEPT Report 63 [5], the worst elevation angle, when using the Recommendation ITU-R F.1336-4 [11], was found to be at 37° for frequencies higher than 1 GHz. This means that when the terrestrial base station antenna points towards the horizon, the on board terminal receives the most power from the base station when the aircraft is at an angle of 37° from it. This angle will be used when determining the maximum e.i.r.p. transmitted by the on board 5G user equipment. The same angle will also be used for the determination of the maximum e.i.r.p. transmitted by the MCA 5G non-AAS base station, as the aircraft fuselage attenuation towards the ground below the aircraft is bigger than that towards side directions (see ANNEX 4).

With respect to the interference protection criterion, the interference over noise ratio (I/N) is equal to -6 dB, which is equivalent to 1 dB desensitisation.

The signal transmitted by the on board station is given by:

$$Power_{ac-station} = I + FSL - G_{Rx} + Att_{AC} \quad (2)$$

Where:

- $Power_{ac-station}$ is the maximum signal transmitted by the on board station (dBm);
- I is the maximum interference signal received from the on board station (dBm);
- FSL is the free space path loss (dB);
- G_{Rx} is the antenna gain of ground station towards aircraft at the worst elevation angle (dBi);
- Att_{AC} is the aircraft attenuation (5 dB as contained in ECC Report 93 [9], ECC Report 187 [10] and CEPT Report 63 [5]).

The signal outside aircraft is given by:

$$Power_{outside\_aircraft} = Power_{ac-station} - Att_{AC} \quad (3)$$

4.1.1.1 Determination of the maximum e.i.r.p. transmitted by the on board 5G user equipment

Table 8 determines ac-UE power level and ac-UE e.i.r.p. outside the aircraft.

Table 8: Determination of maximum e.i.r.p. of on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Thermal noise floor of g-BS (dBm/(4.5 MHz))	-102.5							
Maximum interference received by g-BS (dBm/(4.5 MHz))	-108.5 (I/N=-6)							
Distance g-BS / ac-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
Free space propagation losses (dB)	111.7	114.2	116.1	117.7	119.0	120.2	121.2	122.1
g-BS antenna gain (dBi)	0.041							
Aircraft attenuation (dB)	5							
ac-UE power level (dBm/(4.5 MHz))	8.2	10.7	12.6	14.2	15.5	16.7	17.7	18.6
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	3.2	5.7	7.6	9.2	10.5	11.7	12.7	13.6

4.1.1.2 Determination of the maximum e.i.r.p. transmitted by the on board 5G non-AAS base station

Table 9 determines ac-BS power level and ac-BS e.i.r.p. outside the aircraft. Since the g-UE antenna pattern is omni-directional, in principle, the shortest distance between ac-BS and g-UE should be the aircraft height above ground. By considering the aircraft fuselage attenuation towards the ground below the aircraft is bigger than that into side directions, as shown in ANNEX 4, the calculation of ac-BS e.i.r.p. is also done at 37° angle from the horizontal direction.

Table 9: Determination of maximum e.i.r.p. of on board 5G non-AAS BS in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Thermal noise floor of g-UE (dBm/(4.5 MHz))	-98.5							
Maximum interference received by g-UE (dBm/(4.5 MHz))	-104.5 (I/N=-6 dB)							
Distance ac-BS / g-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
Free space propagation losses (dB)	111.7	114.2	116.2	117.8	119.1	120.3	121.3	122.2
g-UE antenna gain (dBi)	-3							
Aircraft attenuation (dB)	5							
ac-BS power level (dBm/(4.5 MHz))	15.2	17.7	19.6	21.2	22.5	23.7	24.7	25.6
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6

4.1.2 Compatibility studies between 5G non-AAS MCA and other terrestrial mobile systems

The maximum e.i.r.p. defined outside the aircraft for the on board 5G UE and the 5G non-AAS BS was calculated in section 4.1.1.1 and 4.1.1.2. It should be however assessed whether these maximum e.i.r.p. will not have an impact on the other in-band terrestrial technologies, i.e. GSM and LTE.

4.1.2.1 Compatibility studies between 5G non-AAS MCA and terrestrial GSM systems

Table 10 provides the I/N level received by the terrestrial GSM UE due to the aircraft 5G non-AAS BS.

Table 10: Protection threshold I/N verification for GSM UE on the ground caused by on board 5G non-AAS BS in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Distance ac-BS/g-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6
ac-BS e.i.r.p. outside the aircraft (dBm/(200 kHz))	-3.3	-0.8	1.1	2.7	4.0	5.2	6.2	7.1
Free space propagation losses (dB)	111.7	114.2	116.2	117.8	119.1	120.3	121.3	122.2
g-UE antenna gain (dBi)	0							
Interference received by g-UE (dBm/(200 kHz))	-115.0	-115.0	-115.0	-115.0	-115.0	-115.0	-115.0	-115.0
System noise level, reference value (dBm/(200 kHz))	-109.0							
I/N (dB)	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0

The interference protection criterion for GSM UE is met. This verification is done under the assumption that on board MCA 5G 5 MHz channel bandwidth is fully occupied with a uniformly distributed transmit power over each resource block. In case the MCA 5G channel bandwidth is partially occupied, e.g. one RB is used, the MCA 5G BS full power is transmitted over this 1 RB=180 kHz, in this case, the co-channel terrestrial GSM network carrier may suffer more interference.

Table 11 provides the I/N level received by the terrestrial GSM BS due to the aircraft 5G UE.

Table 11: Protection threshold I/N verification for GSM BS on the ground caused by on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Distance g-BS / ac-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	3.2	5.7	7.6	9.2	10.5	11.7	12.7	13.6
ac-UE e.i.r.p. outside the aircraft (dBm/(200 kHz))	-10.3	-7.8	-5.9	-4.3	-3.0	-1.8	-0.8	0.1
Free space propagation losses (dB)	111.7	114.2	116.1	117.7	119.0	120.2	121.2	122.1
g-BS antenna gain (dBi)	0.041							
Interference received by g-BS (dBm/(200 kHz))	-122.0	-122.0	-122.0	-122.0	-122.0	-122.0	-122.0	-122.0
System noise level, reference value (dBm/(200 kHz))	-113							
I/N (dB)	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0

This verification assumes that there is a single on board UE transmitting over the whole channel bandwidth. Normally there are a number of MCA UEs transmitting at the same time; if there are more than two ac-UEs transmitting at full power at the same time, the I/N=-6 dB protection criterion cannot be met and terrestrial GSM BS may suffer more interference.

Table 10 and Table 11 show that interference protection criterion I/N=-6 dB is met under the assumption that the aircraft 5G NR non-AAS system allocates the transmit power always uniformly over its channel bandwidth. However, in a 5G NR non-AAS system, the radio resource allocation does not work in this way. Depending on the number of RBs allocated to a user and number of ac-UE, more power can be allocated to some limited RBs, which means ground BS and/or UE will suffer more interference. It can be then concluded that the operation of a 5G non-AAS service on board in 1800 MHz band may have an impact on the terrestrial GSM networks.

4.1.2.2 Compatibility studies between 5G non-AAS MCA and terrestrial LTE systems

Table 12 provides the I/N level received by the terrestrial LTE UE due to the aircraft 5G non-AAS base station.

Table 12: Protection threshold I/N verification for LTE UE on the ground caused by on board 5G non-AAS BS in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Distance ac-BS/g-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6
Free space propagation losses (dB)	111.7	114.2	116.1	117.7	119.0	120.0	121.2	122.1
g-UE antenna gain (dBi)	-3							
Interference received by g-UE (dBm/(4.5 MHz))	-104.5	-104.5	-104.5	-104.5	-104.5	-104.5	-104.5	-104.5
System noise level, reference value (dBm/(4.5 MHz))	-98.5							
I/N (dB)	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0

Table 13: provides the I/N level received by the terrestrial LTE BS due to the aircraft 5G UE.

Table 13: Protection threshold I/N verification for LTE BS on the ground caused by on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Distance g-BS/ac-UE (km)	4.96	6.64	8.3	9.96	11.62	13.28	14.94	16.59
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	3.2	5.7	7.6	9.2	10.5	11.7	12.7	13.6
Free space propagation losses (dB)	111.7	114.2	116.1	117.7	119.0	120.2	121.2	122.1
g-BS antenna gain (dBi)	0.041							
Interference received by g-BS (dBm/(4.5 MHz))	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5
System noise level, reference value (dBm/(4.5 MHz))	-102.5							
I/N (dB)	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0

Table 12 and Table 13 show that the interference protection criterion I/N=-6 dB is met under the assumption that the on board MCA BS is always transmitting over the full channel bandwidth with uniformly power sharing by all of the resource blocks and a single ac-UE transmitting over the full channel bandwidth. In case of partial channel occupation by the BS or multiple ac-UEs transmitting at full power, the terrestrial LTE BS and/or UE will suffer more interference.

It can be then concluded that the operation of a 5G non-AAS service on board in 1800 MHz band will have an acceptable impact on the terrestrial LTE networks under the assumption of full channel bandwidth occupation by the ac-BS and a single ac-UE occupying the full channel bandwidth with the maximum transmit power.

4.1.3 Summary

The studies show that harmful interference on the ground non-AAS networks (LTE and 5G NR) is below the acceptable level when the technical conditions provided in Table 14 and Table 15 are met under assumption of a single ac-UE and full channel occupation by the ac-BS. The potential impact on GSM could be important when considering that the 5G NR radio resource allocation is not always uniform over the whole channel bandwidth.

Table 14: Maximum e.i.r.p. of on board 5G non-AAS BS in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6
ac-BS power level (dBm/(4.5 MHz)) for 5 MHz channel	15.2	17.7	19.6	21.2	22.5	23.7	24.7	25.6

Table 15: Maximum e.i.r.p. of on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	3.2	5.7	7.6	9.2	10.5	11.7	12.7	13.6
ac-UE power level (dBm/(4.5 MHz)) for 5 MHz channel	8.2	10.7	12.6	14.2	15.5	16.7	17.7	18.6

4.2 5G NON-AAS MCA COMPATIBILITY ANALYSIS WITH 5G AAS GROUND-BASED PUBLIC MOBILE NETWORKS

4.2.1 Determination of the maximum e.i.r.p. of on board 5G non-AAS stations

As AAS does not apply to user terminals in the 1800 MHz frequency band, hence the parameters of g-UE remains the same as for the non-AAS network, therefore there is no change in the outcome of the impact of the ac-BS, as given in section 4.1.3.

Therefore, this section analyses only the impact of the ac-UE onto the terrestrial 5G AAS base station. Based on ANNEX 3, the worst elevation angle is 15° which corresponds to an AAS side lobe gain of 10.9 dBi.

Table 16 determines ac-UE power level and ac-UE e.i.r.p. outside the aircraft using the same approach as in section 4.1.1.1.

Table 16: Determination of maximum e.i.r.p. of on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
Thermal noise floor of g-BS (dBm/(4.5 MHz))	-102.5							
Maximum interference received by g-BS (dBm/(4.5 MHz))	-108.5 (I/N=-6 dB)							
Distance g-BS/ac-UE (km)	11.6	15.5	19.3	23.2	27.0	30.9	34.8	38.6
Free space propagation losses (dB)	119.0	121.6	123.5	125.1	126.4	127.6	128.6	129.5
g-BS antenna gain (dBi)	10.9							
Aircraft attenuation (dB)	5							
ac-UE power level (dBm/(4.5 MHz))	4.6	7.2	9.1	10.7	12.0	13.1	14.2	15.1
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz))	-0.4	2.2	4.1	5.7	7.0	8.1	9.2	10.1

As the values in Table 16 are lower than the values in Table 15 therefore interference protection criterion I/N=-6 dB regarding compatibility with ground GSM and LTE networks will be met (see section 4.1.3) under the assumption of a single ac-UE transmitting at the full power over the full channel bandwidth.

4.2.2 Summary

Based on the above calculation and determination, the maximum e.i.r.p. defined outside the aircraft that an on board UE could transmit is provided in Table 17.

Table 17: Maximum e.i.r.p. of on board 5G UE in 1800 MHz

Height above ground (km)	3	4	5	6	7	8	9	10
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	-0.4	2.2	4.1	5.7	7.0	8.1	9.2	10.1
ac-UE power level (dBm/(4.5 MHz)) for 5 MHz channel	4.6	7.2	9.1	10.7	12.0	13.1	14.2	15.1

5 IMPACT OF AAS USAGE IN TERRESTRIAL MOBILE NETWORKS

Previous studies on MCA within the CEPT did not consider the use of Active Antenna Systems (AAS). CEPT Report 63 [5], which previously investigated NCU requirements, was published in 2016.

Since that time, other CEPT frameworks on mobile issues - such as those governing the use of the 1800 MHz, 2 GHz, 2.6 GHz, and 3.4-3.8 GHz bands - have been updated to take into account AAS. AAS base stations have different antenna gains and beam patterns than traditional terrestrial base stations. For example, AAS systems may incorporate SSB (Synchronisation Signal Block) multi-beam antenna patterns or data beam-forming antenna patterns. Moreover, AAS can be used to provide connectivity for drones or other unmanned aerial systems (UAS), known in this context as “aerial UEs”.

This section refers to compatibility with 5G AAS ground-based public mobile networks and assesses the need for NCU due to AAS base stations.

This Report has studied in section 4.2 the 5G non-AAS MCA compatibility with 5G AAS ground-based public mobile networks.

In addition:

- Assuming that a terminal on board aircraft could establish connection with an AAS base station on the ground, this implies that the SSB beam allows that connection. It appears not to be the case due to the fact that SSB will focus on terrestrial coverage first. In addition, AAS base stations are targeting terrestrial coverage and, taking into account the aircraft speed, the possibility for a terminal on board aircraft to establish connection with AAS base stations would remain extremely limited. In consequence, update of terrestrial mobile networks with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to AAS terrestrial networks (LTE, 5G NR).
- Assuming that cases when the antenna beam is pointing towards a direction above the horizon to serve aerial UEs (drones) would remain limited. Only a few base stations would be affected by this scenario. It is also assumed that the antenna pointing to the aerial UE (drone) would remain momentary. Taking into account the aircraft speed, the possibility for terminal on board aircraft to establish connection with AAS base stations serving aerial UE (drones) would remain extremely limited. In consequence, future usages of aerial UEs (drones) with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to AAS terrestrial networks (LTE, 5G NR).

In consequence, there is no need for an NCU to prevent connection to AAS terrestrial network (LTE, 5G NR).

Assuming that future usages of aerial UEs (drones) with AAS base stations will remain limited no additional measures are required to ensure coexistence with MCA services.

The impact on ground AAS network with UAS operation was not considered in this CEPT Report and may need further study in the future.

6 UMTS NETWORKS IN OPERATION

UMTS networks were first launched in Europe in 2001. In 2013, MCA services using UMTS technology were introduced operating in the 2100 MHz frequency band.

The 900 MHz band is also used extensively for UMTS services across Europe, and an NCU is currently required on MCA flights to protect both the 900 MHz and 2100 MHz bands.

ECO Report 03 [12] is regularly updated by administrations. It provides information on relevant authorisations in force in CEPT countries in 900 MHz and 2.1 GHz bands and, when the information is available, where UMTS systems are in operation. This ECO Report does not give visibility on any trend for the switch off of mobile technology.

CEPT noted a main assumption that UMTS in the 2 GHz band could be refarmed to 4G LTE or 5G NR in the near future, in line with EU regulation to employ up-to-date technology where possible, as well as to increase spectrum efficiency in response to market demand in a competitive environment.

The trend to refarm UMTS 900 MHz band is likely to be less certain due to the fact that UMTS will remain in operation still for very long time in some EU Member States. CEPT is not able to confirm that UMTS will be switched off in the 900 MHz band in all EU Member States.

7 IMPACT OF EASA REGULATION

The MCA framework, providing harmonised technical conditions for MCA BS, UE (GSM, UMTS, LTE, 5G non-AAS) and NCU, has been established in order to ensure coexistence between usage of UE on board aircraft and ground mobile networks and to avoid RF interference from on board MCA usage and any performance impact on ground networks.

Nonetheless, MCA licenced service providers reported at the time of writing this Report that only approximately 3%[3] of European commercial aircraft are equipped with MCA systems and have an NCU on board.

Non-MCA aircraft are either aircraft equipped with an inflight RLAN connectivity system only, or aircraft without inflight connectivity equipment (see also CEPT Report 63, sections 0 and 1 [5]).

Below 3000 m both MCA and non-MCA aircraft are under the same regulatory regime.

During the drafting of this CEPT Report, it has been mentioned that for non-MCA equipped aircraft it is up to airline companies whether to require the passengers to switch off their mobile devices or not (some are already allowing their passengers to use their mobile phones on board during all phases of a flight) in accordance with current EASA regulation 2014/029/R [13] for civil aviation safety and security which does not address coexistence with ground mobile networks and adjacent services.

Additionally, independently from the airlines' rules, some passengers might leave their phones on unintentionally during a flight.

EC should note that even without MCA, if an airline company allows their passengers to use their mobile phone on board during flights, the UE on board may attempt to connect to UMTS ground networks and create a performance impact as described in CEPT Report 63.

CEPT is not aware of any complaints or reports of interference from mobile network operators regarding possible adverse impacts (e.g. increased signalling load, capacity degradation) on terrestrial 900 MHz or 2 GHz UMTS networks from electronic devices on board European commercial aircraft (regardless of whether an MCA system and NCU were installed). However it should be stressed that due to the complexity of such impacts it is difficult to identify the source of interference which may be the reason why operators do not report/complain.

CEPT discussions focused on the technical question about whether there is still a need for a NCU to prevent connection from user terminals on board MCA-equipped aircraft to ground-based UMTS networks.

[3] see CEPT Report 63

8 CONCLUSIONS

This Report has been prepared in response to Task 1 of the Mandate from the European Commission to "*Study and assess conditions to operate 5G non-AAS connectivity for MCA in the 1800 MHz (1710-1785 MHz and 1805-1880 MHz) frequency band and develop harmonised technical conditions for the consequential revision of Commission Implementing Decision 2008/294/EC (as amended)"* and Task 2 to *"Study and assess whether, and under what conditions the usage of an NCU in MCA operations could be made optional."*

8.1 5G NON-AAS SYSTEMS ON BOARD AIRCRAFT AT 1800 MHZ

Minimum coupling loss analysis was used to determine the compatibility of 5G non-AAS systems on board aircraft at 1800 MHz with terrestrial GSM, LTE, 5G NR systems. It also considered possible usage of AAS systems in the ground networks in that band. The criterion of interference over noise ratio (I/N) equals to -6 dB, which is equivalent to an increase of 1 dB over the thermal noise floor, and was used for victim terrestrial user equipment and base stations caused by the external interference from either 5G aircraft user equipment and aircraft base stations. The analysis shows that the harmful interference is below an acceptable level of 1 dB desensitisation (noise rise below 1 dB) if the technical conditions set in Table 18 and Table 19 below are met for 5G non-AAS systems.

It should be pointed out that the impact on the terrestrial MFCN networks when a possible aerial user equipment ("UE") (*e.g.*, drone) operation in 1800 MHz terrestrial MFCN network with both non-AAS and AAS BS was not studied. Further study on this aspect may be required in the future.

Table 18 and Table 19 provide the maximum e.i.r.p., defined outside and inside the aircraft, of the MCA 5G non-AAS BS and on board 5G UE. For channel bandwidth other than 5 MHz, a correction is calculated by adding $10 \times \log_{10}$(channel bandwidth/5 MHz) dB to the aircraft base station (ac-BS) e.i.r.p. values. For a mobile terminal on board an aircraft (ac-UE), the calculated results are per channel regardless of which channel bandwidth is used.

Table 18: Maximum e.i.r.p. of 5G non-AAS on board ac-BS in 1800 MHz band

Height above ground (km)	3	4	5	6	7	8	9	10
ac-BS e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	10.2	12.7	14.6	16.2	17.5	18.7	19.7	20.6
ac-BS e.i.r.p. inside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	15.2	17.7	19.6	21.2	22.5	23.7	24.7	25.6

Table 19: Maximum e.i.r.p. of 5G on board ac-UE in 1800 MHz band

Height above ground (km)	3	4	5	6	7	8	9	10
ac-UE e.i.r.p. outside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	-0.4	2.2	4.1	5.7	7.0	8.1	9.2	10.1
ac-UE e.i.r.p. inside the aircraft (dBm/(4.5 MHz)) for 5 MHz channel	4.6	7.2	9.1	10.7	12.0	13.1	14.2	15.1

8.2 NCU IN MCA OPERATION

MCA systems are currently authorised to operate with GSM, UMTS and LTE technologies. For protecting ground GSM and LTE terrestrial networks at all frequencies, previous studies have shown that there is no need to have an NCU for MCA operation. However, for MCA systems, either n Network Control Unit (NCU) or aircraft fuselage shielding to further attenuate the signal is required to protect UMTS ground networks. The NCU increases the noise floor of the aircraft cabin. It is designed to ensure that signals transmitted by ground-based mobile systems are not detectable by the user equipment within the aircraft cabin. This is to ensure that MCA user terminals can only attempt to connect to the on board MCA base station.

Nonetheless, MCA licensed service providers reported at the time of writing this Report that only approximately 3%[4] of European commercial aircraft are equipped with MCA systems and have an NCU on board. For non-MCA equipped aircraft it is up to airline companies whether to require the passengers to switch off their mobile devices or not, in accordance with current EASA regulation 2014/029/R [13] for civil aviation safety and security. However, the MCA framework has been developed to allow the wireless communication technologies to be used by passengers on board aircraft in order to ensure coexistence of these services with other radio communications services including mobile networks on the ground.

CEPT is not aware of any complains or reports of interference from mobile network operators regarding possible adverse impacts (e.g. increased signalling load, capacity degradation) on terrestrial 900 MHz or 2 GHz UMTS networks from electronic devices on board European commercial aircraft (regardless of whether an MCA system and NCU were installed). However it should be stressed that due to the complexity of such impacts it is difficult to identify the source of interference which may be the reason why operators do not report/complain.

CEPT Report 63 [5] covers MFCN networks with non-AAS and was developed in 2016. It made the assumption concerning 5G "*future technologies related to 5G would likely involve frequency and time multiplexing access schemes for the transmission and the reception of UE and BS, similarly to GSM and LTE, unlike UMTS. Without precluding the frame structure, the waveform, the signalling procedures applicable to 5G systems, it can be expected, therefore, that the results of the studies for future 5G technologies would be similar to the LTE case".* Since then, the CEPT regulatory framework has been updated for MFCN terrestrial networks with AAS operating in the frequency band above 1 GHz (1.8 GHz, 2 GHz, 2.6 GHz and 3.4-3.8 GHz).

CEPT informs also the European Commission that AAS base stations have different antenna gain and patterns (SSB multi-beams antenna pattern and data beam-forming antenna pattern) compared to non-AAS antenna and may create a beam pointing towards a direction above the horizon to serve aerial UEs. The impact of MCA on MFCN with AAS has not been analysed in previous CEPT Reports in response to EC Mandates on MCA. CEPT is currently developing a relevant framework for harmonised operational and technical conditions for the usage of aerial UE in MFCN harmonised bands.

This Report confirms that an update of terrestrial mobile networks with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to AAS terrestrial networks.

Furthermore the future limited usages of aerial UEs (drones) with AAS base stations does not require additional measures (compared with non-AAS terrestrial BS) for MCA to ensure coexistence with MCA services and there is no need for a NCU to prevent connection to this AAS terrestrial networks .

By considering that:

- The discussion of technological neutrality, non-discrimination, and proportionality is separate from the technical question about whether there is still a need for an NCU to prevent connection from user terminals on board MCA-equipped aircraft to ground-based UMTS networks;
- CEPT Report 63 concluded that NCU is only required when UMTS terrestrial network is in operation;
- UMTS networks in the 2 GHz band could be refarmed to 4G LTE or 5G NR in near future to employ up-to-date technology where possible, as well as to increase spectrum efficiency in respond to market demand in a competitive environment;
- UMTS networks in the 900 MHz band will remain in operation still for a very long time in some EU Member States. CEPT is not able to confirm that UMTS will be switched off in 900 MHz band in the near future;
- Development of AAS usage in terrestrial mobile networks including possible limited usages of aerial UEs (drones) with AAS bases stations does not require the need for NCU.

[4] see CEPT Report 63

- The MCA framework has been developed to allow the wireless communication technologies (GSM, UMTS, LTE) to be used by passengers on board aircraft and that this report proposes also harmonised technical conditions for 5G non-AAS technology to be used by passengers on board aircraft;
- Airline companies can allow (and for some are already allowing) their passengers to use their mobile phones on board during all phases of a flight on non-MCA aircraft while respecting current EASA regulation 2014/029/R which does not address coexistence with ground mobile networks and adjacent services. Additionally, independently from the airline's rules, some passengers might leave on their phones unintentionally during a flight.

It can be concluded that:

- The usage of NCU in MCA operations in 900 MHz band to prevent connection to ground-based UMTS networks should remain mandatory.
- The usage of NCU in MCA operations in 2 GHz band may be made optional in the near future.

ANNEX 1: MANDATE TO CEPT

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR COMMUNICATIONS NETWORKS, CONTENT AND TECHNOLOGY

The Director-General

Brussels,
CNECT B4

MANDATE TO CEPT
TO UNDERTAKE TECHNICAL STUDIES ON THE POTENTIAL USE OF 5G TECHNOLOGY AND ON MAKING THE USAGE OF THE NETWORK CONTROL UNIT (NCU) OPTIONAL ON BOARD MCA ENABLED AIRCRAFT

1. Purpose

The purpose of this mandate is to study the possibility of introducing 5G non-AAS technology and making the usage of the Network Control Unit (NCU) optional, for Mobile Communications on board Aircraft (MCA), in order to satisfy the EU policy objectives listed below.

5G

The deployment in Europe of terrestrial 5G network infrastructure is central for meeting the Gigabit connectivity targets and for enhancing the Union's industrial strategy and international competitiveness. In 2016, the Commission adopted the 5G Action Plan to make sure that the Union has the connectivity infrastructure necessary for its digital transformation as of 2020 and for comprehensive 5G deployment. The related Commission Communication on the Gigabit Society sets the ambition of ubiquitous access to broadband connectivity[1]. More recently, the Commission Communication on Shaping Europe's Digital Future of February 2020[2] sets out the need to accelerate investments in Gigabit connectivity under its key objective "Technology that works for people".

In addition to the harmonisation of the three 5G pioneer bands (700 MHz, 3.6 GHz and 26 GHz), a number of other EU-harmonised bands have become "5G ready", including for usage with Active Antennas Systems (AAS) notably the paired terrestrial 2 GHz and the 2.6 GHz bands, through updates of the relevant EU Implementing Decisions. The update of EU harmonised technical conditions in the 900 and 1800 MHz bands is also under study by the CEPT in response to a relevant EC mandate.

[1] COM(2016)587 "Connectivity for a Competitive Digital Single Market – towards a European Gigabit Society".

[2] COM(2020)67 "Shaping Europe's digital future".

Further to a request from MCA stakeholders, CEPT is currently studying the harmonised technical condition to operate 5G non-AAS connectivity for MCA in the 1710-1785 MHz and 1805-1880 MHz (1800 MHz) band.

NCU

The NCU is part of the MCA onboard system. It is designed to ensure that signals transmitted by ground-based mobile systems (ECS networks) are not detectable within the aircraft cabin and that the user terminals on the aircraft transmit at a minimum power level so that they only register with the onboard MCA Base Station.

Further to the last update of the EC framework on MCA, NCU remains mandatory for the UMTS bands (900 MHz and 2100 MHz)[3] to prevent User Terminals onboard the aircraft from seeing terrestrial UMTS networks. The deployment of the NCU has cost implications and should therefore be regularly reviewed in terms of its necessity.

A technical solution based just on the control function of the onboard MCA Base Station (i.e. without the need to deploy a full-fledged NCU system) in order to prevent user terminals from attempting connections to the ground should be studied in order to assess the possibility to operate MCA services on board aircraft without NCU. Enabling MCA systems without NCU would simplify the regulatory framework and reduce operating costs, thus fostering a broader adoption of MCA. It could also reduce the number of "uncontrolled" active mobile devices on board aircraft.

Making the NCU optional was already considered in a previous mandate on MCA[4] and the consequent CEPT Report 63[5]. MCA stakeholders argue that this could be reviewed taking into consideration different assumptions like the primary common pilot channel (CPICH)[6] pollution from terrestrial UMTS networks as seen from the aircraft, which had not been considered in CEPT Report 63, as well as the reduction of UMTS usage in Europe due to evolution towards 4G and 5G.

2. EU Policy objectives

Better regulation: the EU has taken the engagement to design policies and laws so that they achieve their objectives at minimum cost. This ensures that policy is prepared, implemented and reviewed in an open, transparent manner, informed by the best available evidence and backed up by involving stakeholders. To ensure that EU action is effective, the Commission assesses the expected and actual impacts of policies, legislation and other important measures at every stage of the policy cycle - from planning to implementation, to review and subsequent revision.

Competitiveness: should technical studies prove that the MCA services without NCU could coexist with terrestrial mobile networks, keeping the undue obligation of NCU installation would

3 CEPT Report 63 concluded that: *"For UMTS systems, [...] an NCU is necessary to prevent connection of User Equipment onboard to mobile communications networks on the ground, and that the resulting connection will cause a partial and temporary reduction in capacity for the connecting and neighbouring ground based cells"*.

4 RSCOM15-45rev.1

5 https://www.ecodocdb.dk/download/d8623f8a-1ff1/CEPTREP063.pdf

6 To distinguish base stations in the network from each other, to perform handover decisions, cell selections and reselections, each base station transmits on the primary common pilot channel (P-CPICH) and its level is transmitted at a constant power.

constitute an undue hindrance to competitiveness. Inclusion of new 5G connectivity in the MCA capability is needed in order to provide the highest service standards to European citizens.

Socioeconomic dimension: Simplifying and making a less complex regulatory framework for MCA operation while at the same time adding 5G connectivity, facilitates connectivity to citizens during travel, whilst making use of the latest available technologies.

3. Justification

Commission Decision 2008/294/EC of 7 April 2008 on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the Community, as modified by Commission Implementing Decisions 2013/654/EU[7] and 2016/2317/EU[8], contains the obligation to install a Network Control Unit[9] in all MCA enabled aircraft.

Implementing Decision 2013/654/EU imposes, *inter alia*, the upgrading of NCUs in order to cover new terrestrial mobile frequencies. This involves several steps including the design, product certification, airworthiness certification, marketing and installation (which can be done only on the occasion of major aircraft maintenance overhauls).

Meanwhile, at this stage, no interference case has been reported to or from terrestrial mobile systems. Furthermore, every day several mobile terminals are inadvertently left in "transmit" mode in "non-connected" aircraft. It should however be reminded that the sources of interferences (as well as of any signalling issues) on mobile networks are more and more difficult to detect.

Pursuant to Article 4(2) of the Radio Spectrum Decision[10] the Commission may issue mandates to the CEPT for the development of technical implementing measures with a view to ensuring harmonised conditions for the availability and efficient use of radio spectrum necessary for the functioning of the internal market. Such mandates shall set the tasks to be performed and their timetable.

4. Task order and schedule

CEPT is herewith mandated to undertake work to introduce 5G non-AAS technologies on board MCA equipped aircraft and to determine the possibility to make the installation of a Network Control Unit on board MCA equipped aircraft optional.

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7 Commission Implementing Decision 2013/654/EU, of 12 November 2013, amending Decision 2008/294/EC to include additional access technologies and frequency bands for mobile communication services on aircraft (MCA services). OJ L303, 14.11.2013, p.48.

8 Commission Implementing Decision (EU) 2016/2317, of 16 December 2016, amending Decision 2008/294/EC and Implementing Decision 2013/654/EU, in order to simplify the operation of mobile communications on board aircraft (MCA services) in the Union.

9 According to Article 2 (4) of Decision 2008/294/EC, "*network control unit (NCU) means equipment to be located in the aircraft that ensures that signals transmitted by ground-based mobile electronic communication systems listed in Table 2 in the Annex are not detectable within the cabin by raising the noise floor inside the cabin in mobile communication receive bands*".

10 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.

Task 1

Study and assess conditions to operate 5G non- AAS connectivity for MCA in the 1800 MHz (1710-1785 MHz and 1805-1880 MHz) frequency band and develop harmonised technical conditions for the consequential revision of Commission Implementing Decision 2008/294/EC (as amended).

Task 2

Study and assess whether and under what conditions the usage of an NCU in MCA operations could be made optional.

In the work carried out under the Mandate, the general and specific policy objectives of the RSPP, such as effective and efficient spectrum use and the support for specific Union policies shall be given utmost consideration. In implementing this mandate, CEPT shall, where relevant, take utmost account of EU law applicable and support the principles of service and technological neutrality, non-discrimination and proportionality insofar as technically possible.

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

Delivery date	**Deliverable**	**Subject**
March 2021	Interim Report from CEPT to the Commission	Description of work undertaken, initial assessment and, if available, interim results.
September 2021	Draft Report from CEPT to the Commission	Description of work undertaken and final results subject to public consultation.
December 2021	Final Report from CEPT to the Commission, taking into account the outcome of the public consultation.	Description of work undertaken and final results.

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 EU, pursuant to Article 4 of the Radio Spectrum Decision.

ANNEX 2: PROPOSED UPDATES TO EC DECISION

For the Annex of Commission Implementing Decision (EU) 2016/2317 of 16 December 2016 amending Decision 2008/294/EC and Implementing Decision 2013/654/EU.

A2.1 FREQUENCY BANDS AND SYSTEMS ALLOWED FOR 5G NR NON-AAS MCA SERVICES

Table 20: Frequency bands and systems allowed for 5G NR non-AAS MCA services

Type	Frequency	System
5G NR non-AAS	1710-1785 MHz (uplink) 1805-1880 MHz (downlink)	5G NR non-AAS complying with the 5G NR Standards as published by ETSI, EN 301 908-24 [14] and EN 301 908-25 [15]

A2.2 TECHNICAL PARAMETERS

The equivalent isotropic radiated power (e.i.r.p.), outside the aircraft, from the 5G non-AAS aircraft BS must not exceed values in Table 21.

Table 21: The total e.i.r.p., outside the aircraft, from the 5G non-AAS aircraft BS – 1800 MHz band, 5 MHz channel bandwidth

Height above ground (m)	Maximum e.i.r.p. of the system outside the aircraft in dBm/(5°MHz)
3000	10
4000	13
5000	15
6000	16
7000	18
8000	19

For channel bandwidth other than 5 MHz, a correction, calculated by the formula $10 \times \log_{10}$(channel bandwidth/(5 MHz)) dB, shall be added to the e.i.r.p. values.

The equivalent isotropic radiated power (e.i.r.p.), outside the aircraft, from the mobile terminal must not exceed the values in Table 22.

Table 22: The e.i.r.p., outside the aircraft, from the on board 5G terminal, 1800 MHz band

Height above ground (m)	Maximum e.i.r.p., outside the aircraft, from the 5G mobile terminal in dBm/channel
3000	0
4000	2
5000	4
6000	6
7000	7
8000	8

For ac-UE, the e.i.r.p. is specified per channel regardless of the used channel bandwidth due to the fact that multiple ac-UE could be operated.

Operational requirements

To add the following operational requirements to the current operational requirements:

The aircraft base station, during operation, must limit the transmit power of all 5G NR mobile terminals transmitting in the 1800 MHz band to a nominal value of 5 dBm/channel at all stages of communication, including initial access.

ANNEX 3: 5G AAS GROUND-BASED PUBLIC MOBILE NETWORK BS ANTENNA VERTICAL PATTERN AND GAIN

Table 23 and Table 24 provide 1800 MHz terrestrial 5G mobile network deployment-related parameters and AAS parameters that were used in determining BS AAS gain to be used in compatibility analysis.

Table 23: 1800 MHz 5G deployment-related parameters

	Rural	Urban	Reference
Frequency (MHz)	1850	1850	
BS antenna height (m)	30	25	Report ITU-R M.2292 [16]
Cell Radius (m)	3000	500	Report ITU-R M.2292
UE distribution and antenna height (m)	Outdoor 50% (1.5 m) Indoor 50% (1.5 m)	Outdoor 30% (1.5 m) Indoor 70%: Ground floor (h = 1.5 m): 25% 1st floor (h = 4.5 m): 25% 2nd floor (h = 7.5 m): 10% 3rd floor (h = 10.5 m): 10% 4th floor (h = 13.5 m): 10% 5th floor (h = 16.5 m): 10% 6th floor (h = 19.5 m): 10%	Report ITU-R M.2292 ECC Report 309 [17]

Table 24: AAS parameters

	Rural	Urban	Reference
Antenna pattern	Recommendation ITU-R M.2101 [16]		
Antenna array configuration	8x8 elements	8x8 elements	Report ITU-R M.2292
Mechanical downtilt (degrees)	3	10	Report ITU-R M.2292
Horizontal radiating element spacing	0.5λ	0.5λ	ITU-R WP5D contribution 547 [19]
Vertical radiating element spacing	0.9λ	0.7λ	ITU-R WP5D contribution 547
Element gain (dBi)	7.1	6.4	ITU-R WP5D contribution 547
Horizontal/vertical 3 dB beam width of single element (degree)	90º for H 54º for V	90º for H 65º for V	ITU-R WP5D contribution 547
Horizontal/vertical front-to-back ratio (dB)	30 for both H/V	30 for both H/V	ITU-R WP5D contribution 547
Array Ohmic loss (dB)	2	2	ITU-R WP5D contribution 547

A3.1 AAS GAIN IN URBAN AREA

Two typical cases in an urban environment are considered.

Urban Case 1: as shown in Figure 2. AAS BS height is 25 m with a mechanical downtilt of 10°, the main beam is pointing to a user equipment whose height is 19.5 m at 500 m (cell range) from BS.

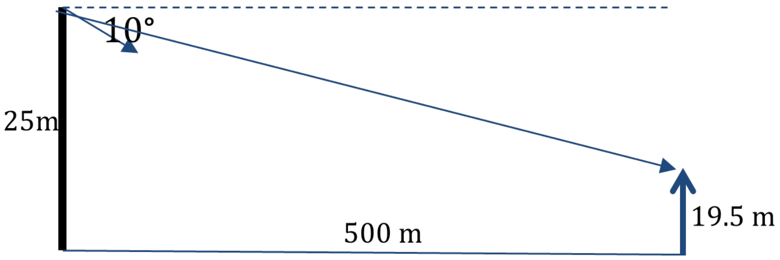


Figure 2: Urban case 1

AAS vertical pattern (Recommendation ITU-R M.2101 [18]) for urban case 1 is plotted in Figure 3 below.

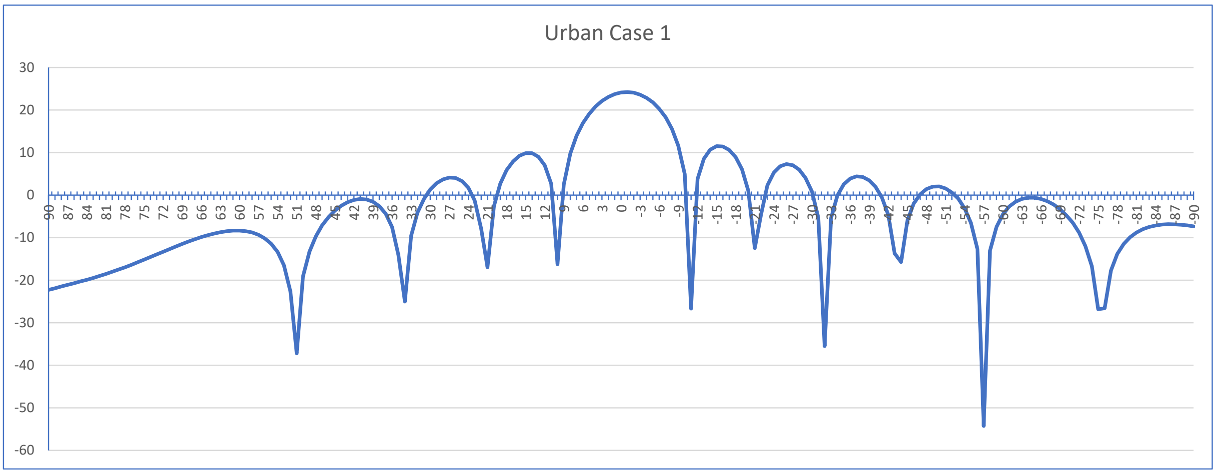


Figure 3: AAS vertical pattern (urban case 1)

Urban case 2: As shown in Figure 4 below. AAS BS height is 25 m with a mechanical downtilt of 10°, main beam is pointing to a user equipment whose height is 1.5 m and located at 50 m from BS.

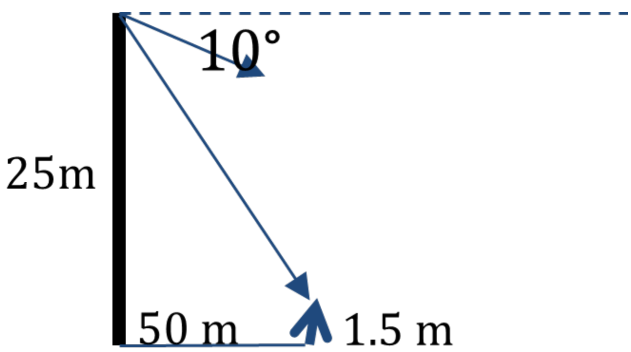


Figure 4: Urban case 2

AAS vertical pattern (Recommendation ITU-R M.2101) for urban case 2 is plotted in Figure 5 below.

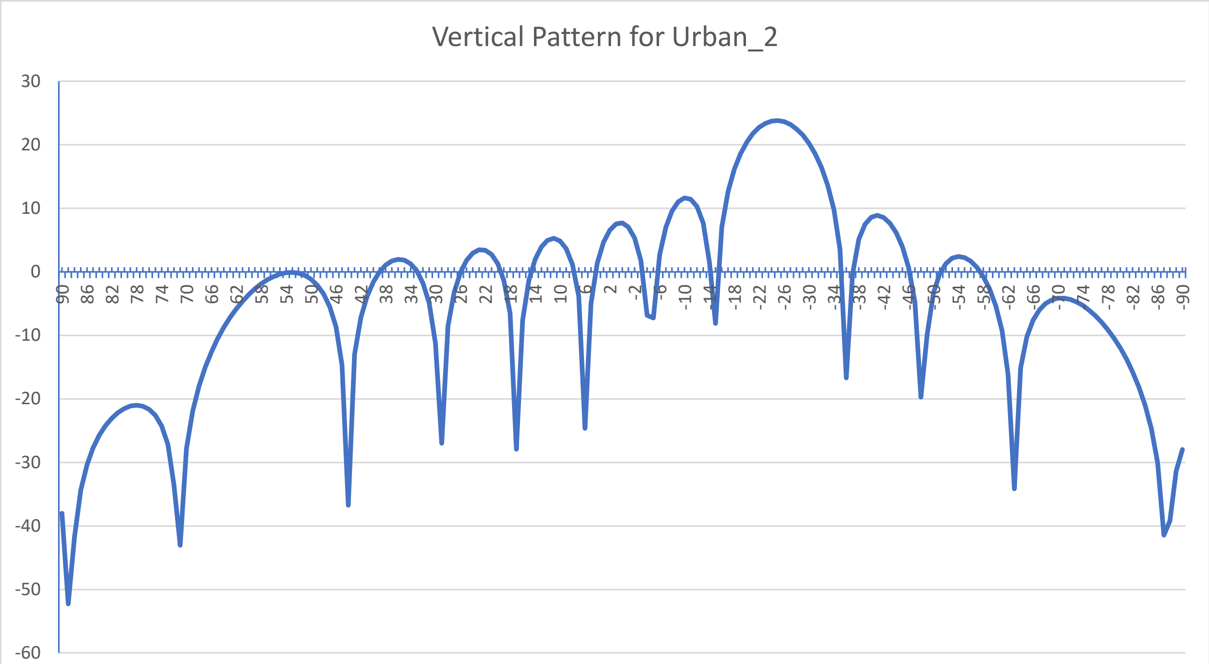


Figure 5: AAS vertical pattern (urban case 2)

A3.2 AAS GAIN IN RURAL AREA

Two typical cases in rural environment are considered.

Rural Case 1: as shown in Figure 6 below. AAS BS height is 30 m with a mechanical downtilt of 3°, the main beam is pointing to a user equipment whose height is 1.5 m and located at 3 km (cell range) from BS.

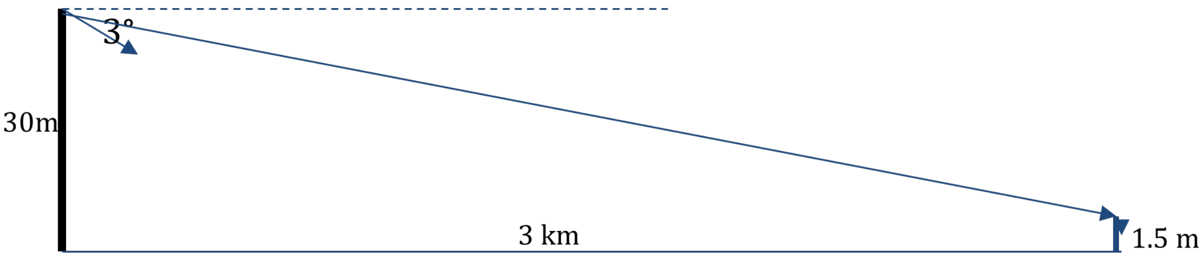


Figure 6: Rural case 1

AAS vertical pattern (Recommendation ITU-R M.2101) for rural case 1 is plotted in Figure 7 below.

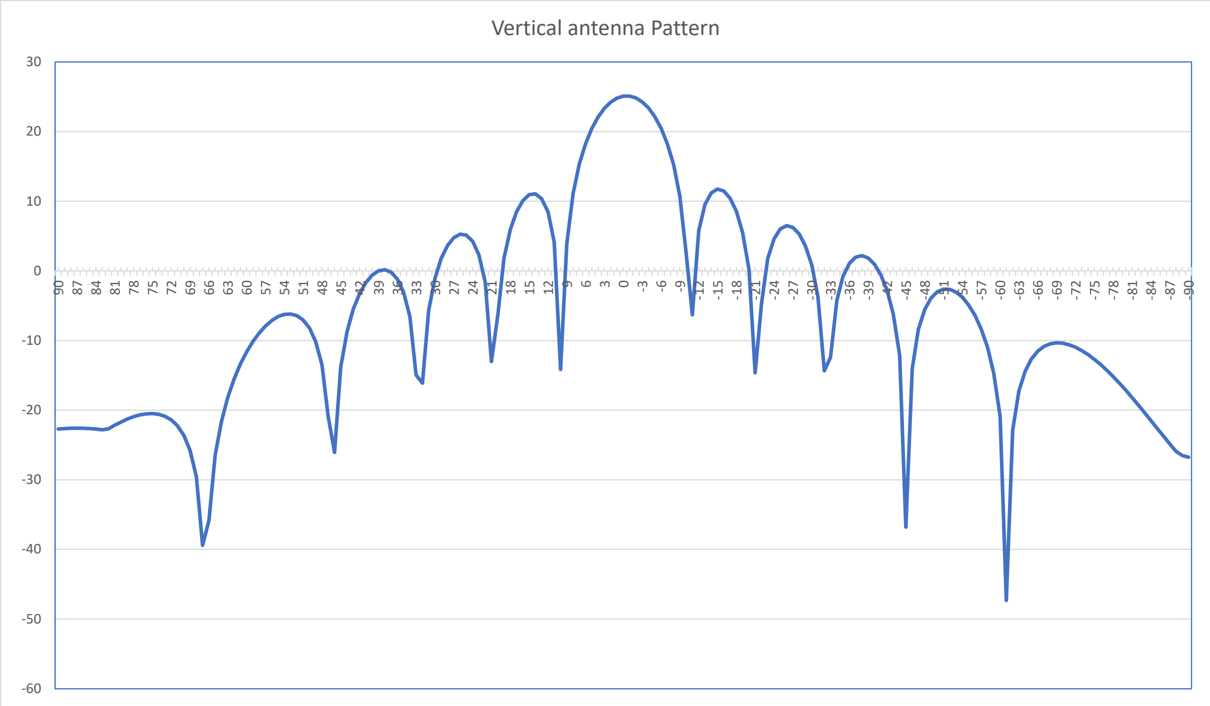


Figure 7: AAS vertical pattern (rural case 1)

Rural Case 2: as shown in Figure 8 below. AAS BS height is 30 m with a mechanical downtilt of 3°, the main beam is pointing to a user equipment whose height is 1.5 m and located at 100 m from BS.

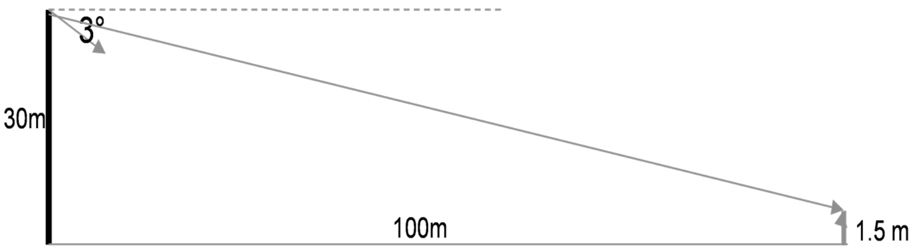


Figure 8: Rural case 2

The AAS vertical pattern (Recommendation ITU-R M.2101 [18]) for rural case 2 is plotted in Figure 9 below.

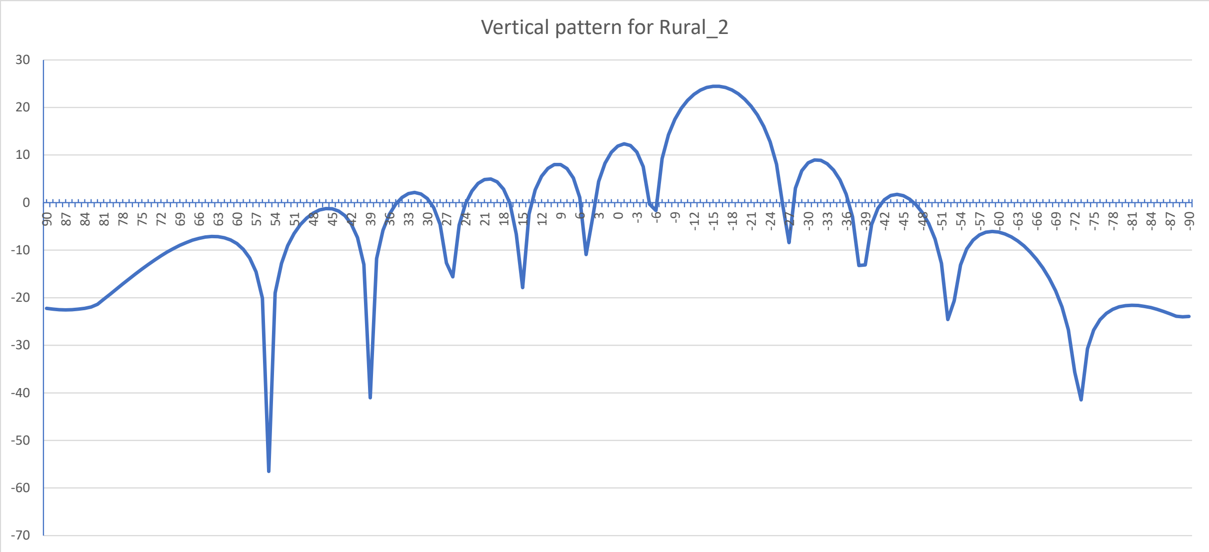


Figure 9: AAS vertical pattern (rural case 2)

A3.3 AAS GAINS

Typical AAS gains (Recommendation ITU-R M.2101 [18]) are summarised in Table 25. 0° is the horizontal plane, 90° is the vertical direction to the sky.

Table 25: Typical AAS gains (Recommendation ITU-R M.2101)

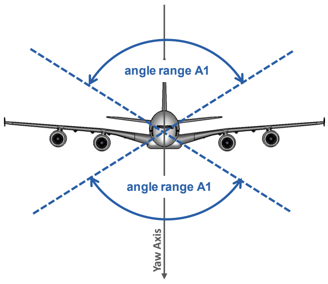
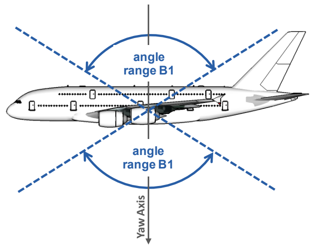
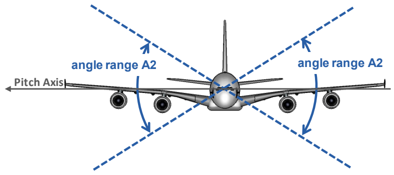
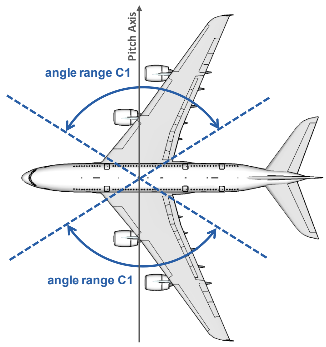
Urban case 1	Urban case 2	Rural case 1	Rural case 2
15°: 9.86 dBi 27°: 4.14 dBi 30°: 1.31 dBi 41°: -0.90 dBi	11°: 5.30 dBi 23°: 3.47 dBi 36°: 1.97 dBi 53°: -0.08 dBi 56°: -0.72 dBi	15°: 10.94 dBi 26°: 5.27 dBi 38°: 0.17 dBi	10°: 7.98 dBi 20°: 4.97 dBi 22° 4.02 dBi 32°: 2.14 dBi 46°: -1.25 dBi

Based on the above analysis, the worst elevation angle is 15° which corresponds to an AAS side lobe gain of 10.9 dBi.

ANNEX 4: AIRCRAFT FUSELAGE ATTENUATION

Table 26 below provides an extract from the Report ITU-R M.2283 [20] which provides some measurement result of aircraft fuselage valid for operating frequency above 1 GHz. It shows that the aircraft fuselage attenuation is greater below the aircraft.

Table 26: Extract from Report ITU-R M.2283

Case	Viewing angle		Configuration	Attenuation
1	viewed from angel within range A1 (+/–60° relative to yaw axis) 	viewed from angle within range B1 (+/–60° relative to yaw axis) 	a) transmitters installed within cabin	25 dB
			b) transmitters installed in lower lobe of aircraft fuselage	35 dB
			c) transmitters installed in enclosed compartments or in aircraft fitted with shielded windows	35 dB
2	viewed from angle within range A2 (+/–30° relative to pitch axis) 	viewed from angle within range C1 (+/–60° relative to pitch axis) 	a) transmitters installed within cabin	10 dB
			b) transmitters installed in lower lobe of aircraft fuselage	30 dB
			c) transmitters installed in enclosed compartments or in aircraft fitted with shielded windows	35 dB

ANNEX 5: LIST OF REFERENCES

[1] CEPT Report 16: "Report from CEPT to the European Commission in response to the Mandate on Mobile Communication Services on board aircraft (MCA)", approved July 2006

[2] EC Decision 2008/294/EC on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the Community, European Commission, 7 April 2008

[3] CEPT Report 48: "Report from CEPT to the European Commission in response to the Second Mandate to CEPT on mobile communication services on board aircraft (MCA)", approved March 2013

[4] EC Decision 2013/654/EC amending Decision 2008/294/EC to include additional access technologies and frequency bands for mobile communications services on aircraft (MCA services), European Commission, 12 November 2013

[5] CEPT Report 63 : "Report from CEPT to the European Commission in response to the Mandate "To undertake technical studies regarding the possibility of making the usage of the network control unit (NCU) optional onboard MCA enabled aircraft"", approved November 2016

[6] Commission Implementing Decision (EU) 2016/2317 of 16 December 2016 amending Decision 2008/294/EC and Implementing Decision 2013/654/EU, in order to simplify the operation of mobile communications on board aircraft (MCA services) in the Union

[7] ECC Decision (06)07: "the harmonised use of airborne GSM and LTE systems in the frequency bands 1710-1785 MHz and 1805-1880 MHz, and airborne UMTS systems in the frequency bands 1920-1980 MHz and 2110-2170 MHz", approved December 2006, updated June 2017

[8] Commission implementing Decision of 12 November 2013 amending Decision 2008/294/EC to include additional access technologies and frequency bands for mobile communications services on aircraft (MCA services)

[9] ECC Report 093: "Compatibility between GSM equipment on board aircraft and terrestrial networks. Revised ECC Report with Annex G (May 2008)", approved October 2006

[10] ECC Report 187: "Compatibility study between mobile communication services on board aircraft (MCA) and ground-based systems", approved February 2013

[11] Recommendation ITU-R F.1336-4: "Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile service for use in sharing studies in the frequency range from 400 MHz to about 70 GHz"

[12] ECO Report 03: "The Licensing of "Mobile Bands" in CEPT", updated April 2021

[13] ED Decision 2014/029/R of 24 September 2014 on amending Decision 2014/015/R of the Executive Director of the Agency of 24 April 2014 on adopting Acceptable Means of Compliance and Guidance Material to Part-CAT of Regulation (EU) No 965/2012

[14] Draft ETSI EN 301 908-24: "IMT cellular networks; Harmonised Standard for access to radio spectrum Part 24: New Radio (NR) Base Stations (BS) Release 15"

[15] Draft ETSI EN 301 908-25: "IMT cellular networks; Harmonised Standard for access to radio spectrum; Part 25: New Radio (NR) User Equipment (UE) Release 15;"

[16] Report ITU-R M.2292: "Characteristics of terrestrial IMT-Advanced systems for frequency sharing/interference analyses"

[17] ECC Report 309: "Analysis of the usage of aerial UE for communication in current MFCN harmonised bands", approved July 2009

[18] Recommendation ITU-R M.2101: "Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies"

[19] ITU-R WP5D Contribution 547: "Reply liaison statement on parameters of terrestrial component of IMT for sharing and compatibility studies in preparation for WRC-23 (6.425 TO 10.5 GHz)", 3GPP TSG RAN WG4, March 2021

[20] Report ITU-R M.2283: "Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation"