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Methodology for showing conformance with
operational requirements

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Introduction

The present document defines methodology for showing conformance to the operational requirements for a GSM onboard aircraft system (GSMOBA) whose essential requirements to demonstrate conformity to Article 3.2 of the R&TTE Directive [i.1] are defined in the EN 302 480 [3].

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 the methodology for showing conformance to the operational requirements for a GSM onboard aircraft system, which allows communication in the GSM 1800 frequency band and which ensures that mobile terminals will not connect to ground based mobile networks.

The present document further specifies measurement methodologies allowing to define 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 GSM onboard aircraft system at the antenna system output port to an E.I.R.P. defined outside the aircraft.

2   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 reference document (including any amendments) applies.

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2.1   Normative references

The following referenced documents are necessary for the application of the present document.

[1]   ECC/DEC/(06)07: "ECC Decision of 1 December 2006 on the harmonised use of airborne GSM systems in the frequency bands 1710 -1785 and 1805 - 1880 MHz".

[2]   ECC REPORT 93: "Compatibility between GSM equipment on board aircraft and terrestrial networks".

[3]   ETSI EN 302 480: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Harmonized EN for the GSM onboard aircraft system covering the essential requirements of Article 3.2 of the R&TTE Directive".

2.2   Informative references

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 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

aircraft type: term given to a 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

GSM onboard aircraft system: system comprising the functions provided by the NCU and the OBTS

installation type: term given to the precise manner of installation of the dedicated antenna system

Network control Unit (NCU): component of the GSM onboard 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 GSM onboard 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
ASP	Additional Screening Power
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
FSL	Free Space Loss
GSM	Global System for Mobile communications
GSMOBA	GSM OnBoard Aircraft
MS	Mobile Station
NCU	Network Control Unit
OBTS	OBA Base Transceiver System
PG	Processing Gain
R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
UMTS	Universal Mobile Telecommunications System
WCDMA	Wide Code Division Multiple Access

4   Operational requirements

4.1   Considerations for installation of GSM onboard aircraft system

The requirements for operation of a GSMOBA 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 GSMOBA 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 must 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 must be low enough to ensure non-interference with terrestrial MSs. The methodology is described in clause 4.4.

c)   The E.I.R.P. outside the aircraft from the MSs must 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 4.4, 4.5 and 4.6 contain a number of input parameters which must be measured or estimated. The test methodologies to derive these parameters are described in clause 4.7.

4.2   Maximum E.I.R.P. of the aircraft due to the GSM onboard aircraft system

It is expected that spectrum regulatory limits imposed on the GSM onboard aircraft 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 Decision ECC\DEC\(06)07 [1] which provides the maximum permitted E.I.R.P. emitted by the NCU/ OBTS and MS. These levels are defined outside the aircraft, and are listed in table 1 and 2 respectively.

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

Starting Height above ground In metres	E.I.R.P. produced by NCU/ OBTS, outside the aircraft in dBm/channel			
	460 MHz to 470 MHz Channel Bandwidth = 1,25 MHz	921 MHz to 960 MHz Channel Bandwidth = 200 kHz	1 805 MHz to 1 880 MHz Channel Bandwidth = 200 kHz	2 110 MHz to 2 170 MHz Channel Bandwidth = 3,84 MHz
3 000	-17,0	-19,0	-13,0	1,0
4 000	-14,5	-16,5	-10,5	3,5
5 000	-12,6	-14,5	-8,5	5,4
6 000	-11,0	-12,9	-6,9	7,0
7 000	-9,6	-11,6	-5,6	8,3
8 000	-8,5	-10,5	-4,4	9,5

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

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

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 follow:

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

Where:

- $P_{max\text{-}outside\_aircraft}$ being the theoretical highest signal strength power values outside the aircraft (and defined in Table 3).

Table 3: Theoretical maximum power received outside aircraft from mobile networks on the ground

Band		Received power per system bandwidth (dBm/bandwidth)					
		450 MHz	900 MHz		1 800 MHz		2GHz
Height		CDMA	GSM	UMTS	GSM	UMTS	UMTS
3	Km	-70,7	-68,5	-78,5	-76,7	-86,7	-87,6
4	Km	-73,0	-70,9	-80,9	-77,6	-89,2	-89,8
5	Km	-74,9	-72,7	-82,7	-78,5	-91,1	-91,4
6	Km	-76,4	-74,2	-84,3	-79,3	-92,7	-92,7
7	Km	-77,7	-75,5	-85,5	-80	-94	-93,8
8	Km	-78,8	-76,6	-86,6	-80,6	-95,2	-94,7
9	Km	-79,7	-77,6	-87,5	-81,1	-96,2	-95,5
10	Km	-80,6	-78,5	-88,4	-81,5	-97,1	-96,2
NOTE:		The values contained in table 2 have been derived from tables contained in section 8.1.1 from the ECC Compatibility Report 93 [2].					

- 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 4.6.4.

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:

$$ASP_{techno\log y} = -\left(\frac{C}{I}\right)$$

For WCDMA/CDMA2000:

$$ASP_{techno\log y} = PG - \frac{Eb}{N0}$$

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

Table 4: 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
CDMA2000	20	-8	2,3
NOTE: Parameters taken from the ECC Compatibility Report 93 [2].			

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 4.6.1.

Translation equation for minimum power required equates to:

$$P_{req} \succ P_{max\_inside\_aircraft} + ASP_{techno\log y} + CCL$$

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 GSMOBA 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 GSMOBA 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$_{in}$: GSMOBA system power level at the dedicated antenna output port (dBm/bandwidth).

- Att$_{aircraftcabinfMHz \, antenna}$: effective attenuation (dB) to GSMOBA system due to the aircraft and the dedicated antenna function of the frequency. The measurement of this parameter is defined in clause 4.6.3.

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

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

Translation equation for equivalent power outside the aircraft:

$$e.i.r.p._{out} = e.i.r.p._{mob} - A_{aircraftWindow1800MHz}$$

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$_{AircraftWindow1\,800MHz}$: aircraft attenuation (dB) at the window at the frequency band 1 800 MHz

4.6 Description of test methodology to derive key parameters

4.6.1 Cabin coupling loss

4.6.1.1 General description of test set up

Location of the aircraft:

The aircraft must 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.

Measurement locations inside the aircraft:

In principle it is not possible to specify generally accepted measurement locations within the aircraft because of the large variability in the aircraft cabin layout of different aircrafts. Therefore, the following rules shall provide guidance for specifying measurement locations for radio coverage testing:

- Coverage shall be tested at least in the forward, mid and aft fuselage section of the aircraft cabin to capture the longitudinal loss of the antenna system.

- Measurement locations should be chosen at the windows, on the aisle(s) and along the longitudinal axis of the aircraft.

Figure 1 gives an example for the measurement locations in a narrow body aircraft.
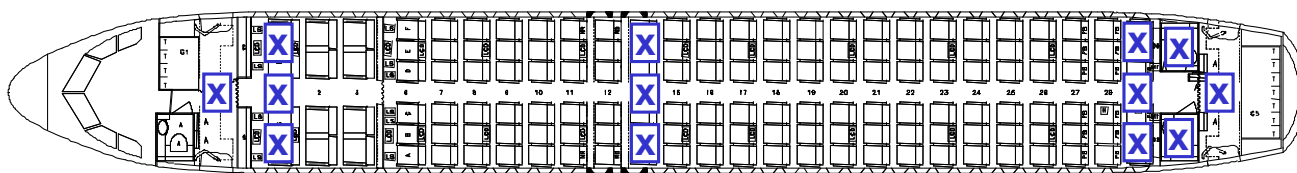

Figure 1: Example of principle aircraft layout for narrow body aircraft type in standard cabin configuration with example measurement locations

Identification of test frequencies

The frequencies used to conduct the tests are subject to local regulatory authorisation. Identification of the frequencies to be used will depend on the national regulatory Administration in the country where the tests are to take place, and hence, the selected frequencies may be outside the operating frequency bands of the NCU.

Prerequisites

The following prerequisites must be fulfilled prior to the start of the measurements within the aircraft cabin:

- Antenna system installed as in its final routing.

- Standard monuments installed (e.g. galley, lavatories, overhead bins).

- Cabin doors locked.

4.6.1.2   Definition

The cabin coupling loss is defined as the loss that the transmitted signal experiences on its way from the test signal generator's output connector to a receive location within the aircraft cabin.

4.6.1.3   Test purpose

This test is to determine the cabin coupling loss parameter (CCL) in selected locations within the aircraft cabin. The CCL is needed to determine the required NCU output power level.

4.6.1.4   Test procedure

Equipment required:

- measurement receiver

- reference antenna(s)

  NOTE 1: Given the multipath propagation environment within the aircraft cabin, it is recommended to use antennas with omni-directional characteristics at least in one of the polarisation planes (e.g. dipole antennas) in order to adequately capture signal-fading statistics.

- RF signal generator or NCU

  NOTE 2: It might be necessary to use different reference antennas for different frequencies or frequency bands.

Test Sequence:

Option A: The regulatory authorization is given for a CW signal.

   ***Step 1*:**   Connect the RF signal generator's output port to the aircraft antenna system connector.

   ***Step 2*:**   Connect the receive antenna to the measurement receiver.

   ***Step 3*:**   Set the resolution bandwidth of the measurement receiver to 10 kHz; set the video bandwidth to approximately three times the value of the resolution bandwidth.

Step 4:   Activate the "Max hold" detector of the measurement receiver.

Step 5:   Select an authorised frequency.

Step 6:   Set the centre frequency of the measurement receiver to the selected frequency. Set the frequency span of the measurement receiver such that the entire spectrum of the test signal is taken into account for power measurement.

Step 7:   Set the RF signal generator accordingly.

Step 8:   Activate transmission of the RF signal generator for the selected frequency at the authorised power level.

Step 9:   Measure the received power at all locations inside the aircraft cabin as specified in clause 4.6.1.1 by using the reference antenna. While measuring, randomly vary the measurement location in the order of $\lambda_c/2$, where λ_c is the wavelength of the selected frequency. Further, while measuring randomly vary the polarisation of the receive antenna by changing the antenna orientation relative to the leaky cable orientation.

Step 10:   Calculate the overall average value of the received power per location defined as:

$$P_{recmean} = \sum_{i=1}^{N} P_{rec}(i) / N$$

Where:

- Prec(i) being the power received for the measurement i.

- N being the number of measurement.

Step 11:   Calculate the standard deviation which is the spread of the data defined as:

$$SD = \sqrt{\frac{(\sum_{i=1}^{N}(P_{rec}(i) - P_{recmean})^2}{N-1}}$$

Step 12:   Determine the 95th percentile (CDF) receive power value per location

$$P_{rec95\%} = P_{recmean} - 1.645 * SD$$

and Calculate the 95th percentile cabin coupling loss for each of the specified locations within the aircraft cabin according to the following equation:

$$CCL_{95} = P_{transmit} - P_{receive\_95} + G_{eff\_reference\_antenna}.$$

Where:

- $P_{transmit}$: total RF signal generator output power at frequency of interest.

- $P_{receive\_95}$: total receive power at frequency of interest.

- $G_{eff\_reference\_antenna}$: effective gain of reference antenna.

Determine the location with maximum 95th percentile cabin coupling loss and declare it as worst-case cabin coupling loss for that particular frequency.

Step 13:   Repeat step 5 through 12 for all other frequencies.

Option B: The regulatory authorization is given within the frequency bands operated by the NCU.

Step 1:   Connect the NCU output port to the aircraft antenna system connector.

Step 2:   Connect the receive antenna to the measurement receiver.

Step 3:   Set the resolution bandwidth of the measurement receiver to 100 kHz; set the video bandwidth to approximately three times the value of the resolution bandwidth.

Step 4:   Activate the "r.m.s" detector of the measurement receiver.

Step 5:   Select an authorised frequency band.

Step 6:   Set the centre frequency of the measurement receiver to the selected frequency. Set the frequency span of the measurement receiver such that the entire spectrum of the test signal is taken into account for power measurement.

Step 7:   Set the NCU accordingly.

Step 8:   Activate transmission of the NCU for the selected frequency at the authorised power level.

Step 9:   Follow the same process as defined in step 9 to step 12 in option A.

Step 10:   Repeat step 5 through 9 for all other frequency bands.

4.6.2   Consideration for RF attenuation measurement on aircraft

High level measurement description

Measurements are made within the aircraft cabin while the external signal, outside the aircraft, is placed on a platform which is moved around the aircraft in a circle as shown in Figure 2.

   NOTE 1: Alternatively the receiver can be placed outside the aircraft while the transmitter is inside the aircraft.

   NOTE 2: If the antenna system installation within the aircraft is fully symmetrical then measurements using a semi-circle around the aircraft will be sufficient.

Location of the aircraft:

The aircraft must 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.

Frequency authorisation:

Due to the radiated measurement, an authorisation has to be requested through the national regulatory administration of the country in which measurements are carried out. Moreover as the use of NCU frequency bands may be impossible, frequencies to be used for the tests should be close to those used by the GSMOBA system.

Separation distance between the aircraft and the transmitter (radius of circle)

The choice of the separation distance between external transmitter and the centre of the aircraft is based on four constraints:

   •   that the 3 dB antenna beam width covers the entire aircraft cabin;

   •   that the separation distance from the transmitter to the centre of the aircraft is bigger than the wingspan and half of the overall aircraft length;

   •   that the Fresnel Zone at half distance between the transmitter and the receiver is not obstructed in order not to have additional absorption/ reflection on the ground. The following equation defining the radius of the Fresnel zone applies:

$$R(m) = 17.32 \sqrt{\frac{D}{4 * F}}$$

   Where:

        ▪   F: is the frequency in MHz

        ▪   D: is the distance between the transmitter and the receiver in meter

        ▪   R: is the radius of the Fresnel zone at half distance in meter
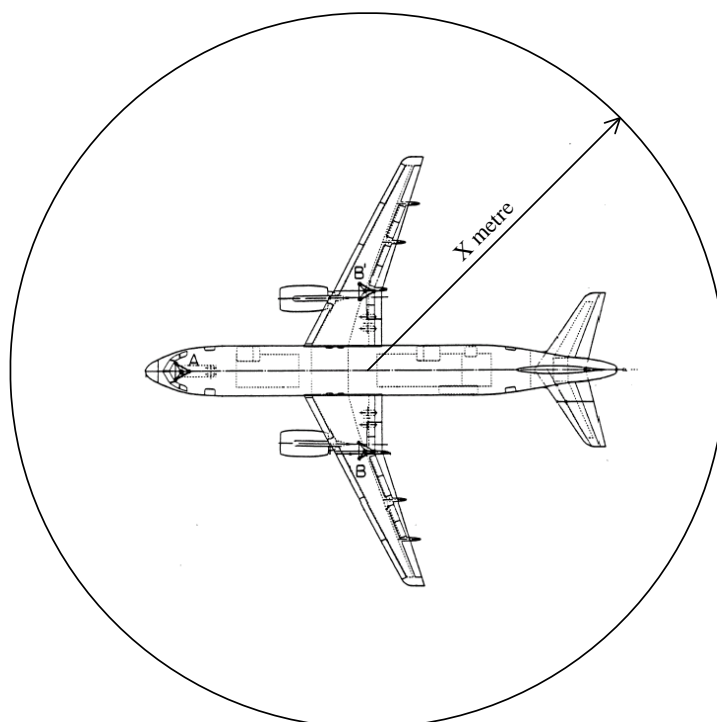
Figure 2: Test location

The external antenna height is set to the same height as the aircraft windows. It is highlighted that by using the transmitter outside the aircraft with receiver located at the window and at the antenna system port then the procedures defined in clauses 4.6.3 and 4.6.4 can be combined.

4.6.3   Aircraft attenuation in combination with the aircraft antenna system

4.6.3.1   Test purpose

To define the attenuation of aircraft in combination with the aircraft antenna system for each operating frequency band covered by the NCU

4.6.3.2   Methods of measurement

Equipment requirement

- RF signal generator

- Power amplifier

  NOTE 1: A power amplifier might not be necessary in case the signal generator delivers enough signal power to ensure, that the receive signal falls into the dynamic range of the measurement receiver.

- Measurement receiver

- Reference antennas for transmission of the test signal

- Antenna system installed as in its final routing

  NOTE 2: It may be necessary to use different signal generators, power amplifiers and antennas for the different authorized frequency.

Test procedure:

Step 1:   Set the transmit antenna and its mast, which is adjustable in height, on the platform outside the aircraft. Set the height of the transmit antenna mast according to the type of aircraft under investigation (i.e. mast at the same height than the aircraft windows).

Step 2: Connect the transmit antenna to the RF signal generator through a power amplifier.

Step 3: *Within the aircraft cabin, c*onnect the aircraft antenna system to the measurement receiver.

Step 4: Set the resolution bandwidth of the measurement receiver to 10 kHz;
set the video bandwidth to approximately three times the value of the resolution bandwidth.

Step 5: *Activate the "Max hold" detector, deactivate the average mode*

Step 6: Select one of the authorised frequency and set the RF signal generator accordingly.

Step 7: Activate transmission of the RF signal generator for the selected frequency at the authorised power level.

NOTE 3: The transmit signal power shall be high enough to be able to be measured by the receiver equipment. Depending on the authorisation constraints, a pre-amplifier may be required to ensure that the signal is within the receiver's dynamic range.

Step 8: Set the centre frequency of the measurement receiver to the selected frequency. Set the frequency span of the measurement receiver such that the entire spectrum of the test signal is taken into account for power measurement (e.g. 100 kHz).

Step 9: Measure the receive power continuously and record the values while the transmit antenna on the movable platform is continuously moved slowly around the aircraft on the defined path.

Step 10: Repeat step 6 to 9 for the other authorised frequency bands.

4.6.3.3 Calculation of combined effective aircraft attenuation and antenna system

Step 1: For a selected frequency, calculate the aircraft attenuation in combination of the antenna system for each transmitter position by using the following formula:

$$Att_{aircraft\_leaky\_cable(n)} = P_{in} + G_{transmmitter} - FSL - P_{measured} \qquad \text{(dB)}$$

with:

- FSL being the free space loss and defined as followed:

$$FSL = -27.4 + 20\log(f_{MHz}) + 20\log(d_m) \qquad \text{(dB)}$$

- d_m being the transmit-receive antenna separation in m; and

- f_{MHz} being the frequency of the test signal in MHz.

Step 2: In order to try to remove the effect of fading and to retain a sharp step, apply a moving average factor which is defined as followed:

$$Att(i) = \frac{1}{M} \sum_{J=0}^{M-1} Att_{aircraft\_leaky\_cable} [i \rightarrow j]$$

- M: number of point considered in the average.

- $Att_{aircraft\_leaky\_cable}$: aircraft attenuation obtained at point i.

- Att(i): output value of the aircraft attenuation.

*Step 3***:** Calculate the overall average value of the attenuation defined as:

$$Att_{mean} = \sum_{i=1}^{N} Att(i) / N$$

Where

- Att(i) being the aircraft attenuation at point i

- N being the number of point

Step 4:   Calculate the standard deviation which is the spread of the data defined as:

$$SD = \sqrt{\frac{(\sum_{i=1}^{N}(Att(i) - Att_{mean})^2}{N-1}}$$

Step 5:   Calculate the 5th percentile attenuation value of the CDF defined as:

$$Att_{5\%} = Att_{mean} - 1.645 * SD$$

Step 6:   Repeat Step 1 for the other frequencies.

4.6.4   Attenuation of aircraft at window

4.6.4.1   Test purpose

To define the attenuation of the aircraft at the window for each frequency band covered by the NCU.

4.6.4.2   Methods of measurement

Equipment requirement

- RF signal generator

- Power amplifier

- Measurement receiver

- Reference antennas for transmission and reception of the test signal

NOTE 1: It might be necessary to use different signal generators, power amplifiers and antennas for different frequency bands.

Test procedure:

Step 1:   Set the transmit antenna and its mast on a platform, which is adjustable in height, outside the aircraft.

Step 2:   Set the height of the transmit antenna mast at the same height than the aircraft windows.

Step 3:   Connect the RF signal generator to the transmit antenna through the power amplifier.

Step 4:   Within the aircraft cabin, place the receive antenna close to an aircraft window, which is not shadowed by any part of the aircraft, i.e. a window having direct line-of-sight towards the transmit antenna outside the aircraft.

Step 5:   Connect the receive antenna to the measurement receiver.

Step 6:   Set the resolution bandwidth of the measurement receiver to 10 kHz;
Set the video bandwidth to approximately three times the value of the resolution bandwidth;
Check the average mode is deactivated

Step 7:   *Activate the "Max hold" detector, deactivate the average mode*

Step 8:   Select an authorised frequency and set the RF signal generator accordingly.

Step 9:   Activate transmission of the RF signal generator for the selected frequency at the authorised power level.

NOTE 2: The transmit signal power shall be high enough to be able to be measured by the receiver equipment. Depending on the authorisation constraints, a pre-amplifier may be required to ensure that the signal is within the receiver's dynamic range.

Step 9:   Set the centre frequency of the measurement receiver to the selected frequency. Set the frequency span of the measurement receiver such that the entire spectrum of the test signal is taken into account for power measurement (e.g. 100 kHz).

Step 10:   Measure the receive power continuously and record the values while the transmit antenna on the movable platform is continuously moved around the aircraft on the defined (semi) circle.

Step 11:   Repeat step 7 to 10 for all the other test frequencies.

4.6.4.3   Calculation of aircraft attenuation at the window

Step 1:   For a selected frequency, calculate the aircraft attenuation at the window for each position by using the following formula:

$$Att_{\text{aircraft\_window(n)}} = P_{\text{in}} + G_{\text{transmmitter}} + G_{receiver} - FSL - P_{\text{measured}} \quad \text{(dB)}$$

with:

-    P_{in} being the power transmitted (dBm)

-    $G_{\text{transmitter}}$ being the transmitter antenna gain (dBi)

-    G_{receiver} being the receiver antenna gain (dBi)

-    FSL being the free space loss (dB) and defined as follow;

$$FSL = -27.4 + 20\log(f_{\text{MHz}}) + 20\log(d1_{\text{m}}) \quad \text{(dB)}$$

where:

-    f_{MHz} being the frequency of the test signal in MHz and

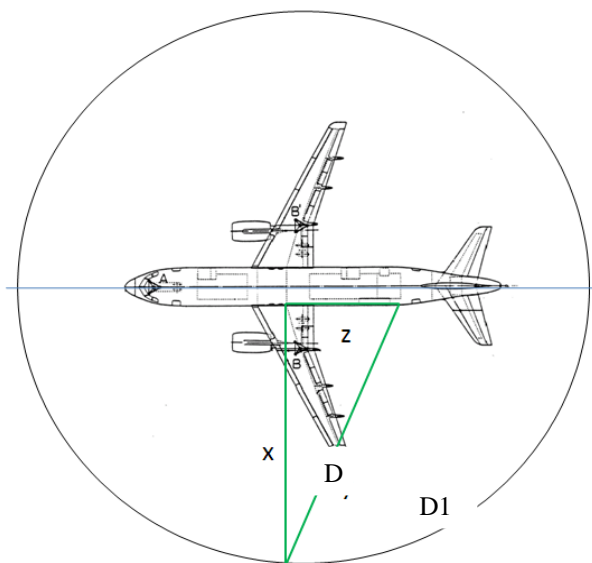- $d1_{\text{m}}$ being the transmit-receive antenna separation in m which is defined as:

Figure 3: Calculation of separation distance

$$D1 = \sqrt{(z + D\cos\alpha)^2 + (D\sin\alpha)^2}$$

Where:

- D is the radius of the circle (m)

- z is the separation distance between the antenna located inside the cabin and the aircraft - centre (m)

- α is the angle defined by the position of the transmitter on the circle according to the reference (e.g.: aircraft nose is the reference and the transmitter runs clockwise)

Step 2:   In order to try to remove the effect of fading and to retain a sharp step, apply a moving average factor which is defined as followed:

$$Att(i) = \frac{1}{M} \sum_{J=0}^{M-1} Att_{aircraft\_window} [i \rightarrow j]$$

- M: number of point considered in the average

- $Att_{aircraft\_window}$: aircraft attenuation obtained at point i

- Att(i): output value of the aircraft attenuation

Step 3:   Calculate the overall average value of the attenuation defined as:

$$Att_{mean} = \sum_{i=1}^{N} Att(i) / N$$

Where

- Att(i) being the aircraft attenuation at point i

- N being the number of point

Step 4:   Calculate the standard deviation, which is the spread of the data defined as:

$$SD = \sqrt{\frac{(\sum_{i=1}^{N} (Att(i) - Att_{mean})^2}{N-1}}$$

Step 5:   Calculate the 5th percentile attenuation value of the CDF defined as:

$$Att_{5\%} = Att_{mean} - 1.645 * SD$$

Step 6:   Repeat Step 1 for the other frequencies.

Annex A (informative):
System Description

A.1 High level System Description

The GSMOBA system comprises of an onboard BTS (OBTS) and a Network Control Unit (NCU). These are connected to a dedicated antenna system. The whole system is then connected to the ground network via a satellite link. The Figure A.1 represents the high level system description.
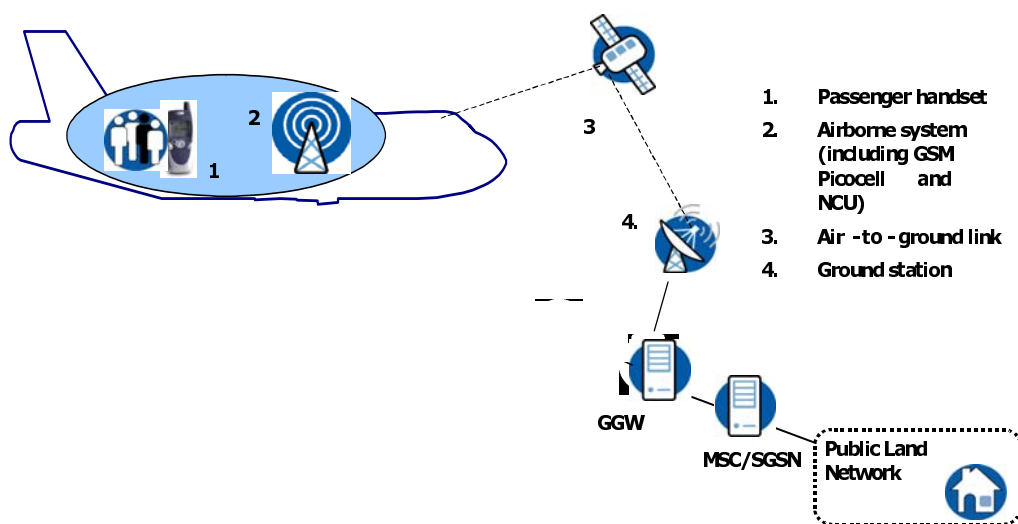

1. Passenger handset
2. Airborne system (including GSM Picocell and NCU)
3. Air-to-ground link
4. Ground station

GGW

MSC/SGSN

Public Land Network

Figure A.1: Overview of the GSMOBA system and associated terrestrial components

This description covers the onboard elements; OBTS, NCU and the antenna system.

Figure A.2 represents the functional organization of the GSMOBA system. The dotted box identifies the equipment specified in EN 302 480 [3]. This system may comprise one or more NCUs, one or more BTS functions, antenna coupling units (ACU) and an antenna system.
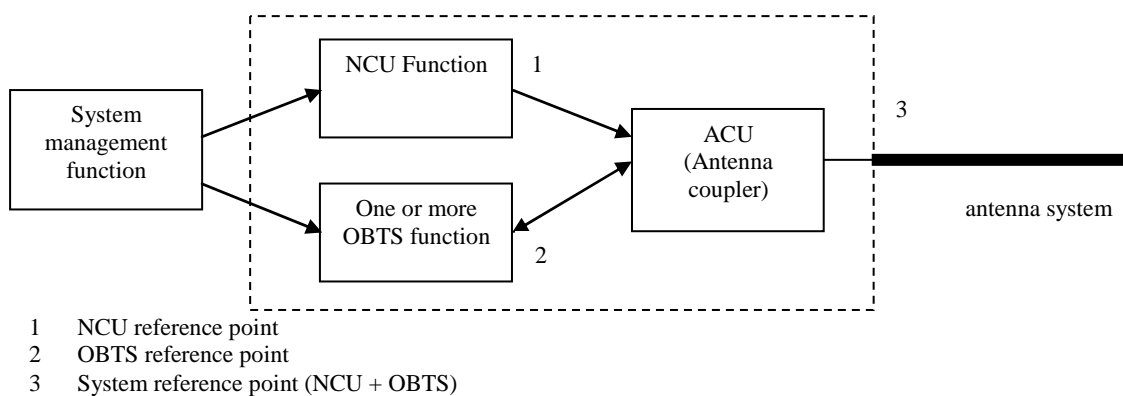

1   NCU reference point
2   OBTS reference point
3   System reference point (NCU + OBTS)

Figure A.2: System description

A.2   OBTS

The OBTS establishes the communication access to the MS in the aircraft and supports all necessary system features such as radio access and radio resource management.

The OBTS has the following characteristics:

-      Support of GSM services;

-      Operates in the 1 800 MHz spectrum band;

-      Operates at a sufficient margin (at least 9dB) over the NCU level;

-      Ensures that an MS communicating with the OBTS transmits at the nominal minimum power level (0 dBm).

A.3   RF Screening

Onboard aircraft mobile terminals should be prevented from attempting to access networks on the ground. This could be done:

-      By passive means e.g. through RF shielding of the aircraft fuselage to further attenuate the signal entering and leaving the fuselage.

-      By the inclusion of a Network Control Unit (NCU), which raises the noise floor inside the cabin in mobile receive bands by transmitting a broadband signal within those operating frequency bands.

These methods can be combined to minimize the active NCU power level.

The RF Screening covers the appropriate frequency ranges as identified in EN 302 480 [3]

NOTE: Any NCU will only be operational above the minimum height above the ground at which the system is permitted to be operated.

A.4   Antenna system

Transmission of the signals is distributed in the cabin by an antenna system. This antenna system is specially designed for use onboard aircraft. The antenna system RF characteristics are defined by the following parameters:

-      Number and type of transmit antennas in use.

-      Method of transmission.

-      Insertion loss.

-      Coupling loss.

A.5   Antenna system installation

Transmission of the signals distributed in the cabin may be affected by the type of installation used. The characteristics for the dedicated installation type are defined by the following parameters:

-      Placement of the installation.

-      Additional characteristics of installation.

History

Document history		
V1.1.1	March 2012	Publication