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TECHNICAL SPECIFICATION

Radio access network equipment specification;
Mobile Communication On Board Aircraft (MCOBA) systems;
Operational requirements and methodology
for showing conformance

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Foreword

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Modal verbs terminology

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Introduction

The present document defines operational requirements and the methodology for showing conformance to the operational requirements for a Mobile Communication Onboard Aircraft system (MCOBA) whose essential requirements are defined in the ETSI EN 302 480 [i.4] to demonstrate conformity to Article 3.2 of the Radio Equipment Directive [i.1].

The present document provides a methodology in order to derive power values at the antenna output port of the system which can be used to demonstrate conformance to any E.I.R.P. limits defined outside the aircraft. Given the dependence of the E.I.R.P. levels outside the aircraft on the specific system implementation, the present document also identifies testing procedures to determine the value of the key relevant RF parameters of the aircraft.

1 Scope

The present document specifies operational requirements and the methodology for showing conformance to the operational requirements for a Mobile Communication Onboard Aircraft system, which allows communication in the GSM and LTE (FDD) 1 800 MHz frequency band and the UMTS 2 100 MHz frequency band to ensure, that mobile terminals will not connect to ground based mobile networks.

The present document further specifies measurement methodologies allowing the definition of the key RF parameters of the aircraft, which are:

- the aircraft attenuation as observed at the windows;
- the aircraft attenuation in combination of the antenna system as observed at the antenna system feeding point;
- the effective cabin coupling loss within the aircraft cabin.

The present document also provides a way to translate the power level generated by the Mobile Communication Onboard Aircraft system at the antenna system output port to an E.I.R.P. defined outside the aircraft.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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Not applicable.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC(Radio Equipment Directive).

[i.2] Commission Implementing Decision 2016/2317/EU of 12 November 2013 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.

[i.3] ECC Report 93: "Compatibility between GSM equipment on board aircraft and terrestrial networks".

[i.4] ETSI EN 302 480 (V2.2.0): "Mobile Communication On Board Aircraft (MCOBA) systems; Harmonised Standard for access to radio spectrum".

[i.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".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

aircraft type: common platform of aircraft which possess the same RF characteristics

antenna system type: specific antenna characteristics which are uniquely defined by a set of RF parameters

installation type: precise manner of installation of the dedicated antenna system

Mobile Communication On Board Aircraft system (MCOBA): system comprising the functions provided by the NCU and the OBTS

Network Control Unit (NCU): component of the Mobile Communication On Board Aircraft system preventing direct connection of the onboard mobile terminals with mobile networks on the ground by raising the noise floor in the cabin

Onboard Base Transceiver Station (OBTS): component of the Mobile Communication On Board Aircraft system responsible for radio transmission and reception to or from the onboard mobile terminals

3.2 Symbols

For the purposes of the present document, the following symbols apply:

λ	wavelength
dB	decibel
dBm	power in decibel relative to 1 mW

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACU	Antenna Coupling Units
BTS	Base Transceiver station
CCL	Cabin Coupling Loss
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
CW	Continuous Wave
E.I.R.P.	Effective Isotropic Radiated Power
ECC	Electronic Communications Committee
FDD	Frequency Division Duplexing
FSL	Free Space Loss
GSM	Global System for Mobile communications
LTE	Long Term Evolution
MCOBA	Mobile Communication On Board Aircraft
NCU	Network Control Unit
OBTS	On board aircraft Base Transceiver System
PG	Processing Gain
RF	Radio Frequency
RMS	Root Mean Square
UE	User Equipment

UMTS	Universal Mobile Telecommunications System
WCDMA	Wide Code Division Multiple Access

4 Operational requirements

4.1 Considerations for installation of Mobile Communication On Board Aircraft systems

The requirements for operation of a MCOBA system in order to comply with defined limits, are highly dependent on many factors, including the aircraft size and type, its RF isolation characteristics, propagation characteristics within the cabin and the installation of the MCOBA system.

Considerations to show compliancy will depend on different elements of technical system design and choice of installation for achieving compliance with the limits, such as:

- Variation of the output power of NCU/ OBTS outside the aircraft depending on the fuselage attenuation.
- Choosing for the NCU/OBTS an appropriate antenna type, number and their placement so as to achieve the most efficient coverage along the cabin while limiting radiation outside the aircraft.
- Valuating the propagation characteristics inside the cabin, e.g. variation of signal strength due to the layout of the cabin, and factoring this into the evaluation of emissions radiated outside the aircraft.

Results of measurement campaigns have indicated that the effective attenuation of signals by an aircraft is dependent on the aircraft type. Furthermore the signal leakage of the OBTS will be subject to the RF variations of different antenna systems and their various installations. Hence system compliancy tests carried out on aircraft can only be used as validation for the same combination of the system type and the aircraft type, i.e. validation of antenna system "A" with aircraft type "X" cannot be used on an aircraft type "Z" or using antenna system "B".

To show conformance with the requirements the methodology described in the following clauses is defined. Conformance shall be shown with respect to the following three criteria:

a) Minimum power at NCU antenna connector shall be sufficient to inhibit connection to all relevant terrestrial networks at the height above ground the system is to be operated. The methodology is described in clause 4.3.

b) The far field E.I.R.P. outside the aircraft from the OBTS/NCU shall be low enough to ensure non-interference with terrestrial UEs. The methodology is described in clause 4.4.

c) The E.I.R.P. outside the aircraft from the UEs shall be low enough to ensure non-interference with terrestrial base stations. The methodology is described in clause 4.5.

The criteria will be referred to as A, B and C in the remainder of the present document. The system can only be operated at height above ground for which compliance with all the criteria A, B and C can be shown.

The calculations shown in clauses 4.3, 4.4 and 4.5 contain a number of input parameters which shall be measured or estimated. The test methodologies to derive these parameters are described in clause 5.

Table 4.1-1: Operational requirements and methodology for showing conformance

Operational requirements	Maximum permitted E.I.R.P. from NCU/OBTS	Maximum permitted E.I.R.P. from onboard UE	Minimum NCU power
Test methodology	Aircraft Attenuation with onboard antenna system	Aircraft Window Attenuation	Aircraft Window Attenuation and Cabin Coupling Loss

4.2 Maximum E.I.R.P. of the aircraft due to the Mobile Communication On Board Aircraft system

It is expected that spectrum regulatory limits imposed on the MCOBA system when installed in the aircraft will be specified as an E.I.R.P. value defined outside the aircraft. The benefits for a regulatory body using this approach are that the limits are independent of the aircraft type and technical characteristics, such as size, fuselage construction and its RF shielding features and they are technology neutral.

Such limits can be found in the Annex of ECC Commission implementing Decision 2016/2317/EU [i.2] which provides the maximum permitted E.I.R.P. emitted by the NCU/OBTS and UE. These levels are defined outside the aircraft, and are listed in tables 4.2-1 and 4.2-2 respectively.

Table 4.2-1: Maximum permitted E.I.R.P. outside the aircraft produced by NCU/ OBTS

Height above ground (m)	Maximum E.I.R.P. produced by the NCU/OBTS outside the aircraft in dBm/channel					
	460 to 470 MHz (see note)	791 to 821 MHz (see note)	925 to 960 MHz	1 805 to 1 880 MHz (see note)	2 110 to 2 170 MHz	2 570 to 2 690 MHz (see note)
	dBm/1,25 MHz	dBm/10 MHz	dBm/3,84 MHz	dBm/200 kHz	dBm/3,84 MHz	dBm/4,75 MHz
3 000	-17,0	-0,87	-6,2	-13,0	1,0	1,9
4 000	-14,5	1,63	-3,7	-10,5	3,5	4,4
5 000	-12,6	3,57	-1,7	-8,5	5,4	6,3
6 000	-11,0	5,15	-0,1	-6,9	7,0	7,9
7 000	-9,6	6,49	1,2	-5,6	8,3	9,3
8 000	-8,5	7,65	2,3	-4,4	9,5	10,4
NOTE: This operating band is not mandatory to be implemented in a NCU.						

Table 4.2-2: Maximum permitted E.I.R.P. outside the aircraft produced by the onboard terminal

Height above ground (m)	Maximum E.I.R.P., defined outside the aircraft, resulting from the GSM mobile terminal in dBm/200 kHz	Maximum E.I.R.P., defined outside the aircraft, resulting from the LTE mobile terminal in dBm/5 MHz	Maximum E.I.R.P., defined outside the aircraft, resulting from the UMTS mobile terminal in dBm/3,84 MHz
	GSM 1 800 MHz	LTE 1 800 MHz	UMTS 2 100 MHz
3 000	-3,3	1,7	3,1
4 000	-1,1	3,9	5,6
5 000	0,5	5	7
6 000	1,8	5	7
7 000	2,9	5	7
8 000	3,8	5	7

4.3 Derivation of the minimum power level of the NCU at the antenna input (Criterion A)

The minimum power level required will depend on the following parameters:

1) Maximum power level of mobile network from the ground received inside the aircraft cabin $P_{max\text{-}inside\_aircraft}$ is defined as follows:

$$P_{\max\_inside\_aircraft} = P_{\max\_outside\_aircraft} - A_{aircrafWindowfMHz}$$

Where:

- $P_{max\text{-}outside\_aircraft}$ being the theoretical highest signal strength power values outside the aircraft (and defined in table 4.2-1.
- $A_{aircraft\ windowf\ MHz}$ being the effective attenuation to the ground based signals due to the aircraft at the window. The measurement of this parameter is defined in clause 5.4.

Table 4.3-1: Theoretical maximum power received outside aircraft from mobile networks on the ground

	Received power per system bandwidth (dBm/bandwidth)					
Technology Band Height (m)	LTE 450 MHz	LTE 800 MHz	GSM UMTS 900 MHz		GSM 1 800 MHz	UMTS 2 100 MHz
3 000	-61,4	-66,1	-67,5	-80,5	-75,4	-89,8
5 000	-65,9	-70,6	-71,9	-84,9	-79,9	-94,2
8 000	-70,0	-74,7	-76,0	-89,0	-84,0	-98,3
10 000	-72,0	-76,5	-78,0	-91,0	-85,9	-100,3
NOTE: The values have been derived from tables contained in annex 3 from the CEPT Report 63 [i.5].						

2) The consideration of additional screening power ($ASP_{technology}$) which is the combination of the screening margin necessary for controlling additional processing gain (PG) inherent to some cellular technologies and the C/I or Eb/N0 (signal to noise ratio or energy per bit to power spectral density ratio) value according to the cellular technology in to provide effective screening of the pilot broadcast signals:

For GSM:

$$ASP_{technology} = -\left(\frac{C}{I}\right)$$

For WCDMA/CDMA2000:

$$ASP_{technology} = PG - \frac{Eb}{N0}$$

Note that the pilot channel for CDMA systems is a fraction of the total channel power.

Table 4.3-2: Processing gain, C/I and Eb/N0

Mobile Technology	Processing gain (dB) (see note)	Delta between Pilot Channel and total power (dB) (see note)	C/I or Eb/N0
GSM	N/A	N/A	4
WCDMA	21	-10	4,3
CDMA 2000	20	-8	2,3
NOTE: Parameters taken from the ECC Compatibility Report 93 [i.3].			

3) The required NCU input power at the antenna port in order to provide the necessary power level at the aircraft window: i.e. the effective coupling loss within the cabin:

- The measurement of the Cabin coupling loss (CCL) is defined in clause 5.1.

Translation equation for minimum power required equates to:

$$P_{req} \succ P_{max\_inside\_aircraft} + ASP_{technology} + CCL$$

Where:

- P_{req}: power required to screen (dBm/ bandwidth).
- $P_{max\_inside\_aircraft}$: Maximum power received from the ground based network inside the aircraft (dBm/bandwidth) the value may be calculated from theoretical principles or directly measured.
- $ASP_{technology}$: additional screening power (dB).
- CCL: cabin coupling loss (dB).

4.4 Derivation of the permitted maximum power level of the MCOBA system at the antenna input (Criterion B)

The maximum permitted power level will depend on the attenuation due to the aircraft fuselage in combination of the dedicated antenna.

Translation equation for MCOBA system power equates to:

$$e.i.r.p_{outside} \geq P_{in} - Att_{aircraftcab\inf MHz+antenna}$$

Where:

- E.I.R.P.$_{outside}$: E.I.R.P. defined outside the aircraft (dBm/bandwidth) and values contained in clause 4.2.
- P_{in}: MCOBA system power level at the dedicated antenna output port (dBm/bandwidth).
- $Att_{aircraftcabinfMHz\ antenna}$: effective attenuation (dB) to MCOBA system due to the aircraft and the dedicated antenna function of the frequency. The measurement of this parameter is defined in clause 5.3.

4.5 Derivation of the effective power level due to the UE onboard aircraft (Criterion C)

The effective power level outside the aircraft due to the onboard UE will depend on the effective aircraft attenuation at the window.

Translation equation for equivalent power outside the aircraft:

$$e.i.r.p._{out} = e.i.r.p._{mob} - A_{aircraftWindow\_f\_MHz}$$

Where:

- E.I.R.P.$_{out}$: E.I.R.P. defined outside the aircraft (dBm/200 kHz)
- E.I.R.P.$_{mob}$: onboard mobile E.I.R.P. (0 dBm/200 kHz)
- $A_{AircraftWindow\_f\_MHz}$: aircraft attenuation (dB) at the window at the desired frequency band

5 Description of test methodology to derive key parameters

5.1 Cabin coupling loss

5.1.1 General description of test set up

Location of the aircraft:

The aircraft should be located in a clear outdoor environment in order to keep the probability of possible corruption of measurement results due to signal reflections at obstacles outside the aircraft as low as possible.