

## **Report ITU-R M.2529-0 (09/2023)**

M Series: Mobile, radiodetermination, amateur  
and related satellite services

**Adjacent band compatibility studies of  
IMT systems in the mobile service in the  
band 1 492-1 518 MHz with respect to  
systems in the mobile-satellite service  
in the frequency band 1 518-1 525 MHz**

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## REPORT ITU-R M.2529-0

**Adjacent band compatibility studies of IMT systems in the mobile service in the band 1 492-1 518 MHz with respect to systems in the mobile-satellite service in the frequency band 1 518-1 525 MHz<sup>1</sup>**

(2023)

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<sup>1</sup> While the present Report is based on studies requested by Resolution 223 (Rev.WRC-19) relating to coexistence between IMT in the band 1 492-1 518 MHz and MSS in the band 1 518-1 525 MHz, some of the studies and results of those studies cover MESs operating in the band 1 525-1 559 MHz.

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## 1 Introduction

The frequency band 1 518-1 525 MHz is allocated in all three Regions to the mobile-satellite service (MSS) on a primary basis in Radio Regulations (RR). Since WRC-15 has identified the frequency band 1 427-1 518 MHz for use by administrations wishing to implement terrestrial IMT systems, and considering that there is a need to ensure the continued operations of the MSS in the frequency band 1 518-1 525 MHz, Resolution **223 (Rev.WRC-15)** invites the ITU-R to conduct compatibility studies in order to provide technical measures to ensure coexistence between MSS in the frequency band 1 518-1 525 MHz and IMT in the frequency band 1 492-1 518 MHz.

## 2 Background

The frequency band 1 518-1 525 MHz (space-to-Earth) was allocated to the MSS at WRC-03, adjacent to the MSS allocation in 1 525-1 559 MHz and is subject to the provisions in RR Nos. **5.348, 5.348A, 5.348B** and **5.351A**.

The 1 525-1 559 MHz frequency band is also identified as being available for the satellite component of IMT and the services offered by MSS operators include part of the satellite component for IMT-2000, as defined by Recommendation ITU-R M.1850-2.

WRC-15 identified the band 1 427-1 518 MHz for the use of IMT and adopted Resolution **223 (Rev.WRC-15)** which considers the need to ensure the continued operations of the MSS in the frequency band 1 518-1 525 MHz and invites ITU-R to conduct compatibility studies in order to provide technical measures to ensure coexistence between MSS in the frequency band 1 518-1 525 MHz and IMT in the frequency band 1 492-1 518 MHz.

## 3 Technical characteristics

### 3.1 Mobile earth station parameters

Mobile earth stations (MES) in this band may be operated on land, on aircraft and on ships. Recommendation ITU-R M.1184-3 contains a range of characteristics of MSS systems operating in these bands. MSS characteristics are provided below.

The characteristics are within the range of those contained in the Recommendation but may not be worst case from an interference perspective.

TABLE 1  
MSS terminal characteristics

	MSS-1 (example based on GMR-2)	MSS-2 (GMR-1 example based on voice)	MSS-3 (GMR-1 example based on data)
MES receiver system noise temp (K)	316	340	320
Polarisation	Circular	Circular	Circular
MES reference bandwidth (kHz)	200	31.25	156.25
MES noise in reference BW (dBW)	-150.6	-158.9	-151.9
ACS (dB)	30	30	30
Protection criteria used in the studies ( <i>I/N</i> ) (dB)	-20, -15.2, -10, -6		

This Report has used various values for interference criteria to address unwanted emissions from IMT into MSS, as currently there is no ITU-R Recommendation addressing the protection criteria for MSS from terrestrial service. More information on the protection criteria used in the studies can be found in Annex 4.

For the interference analysis from IMT UEs to MESs, with a TDD frequency arrangement, it is proposed that the following criteria can be used to assess the maximum level of UE unwanted emissions above 1 518 MHz. For the MCL analysis, the proposed criterion is:

Maximum <i>I/N</i> (dB)	-20 / -15.2, -6 / -10
Minimum separation distance from UE to MES	10 m

For a Monte Carlo analysis, the proposed criterion is:

Maximum <i>I/N</i> (dB)	-20 / -15.2, -6 / -10
To be met for x% locations/time	x = 99%

Some studies in this Report considered potential interference due to blocking of GMR-1 and GMR-2 MES receivers. Other values of blocking requirements are also used in this report in order to do the studies with range of blocking characteristics, also reflecting expectations of improved blocking performance of future terminals. Further information on receiver blocking characteristics is contained in Annex 4.

It is proposed to use the antenna gains and patterns as presented in Table 2. All antenna patterns are average sidelobe levels.

TABLE 2  
MES maximum antenna gain for the different scenarios

Scenario	Antenna gain (dBi)	Antenna pattern
Land	1	Non directional
	3	Figure A1-3 (see Annex 1)
	17.5	Figure A1-2 (see Annex 1)
	12	Figure A1-4 (see Annex 1)
	6	Figure A1-5 (see Annex 1)
	16	Figure A1-6 (see Annex 1)
	32	See Appendix 8 of RR antenna pattern
Sea (maritime)	3	Figure A1-3 (see Annex 1)
	21	Figure A1-1 (see Annex 1)
	1	Non directional
	12	Figure A1-4 (see Annex 1)
	6	Figure A1-5 (see Annex 1)
	16	Figure A1-6 (see Annex 1)
Air (aeronautical)	3	Figure A1-3 (see Annex 1)
	17.5	Figure A1-2 (see Annex 1)

### 3.2 IMT parameters

The characteristics of IMT-Advanced macro base station are in accordance to Report ITU-R M.2292 and are contained in Tables 7 and 8 below. The IMT BS unwanted emission levels and spectrum emission mask are contained in 3GPP TS 36.104 v.11.2.0. The UE unwanted emission levels and spectrum emission mask are contained in 3GPP TS 36.101 v.11.2.0. For study purpose channel bandwidth 5, 10 MHz will be considered for IMT, however other channel bandwidth values may be also considered.

TABLE 3

**IMT base station unwanted emission limits**  
(according to 3GPP 36.104 v.11.2.0, Table 6.6.3.2.2-1 (Category B, Option 2))

Frequency offset of measurement filter -3 dB point, $\Delta f$	Frequency offset of measurement filter centre frequency, $f_{\text{offset}}$	Minimum requirement	Measurement bandwidth
$0 \text{ MHz} \leq \Delta f < 0.2 \text{ MHz}$	$0.015 \text{ MHz} \leq f_{\text{offset}} < 0.215 \text{ MHz}$	-14 dBm	30 kHz
$0.2 \text{ MHz} \leq \Delta f < 1 \text{ MHz}$	$0.215 \text{ MHz} \leq f_{\text{offset}} < 1.015 \text{ MHz}$	$-14 \text{ dBm} - 15 \cdot \left( \frac{f_{\text{offset}}}{\text{MHz}} - 0.215 \right) \text{ dB}$	30 kHz
(Note 5)	$1.015 \text{ MHz} \leq f_{\text{offset}} < 1.5 \text{ MHz}$	-26 dBm	30 kHz
$1 \text{ MHz} \leq \Delta f \leq \min(10 \text{ MHz}, \Delta f_{\text{max}})$	$1.5 \text{ MHz} \leq f_{\text{offset}} < \min(10.5 \text{ MHz}, f_{\text{offsetmax}})$	-13 dBm	1 MHz
$10 \text{ MHz} \leq \Delta f \leq \Delta f_{\text{max}}$	$10.5 \text{ MHz} \leq f_{\text{offset}} < f_{\text{offsetmax}}$	-15 dBm	1 MHz

TABLE 4

**IMT base station unwanted e.i.r.p. values used in the studies**

Frequency Separation from channel edge	0-1 MHz	1-3 MHz	>3 MHz
Rural	-0.8 dBm/MHz	-0.8 dBm/MHz	-30 dBm/MHz
Suburban/Urban	-2.8 dBm/MHz	-2.8 dBm/MHz	-32 dBm/MHz

TABLE 5

**IMT base station unwanted e.i.r.p. values used in the studies**

Frequency separation from channel edge (MHz)	Rural used in Study B (dBm/MHz)	Suburban/Urban used in Studies A, B (dBm/MHz)
1	-0.8	-2.8
3	-30	-32
6	-33	-35
13	-40	-42
43	-60	-62
70	-78	-80
73	-80	-80
80	-80	-80



TABLE 6  
IMT UE unwanted e.i.r.p. values used in the studies

Study	Frequency separation from channel edge (MHz)	Rural/Suburban/Urban (dBm/MHz)
Study C	2	-20 and -30
Study E	0	-74 up to -25
Study F	0	-80 up to -20
Study G	0	-20

TABLE 7  
IMT-Advanced specification related parameters

		IMT-Advanced			
Duplex mode		FDD		TDD	
No.	Parameter	Base station	Mobile station	Base station	Mobile station
1	Access technique	OFDM	SC-FDMA	OFDM	SC-FDMA

TABLE 8  
Deployment parameters of the terrestrial IMT-Advanced system

	Macro rural	Macro suburban	Macro urban	Small cell outdoor/ Micro urban
<b>Base station characteristics/Cell structure</b>				
Cell radius/ Deployment density (for bands between 1 and 2 GHz)	> 3 km (typical figure to be used in sharing studies 5 km)	0.5-3 km (typical figure to be used in sharing studies 1 km)	0.25-1 km (typical figure to be used in sharing studies 0.5 km)	1-3 per urban macro cell <1 per suburban macro site
Cell radius/ Deployment density (for bands between 2 and 3 GHz)	> 2 km (typical figure to be used in sharing studies 4 km)	0.4-2.5 km (typical figure to be used in sharing studies 0.8 km)	0.2-0.8 km (typical figure to be used in sharing studies 0.4 km)	1-3 per urban macro cell <1 per suburban macro site
Antenna height	30 m	30 m (1-2 GHz) 25 m (2-3 GHz)	25 m (1-2 GHz) 20 m (2-3 GHz)	6 m
Sectorization	3 sectors	3 sectors	3 sectors	Single sector
Downtilt	3 degrees	6 degrees	10 degrees	n.a.
Frequency reuse	1	1	1	1

TABLE 8 (continued)

	Macro rural	Macro suburban	Macro urban	Small cell outdoor/ Micro urban
<b>Base station characteristics/Cell structure</b>				
Antenna pattern	Recommendation ITU-R F.1336 ( <i>recommends</i> 3.1) $k_a = 0.7$ $k_p = 0.7$ $k_h = 0.7$ $k_v = 0.3$ Horizontal 3 dB beamwidth: 65 degrees Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.			Recommendation ITU-R F.1336 (omni: <i>recommends</i> 2)
Antenna polarization	Linear/ $\pm 45$ degrees	Linear/ $\pm 45$ degrees	Linear/ $\pm 45$ degrees	Linear
Indoor base station deployment	n.a.	n.a.	n.a.	n.a.
Indoor base station penetration loss	n.a.	n.a.	n.a.	n.a.
Below rooftop base station antenna deployment	0%	0%	30% (1-2 GHz) 50% (2-3 GHz)	100%
Feeder loss (dB)	3	3	3	n.a.
Maximum base station output power (5/10/20 MHz) (dBm)	43/46/46	43/46/46	43/46/46	35
Maximum base station antenna gain (dBi)	18	16	16	5
Maximum base station output power/sector (e.i.r.p.) (dBm)	58/61/61	56/59/59	56/59/59	40
Average base station activity	50%	50%	50%	50%
Average base station power/sector taking into account activity factor (dBm)	55/58/58	53/56/56	53/56/56	37
<b>User terminal characteristics</b>				
Indoor user terminal usage	50%	70%	70%	70%
Indoor user terminal penetration loss (dB)	15	20	20	20
User terminal density in active mode (MHz/km <sup>2</sup> )	0.17/5	2.16/5	3/5	3/5
Maximum user terminal output power (dBm)	23	23	23	23

TABLE 8 (end)

	Macro rural	Macro suburban	Macro urban	Small cell outdoor/ Micro urban
<b>User terminal characteristics</b>				
Average user terminal output power (dBm)	2	-9	-9	-9
Typical antenna gain for user terminals (dBi)	-3	-3	-3	-3
Body loss (dB)	4	4	4	4

### 3.3 Scenario

Interference from IMT base station and user equipment into MSS terminals may occur for the following reasons:

- 1 IMT unwanted emissions: IMT unwanted emissions into the MSS band above 1 518 MHz increasing the MSS receiver noise floor thereby degrading the receivers sensitivity.
- 2 Overload/blocking: IMT signal below 1 518 MHz causing overload/blocking inside the MSS receiver.

### 3.4 Propagation models

An appropriate propagation model will need to be used. It may be necessary to use different propagation model assumptions for each of the three scenarios: maritime, aeronautical and land.

Different models can be used for terrestrial path (land/maritime analysis) and can be summarized as follow:

- Recommendation ITU-R P.452-16 is a path specific interference prediction method which requires a terrain profile. It operates correctly with a smooth Earth profile; it should be noted that this is not equivalent to a path general model such as in Recommendation ITU-R P.1546-5. Recommendation ITU-R P.452-16 predicts median signal levels and enhancements exceeded down to  $p = 0.001\%$  time.
- Recommendation ITU-R P.2001-2 is an alternative to Recommendation ITU-R P.452-16 which is especially suitable for Monte Carlo simulations. This Recommendation predicts across the entire probability range for enhancements exceeded  $p = 0.001\%$  time to fades exceeded  $p = 0.001\%$  time.
- Recommendation ITU-R P.1546-5 is a path general terrestrial model derived from measurements over gently rolling terrain and is valid up to 3 GHz. This Recommendation predicts median signal levels and enhancements exceeded down to  $p=1\%$  time.
- Recommendation ITU-R P.1812 can also be used in the cases of rural areas where the clutter is less than 10 m.

#### Land BS into MES

- Rural case – Recommendation ITU-R P.1546-5, and Recommendation ITU-R P.1812-4 for lower clutter height than 10 m.
- Suburban case – Recommendation ITU-R P.1546-5 with 10 m clutter height.

– Urban case – Recommendation ITU-R P.1546-5 with 20 m clutter height.

All of these scenarios are carried out with 50% location variability and 50% time.

Annex 2 contains a short description of the considerations that has gone into the selection of propagation models and the associated clutter height.

### Sea (maritime)

Recommendation ITU-R P.452-16 with 50% time. For the sea case, interference from a rural IMT base station only is considered.

### Air (aeronautical)

Recommendation ITU-R P.525-2 (i.e. free space loss) is used to consider cases of interference to an AES in flight.

To consider potential interference to an AES located on an aircraft at an airport, analysis of interference to an AES located 10 m a.g.l. is also made in the land-rural environment.

## 4 Methodology

Two methodologies have been used in this Report, Minimum Coupling Loss (MCL) and Monte Carlo.

### 4.1 Minimum Coupling Loss (MCL)

The Minimum Coupling Loss is calculated with the antenna in boresight to each other and taking into account frequency separation. The corresponding separation distance at which each interference criterion is just met is then calculated taking into account the discrimination of both antennas and the frequency separation.

#### 4.1.1 For assessment of interference due to IMT unwanted emissions

The interference from IMT unwanted emissions is evaluated using the following equation:

$$I_1 = P_{T,OOB} + G_T + G_{T,REL} - L_F + G_R + G_{R,REL} - L_{prop} - L_{pol} = P_{T,OOB} + G_T - L_F + G_R - L_{pol} - CL \quad (1)$$

where:

- $I_1$  : IMT unwanted emissions interferer power at the MES receiver
- $P_{T,OOB}$  : maximum transmitted power by the interferer falling within the channel bandwidth of the MES receiver
- $L_F$  : IMT station feeder loss
- $G_T$  : peak gain of the transmitter antenna (the interferer)
- $G_{T,REL}$  : gain of the transmitter antenna in the direction of the MES, relative to the peak value
- $G_R$  : peak gain of the receiver antenna (the victim)
- $G_{R,REL}$  : gain of the receiver antenna in the direction of the IMT transmitter, relative to the peak value
- $L_{prop}$  : loss due to the propagation
- $L_{pol}$  : polarization loss
- $CL$  : coupling losses and are given by the following equation:

$$CL = L_{prop} - G_{R,REL} - G_{T,REL} \quad (2)$$

The maximum allowed interference power at the MES receiver is given by:

$$I_{1,MAX} = N + I/N_{th} \quad (3)$$

where:

$I_{1,MAX}$  : maximum acceptable IMT unwanted emissions interferer power at the MES receiver

$N$  : receiver thermal noise power

$I/N_{th}$  : interference criterion.

The minimum coupling loss (MCL) to meet the criterion can be therefore calculated as:

$$MCL = P_{T,OOB} + G_T + G_R - L_{pol} - L_F - I_{1,MAX} \quad (4)$$

In this study, the coupling losses are determined as a function of the separation distance between the IMT transmitter and the MES.

#### 4.1.2 For assessment of blocking of MES receivers

The interferer power from the IMT system into the MES receiver has been calculated using the following equation:

$$I_2 = P_{T,IB} - L_F + G_T + G_{T,REL} + G_R + G_{R,REL} - L_{prop} - L_{pol} = P_{T,IB} + G_T - L_F + G_R - L_{pol} - CL \quad (5)$$

where:

$I_2$  : IMT interferer power at the MES receiver

$P_{T,IB}$  : in-band transmitted power by the interferer

$L_F$  : IMT station feeder loss

$G_T$  : peak gain of the transmitter antenna

$G_{T,REL}$  : gain of the transmitter antenna in the direction of the MES, relative to the peak value

$G_R$  : peak gain of the receiver antenna

$G_{R,REL}$  : gain of the receiver antenna in the direction of the IMT transmitter, relative to the peak value

$L_{prop}$  : loss due to the propagation

$L_{pol}$  : polarisation loss

$CL$  : coupling losses and are given by the following equation:

$$CL = L_{prop} - G_{R,REL} - G_{T,REL} \quad (6)$$

The minimum coupling loss (MCL) to meet the criterion can be therefore calculated as:

$$MCL = P_{T,IB} + G_T + G_R - L_{pol} - L_F - I_{2,MAX} \quad (7)$$

where:

$I_{2,MAX}$  : maximum allowed interference power at the MES receiver.

## 4.2 Statistical analysis

Monte Carlo simulations have been developed to supplement the information available from the Minimum Coupling Loss calculations and to provide information about what the risk of interference

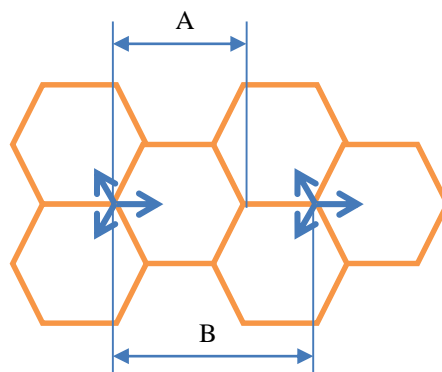
is to a user when both the interferer and the victim system are operating under as close to normal conditions as possible.

In the performed Monte Carlo analysis, it is assumed that the MES may be located at any location within the IMT coverage area. By randomising the location of the MESs and determining the interference at each location, the probability of interference can be assessed.

This addresses the interference probability for a mobile (MES) user and is also taking into account that the MSS system will allocate a channel from within the MSS band to that user.

The deployment of the IMT network is based on the information in Report ITU-R M.2292. The typical macro cell coverage is formed of three hexagons, as illustrated in Fig. 1.

FIGURE 1  
Macro cell geometry (A is the cell radius and B is the inter-site distance)



#### 4.2.1 Monte Carlo analysis for interference from IMT base station into MSS

Monte Carlo simulations have been developed to provide information about the probability of interference from BS into the MSS in adjacent band for the cases of FDD, SDL and downlink part of TDD.

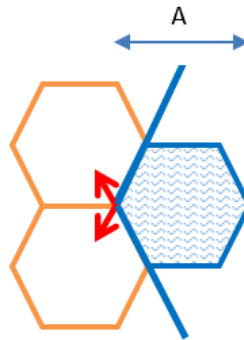
For the maritime environment, the scenarios of interest are where there is cover of a sea area that emanates from rural IMT base stations located inland or a coastal IMT base station which in this location would normally only have two sectors. IMT (SDL) do not generally cover water areas deliberately, it is not cost effective to do so as there is far too little traffic to justify SDL coverage. Rural IMT base stations are considered because base stations covering suburban and urban areas have too much down tilt to reach very far.

The two scenarios of interest are:

- 1 a rural IMT base station located on the coastline with only two sectors pointing towards land;
- 2 a rural land based IMT base station that is covering the area up to the coastline.

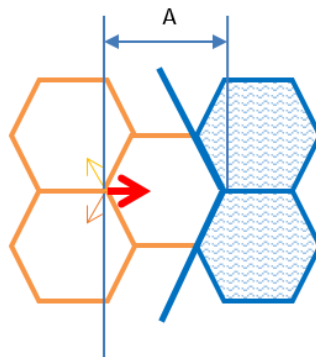
Below is where the IMT base station positioned on the coastline with only two sectors both pointing towards land.

FIGURE 2  
IMT BS on coastline with two sectors pointing towards land



Below is where IMT base station positioned 5 km (A) inland with one sector pointing towards the coast.

FIGURE 3  
IMT BS 5 km inland with one sector pointing towards the coast



#### 4.2.2 Monte Carlo analysis for interference scenario from IMT UE into MSS:

Monte Carlo simulations have been developed to provide information about the probability of interference from IMT UE into the MSS in adjacent band for the case of transmitting UEs.

In the performed Monte Carlo analysis, it is assumed that MES may be located at any location within the IMT coverage. Different deployment scenarios for IMT have been assessed for the cases of rural urban and suburban taking into account different the IMT cell radius is configured to be 5 km for rural, 1 km for suburban scenario and 0.5 km for urban scenario.

The IMT terminals are distributed uniformly, the number of active terminals is set to three terminals in rural, two terminals in suburban and one terminal in urban per cell per 5 MHz.

#### 4.2.3 With random MES location and fixed MES frequency channel

This addresses the situation when the MES is allocated in the first channel above the frequency separation but randomly located in the area of IMT coverage. In addition, some other fixed channels allocated to MES were investigated.

#### 4.2.4 With random MES location and random MES frequency channel

This addresses Monte Carlo simulations trying to establish how much a random user is affected by interference at a random location being allocated a random channel within a defined MSS frequency band.

#### 4.2.5 Network loading and simulation power for IMT BSs

Mobile networks will for the vast majority of time over a day loaded less than 50%<sup>2</sup> and more likely to be in the range of 10-50%<sup>3</sup>. This is because they have to be able to cope with occasional peak traffic.

This means that the Monte Carlo simulations in rural, suburban, urban areas should be performed at average power – a value that is already conservative for these areas. In practice IMT base stations would be subject to different output power levels, but in order to simplify this study the simulation assumed average power, even if this is understood as not reflecting the real situation.

### 5 Summary of the results of studies

In addition to the studies in response of *invites* 1 of the Resolution **223 (Rev.WRC-15)** it is noted that some studies in this Report also address the potential interference due to blocking of MESs operating in the frequency band 1 525-1 559 MHz, including land MES, ship earth stations used in the GMDSS in the frequency band 1 530-1 544 MHz (RR footnote No. **5.353A**) and aircraft earth stations under MSS allocation in the band 1 525-1 559 MHz, noting that priority is given to the AMS(R)S in coordination in the band 1 545-1 555 MHz (see RR No. **5.357A**).

#### 5.1 Summary of results of interference from IMT BS to MES

Study A (Annex 5) is based on a Monte Carlo analysis using fixed MES frequency channel to assess the interference from IMT BS unwanted emissions into land MES. It considered the MSS protection criteria of  $I/N = -15.2$  and  $-20$  dB. The probability of having interference when using different MSS systems and in different deployment scenarios can be summarized as follow: for 1 MHz frequency separation the probability of the MES having interference is within the range of 49.6% to 100% (for most of the MES terminals, the probability of interference is 100%); for 3 MHz frequency separation the probability of the MES having interference reach values of 2.9% to 72.9%; for 6 MHz guard band separation the probability of the MES having interference reaches a value of 2% to 48.3%. The study also examines the required value of the unwanted emissions in order to achieve 99.9% and 99% of availability using Monte Carlo analysis. The study shows that the required unwanted emission limits are as follow: the unwanted emission level is found to be less than  $-62$  dBm/MHz in order to achieve availability of 99.9% for all the studied MES terminals; the unwanted emission level is found to be less than  $-55$  dBm/MHz in order to achieve availability of 99% for all the studied MES terminals.

Study B<sup>4</sup> (Annex 6) used both Monte Carlo and MCL analysis to assess the interference from IMT BS into land, maritime and aeronautical MES. It considered the MSS protection criteria of  $I/N = -6$  and  $-10$  dB, and frequency separations between the two systems of 1, 3 and 6 MHz, in urban, suburban and rural scenarios. It also considered various MES receiver blocking levels

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<sup>2</sup> See Report ITU-R M.2241.

<sup>3</sup> 3GPP TR 36.814 V9.0.0 (2010-03).

<sup>4</sup> Based on these studies, ECC Report 263 establishes compatibility measures based on: (1) a BS in-band e.i.r.p. limit of 58 dBm for the band 1 512-1 517 MHz; (2) a BS unwanted emission e.i.r.p. limit of  $-30$  dBm/MHz above 1 520 MHz; and (3) a receiver blocking requirement of  $-30$  dBm for land mobile earth stations for frequencies above 1 520 MHz, with respect to a broadband signal interferer operating below 1 517 MHz.



depending on different MES receiver characteristics and frequency separation. For MCL calculations, for frequency separation of 1-6 MHz for land, maritime and aeronautical cases, the separation distance due to unwanted emissions is from 5 m to 16.5 km and separation distance due to blocking is from 110 m to 10.785 km. Studies B1, B2 and B3 used Monte Carlo analysis, where both fixed and random MES frequency channel were considered. Study B1 considered land and maritime MESs while studies B2 and B3 considered land MESs only. The studies B1, B2 and B3 found that probability of interference from unwanted emissions for 1 MHz frequency separation is in the range from 0% to 100%, for 3 MHz frequency separation is in the range from 0% to 10.4% and for 6 MHz frequency separation is in the range from 0% to 7.2%. For blocking values ranging from  $-25$  dBm to  $-60$  dBm the interference probability is from 0% to 89.6%. The range of IMT BS unwanted emissions values used in the studies is from  $-0.8$  to  $-80$  dBm/MHz depending on the frequency separation from the channel edge. The unwanted emission level to meet 1% and 0.1% probability of interference is within the range  $-47$  dBm/MHz up to  $-34$  dBm/MHz.

Study D (Annex 8) is based on the measured values of blocking of MSS receivers due to the interference from IMT BS into land, maritime and aeronautical MES. It considered the MSS receiver blocking characteristics for current and next generation MES, and frequency separations between the two systems of 0, 1, 3, 6, 8, 11 and 16 MHz, in urban, suburban, and rural scenarios. For land MES, based on a fixed separation distance of 40 m, the study found that with IMT base station e.i.r.p. limits in the range of 5.5 to 41.5 dBm for current MES, and 18.5 to 68.5 dBm for next generation MES, the interference level from IMT BS would meet the MES receiver blocking criteria. The range of values is due to the range of IMT frequency channel offsets used below 1 518 MHz (from 0 to 16 MHz offset) and the IMT deployment scenario (rural, suburban or urban). For maritime MESs, the study found that with pfd limits in the range of  $-101.9$  to  $-60.9$  dBW/m<sup>2</sup> for current MES, and  $-56.9$  dBW/m<sup>2</sup> to no limits for next generation MES, applied in their respective areas of operation, the interference level from IMT BS would meet the MES receiver blocking criteria.

For aeronautical MESs, the study found that with pfd limits in the range of  $-77.4$  to  $-28.9$  dBW/m<sup>2</sup> for current MES, and  $-54.9$  dBW/m<sup>2</sup> to no limits for next generation MES, applied in their respective areas of operation, the interference level from IMT BS would meet the MES receiver blocking criteria.

The ranges of pfd values are due to the different MES antenna gain assumptions, and the specific frequency characteristics of the IMT base stations.

Study H (Annex 12) provides a two-phase approach that administrations could adopt to address potential blocking of MES operating in bands adjacent to 1 518 MHz (including 1 525-1 559 MHz) at seaports and airports. The approach is based on two phases. During phase 1 a set of pfd coordination thresholds are defined, that would ensure the protection of existing aeronautical and maritime terminals. In phase 2, a new set of pfd coordination thresholds is defined, based on the assumption that after the period of phase 1, MES terminals will be updated to achieve a better blocking performance. For phase 1, the values of pfd for the protection of airports range from  $-63.4$  dBW/m<sup>2</sup> from to  $-12.9$  dBW/m<sup>2</sup> and for ports from  $-85.9$  dBW/m<sup>2</sup> to  $-12.9$  dBW/m<sup>2</sup>. For phase 2, the values of pfd for the protection of both airports and ports range from  $-40.9$  dBW/m<sup>2</sup> to no limits required.

## 5.2 Summary of results of interference from IMT UE to MES

Study C (Annex 7) is based on a Monte Carlo analysis using random MES frequency channel within 1 518-1 525 MHz to assess the interference from IMT UE into land MES. Interference probabilities were analysed for three MSS systems in urban, suburban and rural scenarios considering *I/N* protection ratio of  $-6$  and  $-10$  dB and blocking level of  $-43$  and  $-70$  dBm.

In the case of suburban scenario, the results of interference probability into MSS 2 for *I/N* of  $-6$  dB are found to be 1.8-4.2% for IMT UE unwanted emission limits of  $-20$  dBm/MHz, and 1-2.2% for

-30 dBm/MHz. For MSS 1, the results are found to be 2.4-2.6% for IMT UE unwanted emission limits of -20 dBm/MHz, and 1.4-1.8% for -30 dBm/MHz. For MSS 3, the results are found to be 1.8-3% for IMT UE unwanted emission limits of -20 dBm/MHz, and 1-1.8% for -30 dBm/MHz. For  $I/N$  of -10 dB the interference probabilities were found to be 0.9-6.2% with an unwanted emission limit of -20 dBm/MHz. Interference probabilities were found to be 0.1-2.8% with an unwanted emission limit of -30 dBm/MHz.

In the case of urban scenario, the results of interference probability into MSS 1 for  $I/N$  of -6 dB are found to be 4.8-8.8% for IMT UE unwanted emission limits of -20 dBm/MHz, and 3-3.4% for -30 dBm/MHz. For MSS 2, the results are found to be 8-9.6% for IMT UE unwanted emission limits of -20 dBm/MHz, and 3.6-4.2% for -30 dBm/MHz. For MSS 3, the results are found to be 6-7.6% for IMT UE unwanted emission limits of -20 dBm/MHz, and 2.8-3.4% for -30 dBm/MHz.

The results of analysis for unwanted emissions of -10 dBm/MHz has shown that the interference probabilities which exceed  $I/N$  protect criterion ratio of -6 / -10 dB is less than 6.5% / 11.4% in urban scenario, less than 1.8% / 3.2% in suburban scenario and almost 0% for rural scenario.

The results of rural scenario showed no interference probability for IMT UE unwanted emission limits of -10 dBm/MHz, -20 dBm/MHz, and -30 dBm/MHz for  $I/N$  of -6 dB and -10 dB. The interference probabilities for blockage level of -70 dBm showed less than 0.2% and 0.6% in suburban and urban scenarios, respectively.

Study E (Annex 9) is based on a Monte Carlo analysis using fixed MES frequency channel to assess the interference from IMT UE unwanted emissions into land MES. It considered the MSS protection criteria of  $I/N = -15.2$  and -20 dB, for different MSS systems in urban and suburban scenarios. Results of interference probability into MSS are found to be less than 1% for IMT UE unwanted emission limits of the range of -74 to -25 dBm/MHz.

Study F (Annex 10) is based on a MCL analysis to assess the interference from IMT UE into land, maritime and aeronautical MESs. It considered the MSS protection criteria of  $I/N = -6$ , -10, -15.2 and -20 dB. The study found that with unwanted emission e.i.r.p. *limits* in the range -80 to -66 dBm/MHz, the interference level from IMT UEs would meet the protection criteria for the land, maritime and aeronautical MESs. Regarding blocking of MES receivers, for the current generation of land MESs the interference exceeds the blocking criterion of -63 to -41 dBm for frequency separations up to 16 MHz. However, the IMT UE is compatible with next generation land MESs with respect to blocking interference, provided the UE operates below 1 517 MHz.

Study G (Annex 11) is based on a Monte Carlo statistical analysis to assess the impact of IMT UE unwanted emission interference into MESs. The analysis performed probabilities of interference for urban and suburban deployment scenarios, considering  $I/N$  protection ratio of -6 dB and -10 dB for each deployment scenario. For the case of suburban deployment scenario, the results of probability of interference into MES for  $I/N$  of -6 dB was 13.3% and for  $I/N$  of -10 dB was 20.3%. For the case of urban deployment scenario, the results of probability of interference into MES for  $I/N$  of -6 dB was 14.4% and for  $I/N$  of -10 dB was 18.4%.

## 6 Conclusions

Various studies have been performed regarding potential interference from IMT base stations and IMT UEs to mobile earth stations (based on certain assumptions described in each study), considering the potential for blocking of the MES receiver and interference due to unwanted emissions from IMT base stations and UEs. The outcome of the studies is provided in § 5.

The studies in the Annexes indicate that various mitigation methods may be needed to reduce the potential interference into MES. The studied mitigations include IMT-MSS frequency separation, reduced IMT BS and UE in-band emission, reduced IMT BS and UE unwanted emissions, and pfd

levels applicable to IMT BSs. The methods may be used individually or in combination to provide compatibility. The associated Recommendation ITU-R M.2159-0 provides recommended compatibility measures, to address the interference issues.

## **7 List of Annexes**

Annex 1: Representative MES antenna patterns

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Annex 12: Study H

## Annex 1

## Representative MES antenna patterns

## A1.1 Antenna pattern for 21 dBi antenna

FIGURE A1-1  
Fleet broadband antenna (peak gain = 21 dBi)

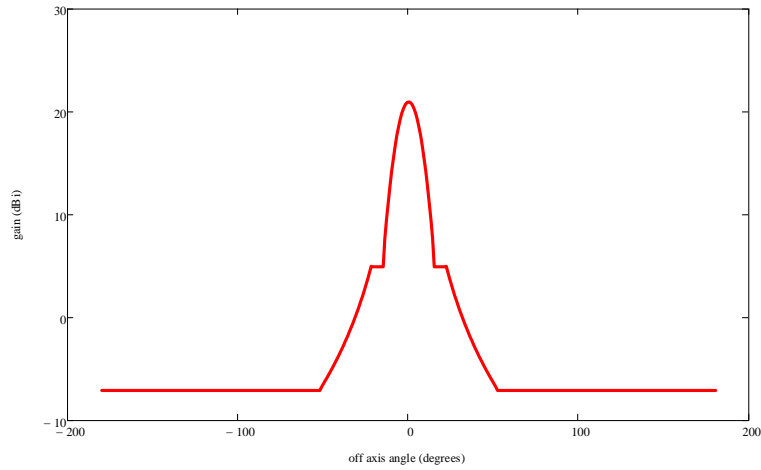


Figure A1-1 is defined by the following equation, where  $G_3(a)$  is the gain in dBi as a function of off-axis angle  $a$ ,  $G_{max} = 21$  dBi, and  $D$  is the diameter, equal to 1.

$$G_3(a) = \begin{cases} G \leftarrow G_{max} - 2.5 \cdot 10^{-3} \cdot \left(\frac{D \cdot a}{\lambda}\right)^2 & \text{if } 0 \leq a \leq 14 \\ G \leftarrow 5 & \text{if } 14 \leq a \leq 21 \\ G \leftarrow 48 - 32 \cdot \log(a) & \text{if } 21 < a \leq 51 \\ G \leftarrow -7 & \text{otherwise} \\ G & \end{cases}$$

### A1.2 Antenna pattern for the 17.5 dBi antenna

FIGURE A1-2  
(peak gain = 17.5 dBi)

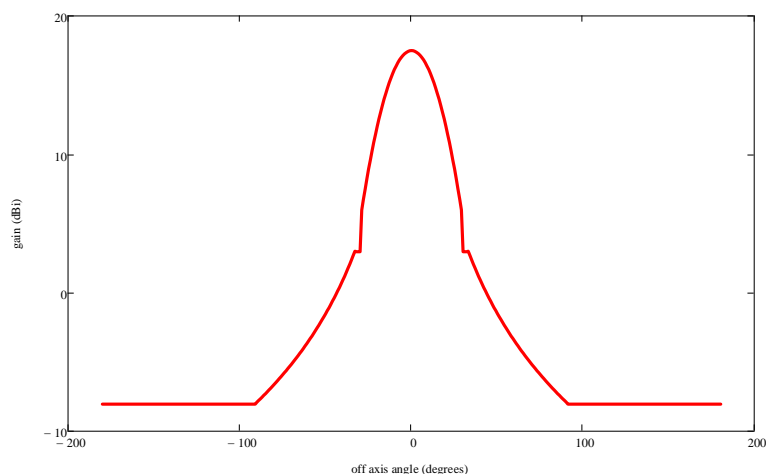


Figure A1-2 is defined by the following equation, where  $G_4(a)$  is the gain in dBi as a function of off-axis angle  $a$ ,  $G_{max} = 17.5$  dBi and  $D$  is the diameter, equal to 0.45 m.

$$G_4(a) = \begin{cases} G \leftarrow G_{max} - 2.5 \cdot 10^{-3} \cdot \left(\frac{D \cdot a}{\lambda}\right)^2 & \text{if } 0 \leq a \leq 29 \\ G \leftarrow 3 & \text{if } 29 < a \leq 32 \\ G \leftarrow 41 - 25 \cdot \log(a) & \text{if } 32 < a \leq 90 \\ G \leftarrow -8 & \text{otherwise} \\ G & \end{cases}$$

### A1.3 Antenna pattern for 3 dBi antenna

FIGURE A1-3  
(peak gain = 3 dBi)

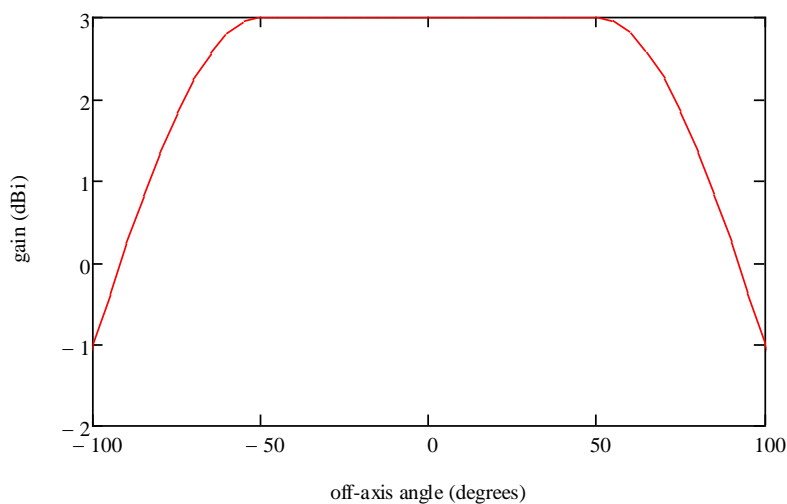


Figure A1-3 is defined by the following equations, where  $GSPS(e)$  is the gain in dBi as a function of elevation angle  $e$ ,  $e = 90 - |\text{off-axis angle}|$ , and  $GSPS_{max} = 3$  dBi.

$$GSPSrels(e) = \begin{cases} 0 & \text{if } 40 \leq e \leq 90 \\ 4 \cdot \cos[1.8 \cdot (e - 40) \cdot \text{deg}] - 4 & \text{if } -15 \leq e < 40 \end{cases}$$

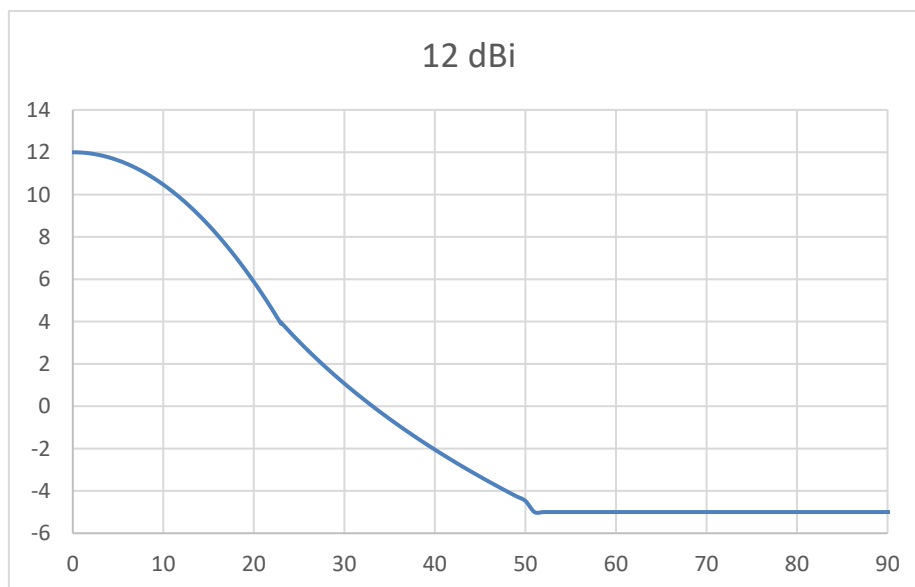
$$GSPS(e) = G_{iSPSmax} + GSPSrels(e)$$

#### A1.4 Antenna pattern for 12 dBi antenna

The antenna pattern is as following:

$$\begin{aligned} G &= G_{max} - 12 \cdot (\theta/28)^2 \text{dBi} & \text{for } \theta < 23^\circ \\ G &\leq 38 - 25 \cdot \log(\theta) \text{ dBi} & \text{for } 23^\circ \leq \theta < 50^\circ \\ G &\leq -5 \text{ dBi} & \text{for } \theta \geq 50^\circ \end{aligned}$$

FIGURE A1-4

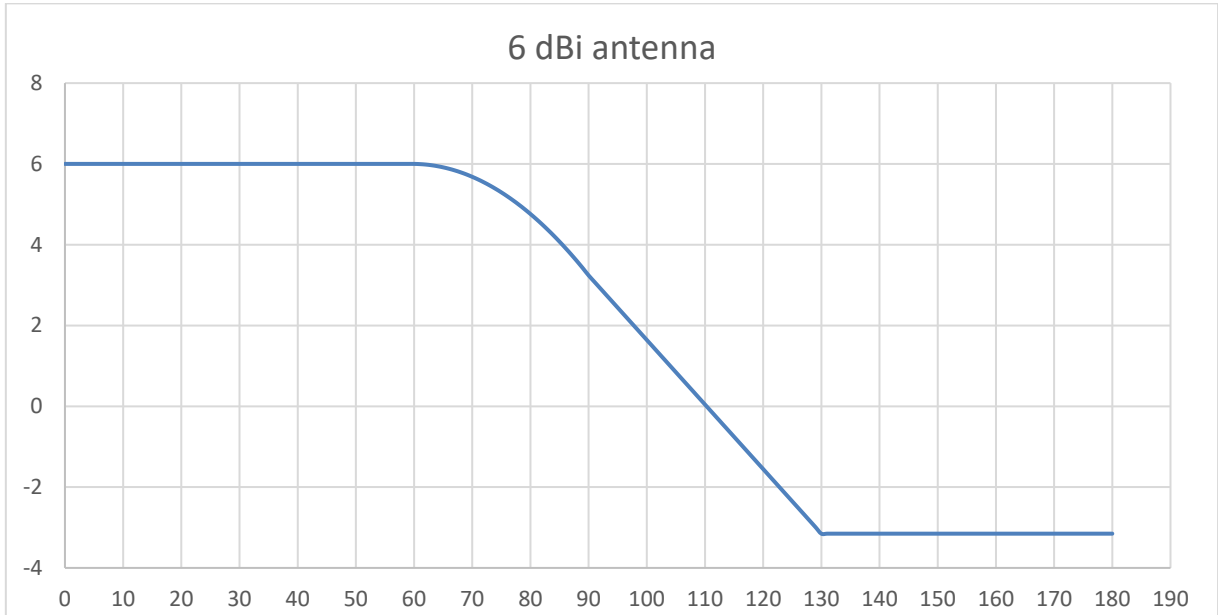


#### A1.5 Antenna pattern for 6 dBi antenna

The antenna pattern is as following:

$$\begin{aligned} G &= G_{max} & \text{dBi} & \text{for } \theta < 60^\circ \\ G &= -0.003 \cdot (\theta)^2 + 0.358 \cdot (\theta) - 4.68 & \text{dBi} & \text{for } 60^\circ \leq \theta < 90^\circ \\ G &= -0.1598 \cdot (\theta) + 17.622 & \text{dBi} & \text{for } 90^\circ \leq \theta < 130^\circ \\ G &= -3.15 & \text{dBi} & \text{for } \theta \geq 130^\circ \end{aligned}$$

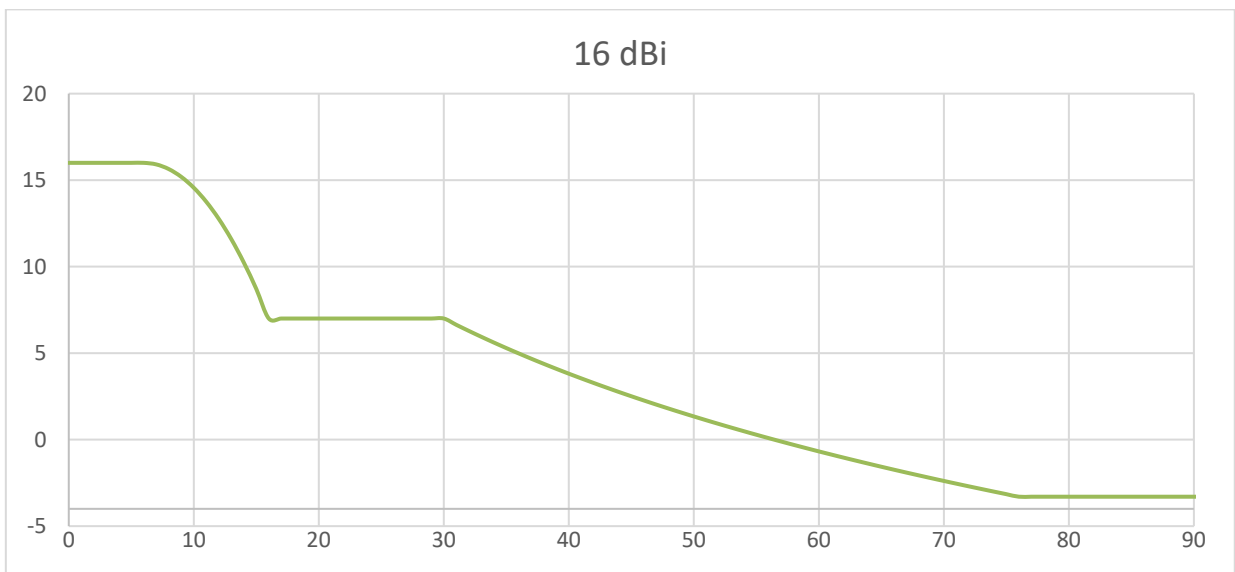
FIGURE A1-5



**A1.6 Antenna pattern for 16 dBi antenna**

$G = G_{max}$	dBi	for	$\theta < 6^\circ$
$G = 16 - 16 \cdot ((\theta - 6)/18.653)^2$	dBi	for	$6^\circ \leq \theta < 16^\circ$
$G = 7$	dBi	for	$16^\circ \leq \theta < 30^\circ$
$G = 44.69 - 25.515 \cdot 2 \cdot \log(\theta)$	dBi	for	$30^\circ \leq \theta < 76^\circ$
$G = -3.299$	dBi	for	$\theta \geq 76^\circ$

FIGURE A1-6



## Annex 2

### Additional information regarding propagation model for land scenario

Recommendation ITU-R P.1546-5 is assumed for the normal environment. However, the applicability of this point-to-area model, based on a huge amount of measurements, is conditioned by the clutter height value (in the vicinity of the mobile receiver). The lower the clutter height, below 10 m, the less applicable this model would be from an interpolation (on receiver height correction) perspective. Because of this other propagation models were investigated, and Recommendation ITU-R P.1812-4 was proposed. Recommendation ITU-R P.1812-4 is a path specific simplified version of Recommendation ITU-R P.452. During the simulations it became clear that the simplifications made to Recommendation ITU-R P.1812-4 does not allow the location of clutter to be as an input parameter and in some of the simulations Recommendation ITU-R P.452 was used to position the clutter correctly. It was agreed that the following values for the clutter heights are used for simulations run: 4 m, 7 m and 10 m for a rural environment. As a comparison, the results are displayed in Table A2-1 for 1 km distance with the clutter height located at 100 m from the MES<sup>5</sup>:

TABLE A2-1

#### Pathloss calculations for 1 km (ground) separation distance

Scenario (Rural case)	4 m	7 m	10 m
Rec. ITU-R P.1812-4, $l = 50\%$ , $t = 50\%$	104.5 dB	116.9 dB	123.5 dB
Rec. ITU-R P.1546-5, $l = 50\%$ , $t = 50\%$	111.2 dB	117.3 dB	121.4 dB

When the clutter height is equal to 10 m, Recommendation ITU-R P.1812-4 gives higher path loss than Recommendation ITU-R P.1546-5, which suggests that Recommendation ITU-R P.1546-5 is more conservative than Recommendation ITU-R P.1812-4. When the clutter height is lower than 10 m, the path loss gap between Recommendations ITU-R P.1546-5 and ITU-R P.1812-4 reduces until it balances (clutter height equals to 7 m), and for clutter height lower than 7 m, Recommendation ITU-R P.1812-4 is more conservative than Recommendation ITU-R P.1546-5.

According to these results in term of conservative approach for underestimating path loss for rural case:

- Recommendation ITU-R P.1546-5 is appropriate for clutter height between 7 m to 10 m.
- Recommendation ITU-R P.1812-4 is appropriate for clutter height between 4 m to 7 m but unable to position the clutter at a distance from the receiver without using profile path rather than clutter.
- Recommendation ITU-R P.452 can however position the clutter correctly and has been used in some studies.

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<sup>5</sup> Using the clearance angle for Recommendation ITU-R P.1546-5, using the specific path for Recommendation ITU-R P.1812-4.



### Annex 3

#### Methodology for protection of MES operations at harbours and airports

Depending on the e.i.r.p. limits applied to IMT base stations operating below 1 518 MHz, additional mitigation may be required to address the protection of MESs located at harbour and airports. The operation of ship earth stations (SESs) in harbours is important since even though other communication means may be available, it is important to be able to test the satellite communication equipment while in harbour. Similarly, for aircraft earth stations, it is important to be able to test the AES operation while the aircraft is on the ground at an airport. For some aircraft, safety operations require that the AES can demonstrate correct functioning of the satellite communication equipment before take-off.

Allowing the interference criteria to be exceeded for a percentage of locations is not appropriate if those locations happen to coincide with the locations where correct operation of the SES or AES is required. Separation distances in Annex 6 (Tables A6-1, A6-2 and A6-3) show the maximum separation distances that can be expected. For the maritime case, the required separation distances range from 0.3 km to 13.6 km. For the aeronautical case, the required separation distances range from 0.3 km to 16.5 km. The range of distances is due to the interference criterion used and due to the assumed frequency separation (1 MHz, 3 MHz or 6 MHz).

Within a certain distance of the harbour/airport, administrations may need to require IMT operators to coordinate their base stations to ensure that SES/AESs do not receive excessive interference. Taking into account factors such as a real propagation path loss, actual IMT base station emissions and MES antenna pointing directions may allow IMT base station operations at closer distances, once a more detailed analysis has taken place. This requirement applies in particular to IMT base stations operating in the uppermost channel(s) below 1 518 MHz.

To ensure that MSS protection requirements at harbours and airports are met, administrations may wish to define pfd values to be met by IMT base stations. The relationship between the maximum pfd and the maximum interference is given by:

$$pfd_{max} = I_{max} - Ae_{iso} - G_{MES}$$

Table A3-1 shows as an example how the pfd values could be determined using the parameter values used in this Report.

TABLE A3-1

#### Examples of pfd values to meet unwanted emission criteria

Parameter	Unit	I/N = -6 dB	I/N = -20 dB
MES noise temperature	K	316.0	316.0
MES receiver bandwidth	kHz	200.0	200.0
MES antenna gain in direction of base station	dBi	3.0	3.0
Maximum received level of unwanted emissions (I/N)	dB	-6.0	-20.0
Maximum received level of unwanted emissions in MES receiver bandwidth	dBW	-156.6	-170.6
Affective area of isotropic antenna at 1 518 MHz	dBm <sup>2</sup>	-25.1	-25.1
Maximum pfd (unwanted emissions in receiver bandwidth)	dBW/m <sup>2</sup>	-134.5	-148.5

TABLE A3-2

**Examples of pfd values to meet blocking criteria**

Parameter	Unit	Blocking value of -70	Blocking value of -30
Maximum receiver blocking level (>5 MHz separation)	dBm	-70	-30
Maximum receiver blocking level (>5 MHz separation)	dBW	-100	-60
MES antenna gain in direction of base station	dBi	3.0	3.0
Affective area of isotropic antenna at 1 518 MHz	dBm <sup>2</sup>	-25.1	-25.1
Maximum pfd (In-band emissions to meet blocking criterion)	dBW/m <sup>2</sup>	-77.9	-37.9

**Annex 4****MSS Protection criteria****A4.1 MSS Protection criteria**

Currently, there is no ITU-R Recommendation providing protection criteria for the MSS Earth stations with respect to other services operating in adjacent bands. However, one ITU-R Recommendation addresses in-band protection criteria for the MSS, and one ITU-R Report has used protection criteria for adjacent band compatibility, which may be a useful reference.

The interference criteria between MSS and terrestrial services of  $I/N$  of -6, -10, -15.2 and -20 dB were used in the studies. In this regard there are two views:

View 1: The value for -20/-15.2 dB is agreed by ITU-R for MSS including MSS operating in a fixed mode similar to FSS for adjacent band criteria in different ITU-R documents within the range 1 to 3 GHz (see Annex-6 for more details). Furthermore, the view was expressed that the -20/-15.2 dB provide sufficient protection for MSS as no more stringent protection criterion were suggested to the meeting. In addition, the studies provided to this meeting are in line with the values of -20/-15.2 dB. The values for -6 and -10 dB  $I/N$  have not been used in any ITU-R document as adjacent band criteria furthermore, it contradicts the ITU RR as the out-of-band emissions needs to be kept to the minimum possible. Furthermore, doing the studies using these inappropriate protection criteria will lead to misleading compatibility results between MSS and IMT that **will** preclude the operation of MSS not only in the range of 1 518-1 525 MHz but also to the range 1 525-1 559 MHz.

The main source of interference is the other MSS satellites operating in the same band. Recommendation ITU-R M.1183 provides protection criteria of up to 24% for the MSS networks in 1-3 GHz range caused by other networks of the MSS operating in the same band. For typical MSS satellite network,  $I/N$  of 30%-32% can be used (corresponds to 1 dB degradation based on the noise temperature used), which leads to 6-8%  $I/N$  interference margin to all services other than MSS. The 6-8% should be distributed among: (a) the services other than Mobile satellite services operating in the same band (FS and MS); and (b) adjacent band services (FS, MS, SOS, EESS). Allocating more than 6-8% percent to these other services and adjacent band services, would cause harmful interference to most MSS systems, which are designed for  $I/N$  less than 32%. Arguing that the entire interference margin should be allocated to IMT is not valid as it contradicts Recommendation ITU-R

M.1183. Furthermore, those studies using such invalid values of  $-6/-10$  dB show very high probability of interference to MSS operations in some parts of the MSS band, e.g. 1 518-1 520 MHz band.

View 2: Since there is no interference criteria in the ITU-R recommendation between the MSS and terrestrial services, it is most appropriate to use an  $I/N$  in the range of  $-10$  to  $-6$  dB for the purpose of studies. There is no basis for using  $-20$  dB /  $-15.2$  dB  $I/N$ , this is overly conservative, not valid for MSS, based on the protection criteria of other services and the co-ordination trigger for satellite co-ordination. It further includes service apportionment (reducing the criteria to  $-15.2$  dB) and geographic / beam apportionment (further reducing the criteria to  $-20$  dB). The 1 492-1 518 MHz band has Fixed and Mobile allocated as co-primary where these two services cannot co-exist in the same geographical area, particularly in a localised area near an Earth station. Therefore, the Fixed and Mobile services cannot simultaneously contribute to interference and service apportionment is not valid. Geographic / beam apportionment is also not valid as this concept is can only be applicable to space stations not Earth stations. The  $-20$  dB  $I/N$  criteria is incorrect as this is based on a criterion for other services (i.e. non-coprimary), in this case Mobile has a primary allocation in the 1 492-1 518 MHz band. The dominant issue in studies is the poor receiver performance MSS Earth stations this contradicts the ITU RR (RR Nos. 3.12 and 3.13) which stipulates that receiver should have an adequate performance to ensure that they do not suffer inference from transmitters. Given that MSS is in the adjacent band the MSS Earth station receiver performance is clearly inadequate.

#### **A4.1.1 Compilation of protection criteria references for MSS**

**A4.1.1.1** Recommendation ITU-R M.1183 provides a protection criterion for the MSS networks from 1-3 GHz caused by other networks of this service and fixed-satellite service. In frequency bands in which the MSS network does not practise frequency re-use, the interference power level should not exceed, for more than  $(100 - X)\%$  of any month, 24% of the total noise power at the input to the demodulator, in frequency bands in which the MSS network practises frequency re-use, the interference power level should not exceed, for more than  $(100 - X)\%$  of any month, 20% of the total noise power at the input to the demodulator that would give rise to the desired performance, for SEI (single entry interference) the maximum level of interference power in any digital channel should not exceed for more than  $(100 - X)\%$  of any month<sup>6</sup>, 6% of the total noise power at the input to the demodulator. However, Recommendation ITU-R M.1183 provide in-band figure of protection and does not contain out-of-band of protection criteria.

**A4.1.1.2** Recommendation ITU-R S.1432-1 “Apportionment of the allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz”.

When sharing frequencies below 30 GHz, the maximum allowable interference from all sources (aggregate) should be limited to 32% or 27% for systems not practising and for systems practising frequency re-use, of the clear-sky satellite system noise. The error performance degradation due to interference at frequencies below 30 GHz should be allotted portions of the aggregate interference budget of 32% or 27% of the clear-sky satellite system noise in the following way:

- 25% for other FSS systems for victim systems not practising frequency re-use;
- 20% for other FSS systems for victim systems practising frequency re-use;
- 6% for other systems having co-primary status;
- 1% for all other sources of interference.

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<sup>6</sup> X is the percentage time availability, for different types of MSS services, as defined under the relevant ITU-R Recommendation on performance objectives.

The use of FSS criteria to protect MSS has been referred to in previous ITU reports, however the FSS protection criteria in some cases was not appropriate as it did not meet the MSS required performance objective.

**A4.1.1.3** Recommendation ITU-R S.741-2, which contains protection criteria for FSS satellite networks. However, the protection criteria described in Recommendation ITU-R S.741-2 is also used by BR for MSS and BSS in accordance with Rules of Procedure (see 2.1 in Section B3 of Part B) for the assessment of probability of harmful interference under RR No. **11.32A**. For SEI (single entry interference) the protection criterion in Recommendation ITU-R S.741-2 is  $C/I$  equal to  $(C/N + 12.2 \text{ dB})$ . As in Recommendation ITU-R M.1183, Recommendation ITU-R S.741-2 provides protection criteria for in-band protection.

**A4.1.1.4** ECC Report 45 for sharing and adjacent band compatibility between UMTS/IMT-2000 in the band 2 500-2 690 MHz and other services. ECC Report 45 uses an adjacent band protection criterion  $\Delta T/T = 3\%$  and in-band protection criterion of 6% for the MES operating in the 2.5/2.6 GHz band.

**A4.1.1.5** Report ITU-R M.2041 also deals with sharing and adjacent band compatibility in the 2.5 GHz band between the terrestrial and satellite components of IMT-2000. This ITU-R Report contains protection criteria for the IMT-satellite component. Report ITU-R M.2041 uses an adjacent band protection criterion  $\Delta T/T = 3\%$  (§ 2.2 of the Report) and in-band protection criterion of 6%. Neither Report provides reference or calculation method for the value used.

#### **A4.1.2 Possible sources of interference**

The following possible sources of interference need to be taken into account when apportioning the overall allowable interference.

Other MSS systems operating in the same band:

**A4.1.2.1** According to Recommendation ITU-R M.1183 aggregate allowable interference of other MSS should not exceed, more than  $(100 - X)\%$  of any month, 24% of the total noise power at the input to the demodulator, in frequency bands in which the MSS network practises frequency re-use, the interference power level should not exceed, for more than  $(100 - X)\%$  of any month, 20% of the total noise power at the input to the demodulator that would give rise to the desired performance.

**A4.1.2.2** Services other than Mobile satellite services operating in the same band:

- Fixed service.
- Mobile service.

Should not exceed 6% if the allowable level of interference will be the same as FSS by analogy.

**A4.1.2.3** Adjacent band services:

- Fixed service.
- Mobile service (including IMT).
- Space operation.
- Earth exploration.

Should not exceed 1% if the allowable level of interference will be the same as FSS by analogy.

### A4.1.3 Performance objectives

Table A4-1 summarizes the ITU Recommendations containing the performance objectives of different MSS systems.

TABLE A4-1

#### ITU Recommendations containing the performance objectives of different MSS systems

System		
	ITU-R Rec.	Performance/Availability objective
GSO/AMSS non-ISDN	M.1229	For transportable and vehicle mobile earth stations: <ul style="list-style-type: none"> <li>For “general purpose” AMSS channel (up to 9.6 kbit/s), in voice mode, BER better than <math>1 \times 10^{-3}</math> for 90% of the available time, and in data and signalling mode, BER better than <math>1 \times 10^{-5}</math> for 90% of the available time.</li> <li>For store and forward (up to 600 bit/s), BER better than <math>1 \times 10^{-5}</math> for 80% of the available time and BER better than <math>4 \times 10^{-5}</math> for 99% of the available time.</li> </ul>
AMS(R)S	M.1037	For voice: BER not worse than $1 \times 10^{-3}$ for more than 0.1% of the time on a daily basis. For packet mode data: BER not worse than $1 \times 10^{-5}$ for more than 0.1% of the time on a daily basis.
GSO/AMS(R)S	M.1180	The resultant availability of AMS(R)S services to aircraft earth stations within a defined coverage areas should be not less than 0.9994.
GSO/non-ISDN	M.1181	For transportable and vehicle mobile earth stations: <ul style="list-style-type: none"> <li>For transportable (up to 16 kbit/s), in voice mode, BER better than <math>1 \times 10^{-2}</math> for not less than 95% of the available time, and in data and signalling mode, BER better than <math>1 \times 10^{-5}</math> for not less than 95% of the available time.</li> <li>For store and forward (up to 16 kbit/s), BER better than <math>4 \times 10^{-5}</math> for not less than 95% of the available time.</li> </ul>
GSO/ISDN	M.1476	BER better than $9 \times 10^{-7}$ after error correction for more than 99% of the available time. See Note 1.

NOTE – The combined MSS radio link unavailability due to propagation should provisionally be not more than 0.1% of the time. Another approach would be to develop an ITU-R Recommendation providing protection criteria for MSS terminals (Land mobile, maritime, aeronautical), based on consideration of the MSS link characteristics, radio interfaces and/or equipment performance. The development of protection criteria applicable to adjacent band compatibility with IMT should take into account the apportionment of the overall allowable error performance degradations due to difference sources of interference.

It is expected that the protection criteria for adjacent band compatibility would not exceed criteria that apply to co-frequency sharing for the equivalent cases.

### A4.2 Overload/Blocking of MSS receiver

Earth station low noise amplifiers (LNAs) are optimized for reception of the very low power level of the incoming satellite signal and, hence, without a pre-selector overload filter, have a high sensitivity to interference. Incoming IMT-Advanced signals at much higher power levels can affect the operating point of the LNA and drive it out of its dynamic range to where it exhibits a non-linear behaviour.

This results in the creation of intermodulation products and gain compression (within the device) that in turn result in distortion of the MSS signal. Typically, LNAs are wideband devices with a low noise figure and flat frequency response over the wanted frequency range. MSS receivers have the bandwidth defining filtering only at intermediate frequency (IF) stage, not at the LNA.

Regarding the MES receiver overload criterion, ETSI standard TS 101 377-5-5 defines the requirements for GMR-2 Mobile Earth Station-to-satellite terminal uplink/downlink operating in the 1 500/1 600 MHz bands in § 7.1 “Mobile Earth Station Blocking characteristics”. In this standard the blocking requirements are defined as  $-43$  dBm for frequency separation greater than 1.6 MHz for CW interference signal.

In addition, Recommendation ITU-R M.1850-2 makes reference to ETSI standard TS 101 376-5-5 which defines the requirements for GMR-1 Mobile Earth Station-to-satellite terminal uplink/downlink operating in the 1 500/1 600 MHz bands in § 7.7 and the blocking requirements are defined as  $-70$  dBm for frequency separation greater than 1.6 MHz for CW interference signal.

The following blocking values are representative for most currently operating MESs:

For MSS-2 and MSS-3, the following values have been used in Study C:

$-70$  dBm for GMR-1 receiver (GMR-1 standard).

The above values are the values in case of CW interfering signal, however for IMT signal the above are to be reduced by 10 dB.

For MSS-1 system, the following values have been used in Study B.

$-60$  dBm ( $< 2$  MHz separation)

$-52$  dBm ( $> 2$  MHz and  $< 5$  MHz separation)

$-40$  dBm ( $> 5$  MHz separation).

In studies D and F, the following values have been used for land portable MESs, based on measured blocking performances of currently operating equipment and expected blocking performance of next generation MESs with improved blocking resilience.

TABLE A4-2

**Current land portable MES blocking performance at different frequency offsets**

Frequency offset	0 MHz Offset	1 MHz Offset	3 MHz Offset	6 MHz Offset	8 MHz Offset	11 MHz Offset	16 MHz Offset
Blocking (dBm/5 MHz)	$-63$	$-63$	$-60$	$-56$	$-53$	$-49$	$-41$

TABLE A4-3

**Next generation land portable MES blocking performance at different frequency offsets**

Frequency offset	0 MHz Offset	1 MHz Offset	3 MHz Offset	6 MHz Offset	8 MHz Offset	11 MHz Offset	16 MHz Offset
Blocking (dBm/10 MHz)	$-50$	$-33$	$-27$	$-18$	$-15$	$-14$	N/A

Study D also examines the blocking of maritime and aeronautical MESs, from single and multiple IMT channels. Based on laboratory testing of currently operating equipment and expected performance of next generation MESs with improved blocking resilience.

TABLE A4-4

**Measured blocking performance of current maritime and aeronautical current terminals from a single LTE channel at different frequencies**

Terminal type	Frequency range (MHz)		
	1 492-1 502	1 502-1 512	1 512-1 517
Maritime (dBm)	-53	-68	-76
Aeronautical (dBm)	-21	-35	-50.3

TABLE A4-5

**Measured blocking performance of current maritime and aeronautical MESs from aggregate multiple LTE channels**

Terminal Type/Model	Aggregate blocker power level at MES RX input from LTE channels in 1 492-1 512 MHz (dBm)	Blocker power level at MES RX input from an LTE channel at 1 512-1 517 MHz (dBm)
Maritime	-67	-78
Aeronautical	-45.6	-55.5

TABLE A4-6

**The expected blocking performances of next generation maritime and aeronautical terminals resulting from a single LTE block at different frequencies**

Blocking signal	Frequency range (MHz)	Blocking level at the antenna connector of MSS terminal (dBm)
LTE signal	1 492-1 512	-20
	1 512-1 517	-30

TABLE A4-7

**The expected blocking performances of next generation maritime and aeronautical terminals resulting from multiple LTE channel**

Maximum aggregate blocker power at MES antenna connector from LTE blocks in 1 492-1 512 MHz	Maximum blocker power at MES antenna connector from LTE block at 1 512-1 517 MHz
-23 dBm	-33 dBm

These values of blocking correspond to high degradation of receiver performance, in many cases rendering the MES inoperable. Therefore, in Monte Carlo analyses, these values should be associated with a low percentage of time, i.e. 0.1% probability.

Moreover, considering that the current blocking response of some MES receivers is the result of a receiver design conceived before the identification of the band below 1 518 MHz to the IMT, some studies in this Report consider the case that the blocking requirement for future MES receivers,

expected to have improved blocking performance: set to  $-20$  dBm and  $-30$  dBm for interfering signals in the from the band 1 502-1 512 MHz and the band 1 512-1 517 MHz respectively. It is expected that those ranges of values should be achievable in the near term. This hypothesis reflects the approach of improving, at some point in time, the blocking requirement for future MES receivers, in order to achieve a better use of spectrum and improved sharing conditions, pursuant Nos. 3.2 and 3.3 of Article 3 of the Radio Regulations.

## Annex 5

### Study A

#### A5.1 Analysis for interference from BS to MES

##### A5.1.1 Land analysis

The following analysis, probabilistic simulations over a general area of IMT coverage are performed from a limited simulation area covered by a three sector IMT Base Station site.

The simulations investigate scenarios where IMT is deployed in urban areas and suburban. Clutter of 10 m is used for Suburban case and 20 m in urban cases. Frequency separations of 1 MHz, 3 MHz and 6 MHz are included. The simulations also investigate scenarios for the required unwanted emissions in order to get a degradation less than 1% and 0.1%.

The following results for this study are based on protection criteria of  $I/N = -15.2$  and  $-20$  dB.

TABLE A5-1

Probability of interference (1 MHz separation analysis)

System	MES antenna gain (dBi)	Scenario			
		Urban		Suburban	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	100%	100%	100%	100%
	17.5	100%	100%	100%	97.8%
MSS 2	1	100%	100%	100%	100%
	6	100%	100%	100%	100%
	12	100%	100%	100%	98.5%
	32	99%	86.7%	83.7%	49.6%
MSS 3	1	100%	100%	100%	100%
	6	100%	100%	100%	100%
	12	100%	100%	100%	100%
	32	99.1%	87.8	84%	51.6%



TABLE A5-2  
Probability of interference (3 MHz separation analysis)

System	MES antenna gain (dBi)	Scenario			
		Urban		Suburban	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	45.9%	22%	17.3%	8.6%
	17.5	23.8%	12.2%	9.2%	4.7%
MSS 2	1	70.7%	33.3%	26.7%	13.4%
	6	69.45%	34.1%	25.1%	13.18%
	12	21%	10.27%	8%	3.9%
	32	11.2%	6.1%	5.7%	2.9%
MSS 3	1	72.9%	35.3%	26.1	13.4%
	6	72.47%	35.24%	26.29	13.7%
	12	21.8%	10.8%	8.6%	4.2%
	32	10.5%	6.1%	5.5%	3.1%

TABLE A5-3  
Probability of interference (6 MHz separation analysis)

System	Antenna gain (dBi)	Scenario			
		Urban		Suburban	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	29.1%	14.1%	11.1%	5.5%
	17.5	16.1%	7.9%	6.2%	3%
MSS 2	1	45.6%	20.6%	17.1%	8.9%
	6	46.26%	22.4%	17.7%	9.17%
	12	13.3%	6.2%	4.9%	2.3%
	32	7.4%	4.17%	3.7%	2.1%
MSS 3	1	47.4%	21.4%	17.1%	8.7%
	6	48.3%	22.5%	17.7%	9.0%
	12	14.1%	6.7%	5.6%	2.28%
	32	7.4%	4.2%	3.9%	2.0%

TABLE A5-4

Unwanted emission limits in units of dBm/MHz for probability of interference less than 0.1%

System	MES antenna gain (dBi)	Less than 0.1%			
		Urban		Suburban	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	-57	-52	-54	-48
	17.5	-62	-58	-59	-54
MSS 2	1	-59	-54	-54	-50
	6	-60	-55	-56	-52
	12	-56	-52	-52	-47
	32	-61	-56	-53	-48
MSS 3	1	-58	-53	-55	-50
	6	-60	-55	-57	-52
	12	-58	-53	-54	-49
	32	-61	-56	-56	-51

TABLE A5-5

Unwanted emission limits in units of dBm/MHz for probability of interference less than 1%

System	MES antenna gain (dBi)	Less than 1%			
		Urban		Suburban	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	-43	-48	-49	-44
	17.5	-54	-49	-50	-45
MSS 2	1	-53	-48	-50	-45
	6	-55	-50	-51	-46
	12	-50	-46	-44	-39
	32	-50	-45	-45	-40
MSS 3	1	-54	-49	-50	-45
	6	-55	-50	-42	-47
	12	-50	-45	-44	-39
	32	-50	-46	-45	-40

## A5.2 Summary of Study A

Study A is based on a Monte Carlo analysis using fixed MES frequency channel to assess the interference from IMT BS into land MES. It considered the MSS protection criteria of  $I/N = -15.2$  dB and  $-20$  dB. The probability of having interference when using different MSS systems and in different deployment scenarios can be summarized as follow:

- for 1 MHz guard band separation the probability of the MES having interference is within the range of 49.6% to 100% (for most of the MES terminals, the interference is for 100% probability);
- for 3 MHz guard band separation the probability of the MES having interference reach values of 2.9% to 72.9%;
- for 6 MHz guard band separation the probability of the MES having interference reach a value of 2% to 48.3%.

The study also examines the required value of the unwanted emissions in order to achieve 99.9% and 99% availability using Monte Carlo analysis. The study shows that the required unwanted emission limits are as follow:

- the unwanted emissions should be less than  $-62$  dBm/MHz in order to achieve availability of 99.9% for all the studied MES terminals;
- the unwanted emissions should be less than  $-55$  dBm/MHz in order to achieve availability of 99% for all the studied MES terminals.

## **Annex 6**

### **Study B**

#### **A6.1 Analysis for interference from BS to MES**

The following results for this study are based on protection criteria of  $I/N = -6$  and  $-10$  dB.

##### **A6.1.1 MCL results**

Tables A6-1, A6-2 and A6-3 show the calculated MCL for the different scenarios. For the case of unwanted emissions,  $I_{MAX}$  is based on the  $I/N$  criterion of  $-6$  dB and  $-10$  dB and is equal to  $-126.6$  dBm and  $-130.6$  dBm accordingly. For the case of MES receiver blocking the values of  $I_{MAX}$  are  $-60$  dBm for 1 MHz frequency separation,  $-52$  dBm for 3 MHz frequency separation,  $-40$  dBm for 6 MHz frequency separation.

TABLE A6-1

**MCL and separation distances for 1 MHz frequency separation**

Scenario	MES antenna	Interference type	I/N (dB)	MCL (dB) (Rural/non-rural)		Separation distance (m)				
						Rural (4 m clutter)	Rural (7 m clutter)	Rural (10 m clutter)	Suburban	Urban
Land	Low gain, 3 dBi	Blocking	N/A	118	116	3 650	2 010	1 375	705	435
		Unwanted emissions	-6	118.8	116.8	4 000	2 180	1 495	740	450
			-10	122.8	120.8	5 000	3 340	2 295	930	550
	High gain, 17.5 dBi	Blocking	N/A	132.5	130.5	5 620	3 210	2 275	845	450
		Unwanted emissions	-6	133.3	131.3	5 000	3 300	2 470	880	470
			-10	137.3	135.3	6 100	4 490	3 505	1 200	550
Sea (maritime)	Low gain, 3 dBi	Blocking	N/A	118		7 700				
		Unwanted emissions	-6	118.8		8 500				
			-10	122.8		13 200				
	High gain, 21 dBi	Blocking	N/A	136		8 000				
		Unwanted emissions	-6	136.8		8 800-3 700				
			-10	140.8		13 600				
Air (aeronautical)	Low gain, 3 dBi	Blocking	N/A	118		7 700				
		Unwanted emissions	-6	118.8		8 600				
			-10	122.8		13 400				
	High gain, 17.5 dBi	Blocking	N/A	132.5		10 785				
		Unwanted emissions	-6	133.3		11 700				
			-10	137.3		16 500				

TABLE A6-2

**MCL and separation distances for 3 MHz frequency separation**

Scenario	MES antenna	Interference type	I/N (dB)	MCL (dB) (Rural/non-rural)		Separation distance (m)				
						Rural (4 m clutter)	Rural (7 m clutter)	Rural (10 m clutter)	Suburban	Urban
Land	Low gain, 3 dBi	Blocking	N/A	110	108	1 550	865	610	450	280
		Unwanted emissions	-6	89.6	87.6	30	10	25	60	60
			-10	93.6	91.6	60	20	60	80	70
	High gain, 17.5 dBi	Blocking	N/A	124.5	122.5	2 560	1 605	1 150	570	335
		Unwanted emissions	-6	104.1	102.1	500	100	70	220	170
			-10	108.1	106.1	600	330	105	270	190
Sea (maritime)	Low gain, 3 dBi	Blocking	N/A	110		3 200				
		Unwanted emissions	-6	89.6		400				
			-10	93.6		600				
	High gain, 21 dBi	Blocking	N/A	128		3 400				

TABLE A6-2 (*end*)

Scenario	MES antenna	Interference type	I/N (dB)	MCL (dB) (Rural/non-rural)	Separation distance (m)				
					Rural (4 m clutter)	Rural (7 m clutter)	Rural (10 m clutter)	Suburban	Urban
		Unwanted emissions	-6	107.6	500				
			-10	111.6	700				
Air (aeronautical)	Low gain, 3 dBi	Blocking	N/A	110	3 175				
		Unwanted emissions	-6	89.6	400				
			-10	93.6	600				
	High gain, 17.5 dBi	Blocking	N/A	124.5	4 585				
		Unwanted emissions	-6	104.1	800				
			-10	108.1	1 100				

TABLE A6-3

**MCL and separation distances for 6 MHz frequency separation**

Scenario	MES antenna	Interference type	I/N (dB)	MCL (dB) (Rural/non-rural)		Separation distance (m)				
						Rural (4 m clutter)	Rural (7 m clutter)	Rural (10 m clutter)	Suburban	Urban
Land	Low gain, 3 dBi	Blocking	N/A	101	99	700	310	50	220	110
		Unwanted emissions	-6	86.6	84.6	20	10	5	50	50
			-10	90.6	88.6	40	10	10	70	60
	High gain, 17.5 dBi	Blocking	N/A	115.5	113.5	1 100	700	510	380	250
		Unwanted emissions	-6	101.1	99.1	300	80	50	190	150
			-10	105.1	103.1	500	110	80	230	170
Sea (maritime)	Low gain, 3 dBi	Blocking	N/A	101		1 200				
		Unwanted emissions	-6	86.6		300				
			-10	90.6		500				
	High gain, 21 dBi	Blocking	N/A	119		1 300				
		Unwanted emissions	-6	104.6		400				
			-10	108.6		500				
Air (aeronautical)	Low gain, 3 dBi	Blocking	N/A	101		1 300				
		Unwanted emissions	-6	86.6		300				
			-10	90.6		500				
	High gain, 17.5 dBi	Blocking	N/A	115.5		2 000				
		Unwanted emissions	-6	101.1		600				
			-10	105.1		800				

**A6.1.2 MCL results for AES on aircraft in flight**

This section shows the potential interference from IMT base stations to AESs operated on aircraft in flight. Interference from a rural base station only is considered, with the AES at example altitudes of 1 000 m, 3 000 m and 10 000 m above ground level (a.g.l.).

A summary of MCL requirements for each of three cases: 1 MHz, 3 MHz and 6 MHz frequency separation, is shown in Tables A6-4, A6-5 and A6-6.

TABLE A6-4

**MCL requirements for 1 MHz frequency separation**

<b>AES antenna</b>	<b>Blocking/Unwanted emissions</b>	<b>Criterion</b>	<b>MCL (dB)</b>
Low gain, 3 dBi	Blocking	$I < -60$ dBm	121.0
	Unwanted emissions	$I/N < -6$ dB	118.8
		$I/N < -10$ dB	122.8
High gain, 17.5 dBi	Blocking	$I < -60$ dBm	135.5
	Unwanted emissions	$I/N < -6$ dB	133.3
		$I/N < -10$ dB	137.3

TABLE A6-5

**MCL requirements for 3 MHz frequency separation**

<b>AES antenna</b>	<b>Blocking/Unwanted emissions</b>	<b>Criterion</b>	<b>MCL (dB)</b>
Low gain, 3 dBi	Blocking	$I < -52$ dBm	113.0
	Unwanted emissions	$I/N < -6$ dB	89.6
		$I/N < -10$ dB	93.6
High gain, 17.5 dBi	Blocking	$I < -52$ dBm	127.5
	Unwanted emissions	$I/N < -6$ dB	104.1
		$I/N < -10$ dB	108.1

TABLE A6-6

**MCL requirements for 6 MHz frequency separation**

<b>AES antenna</b>	<b>Blocking/Unwanted emissions</b>	<b>Criterion</b>	<b>MCL (dB)</b>
Low gain, 3 dBi	Blocking	$I < -40$ dBm	101.0
	Unwanted emissions	$I/N < -6$ dB	86.6
		$I/N < -10$ dB	90.6
High gain, 17.5 dBi	Blocking	$I < -40$ dBm	115.5
	Unwanted emissions	$I/N < -6$ dB	101.1
		$I/N < -10$ dB	105.1

Figure A6-1 shows the coupling loss and the minimum coupling loss for an AES with the high gain antenna. Figure A6-2 shows the coupling loss and minimum coupling loss for an AES with the low gain antenna. The MCL values shown are applicable for the case of 1 MHz frequency separation to represent the worst case frequency separation.

FIGURE A6-1  
**CL and MCL for interference from a rural IMT base station to a high gain AES at various altitudes**

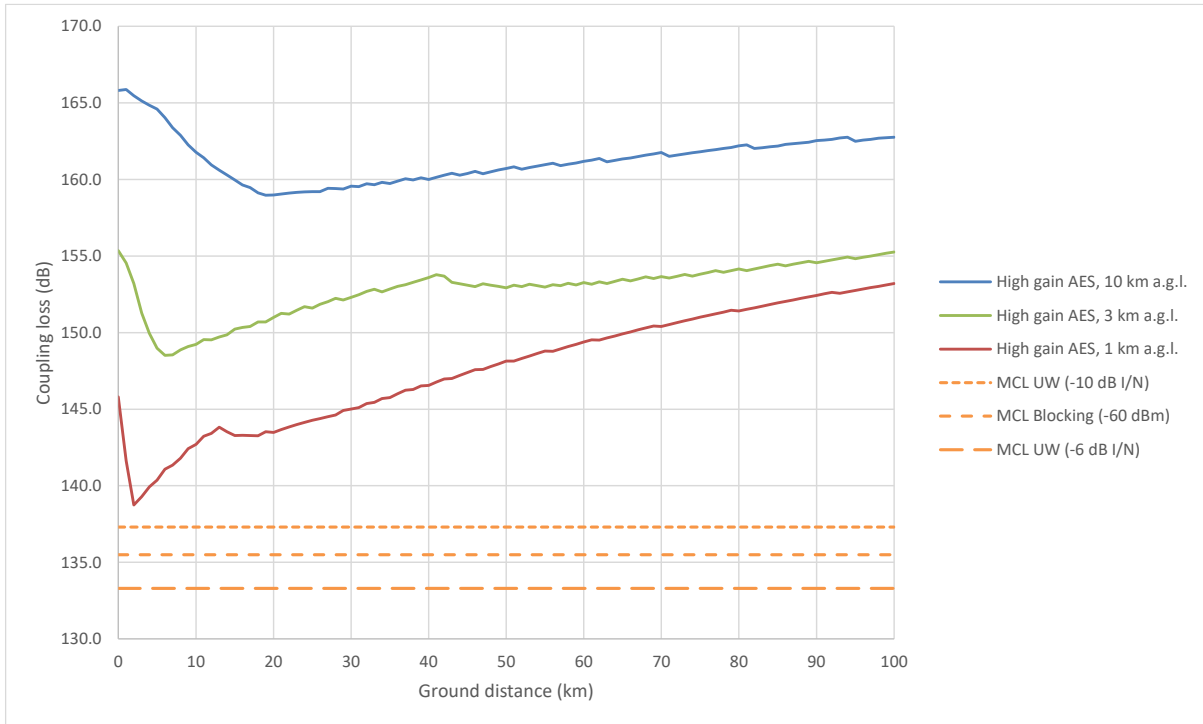
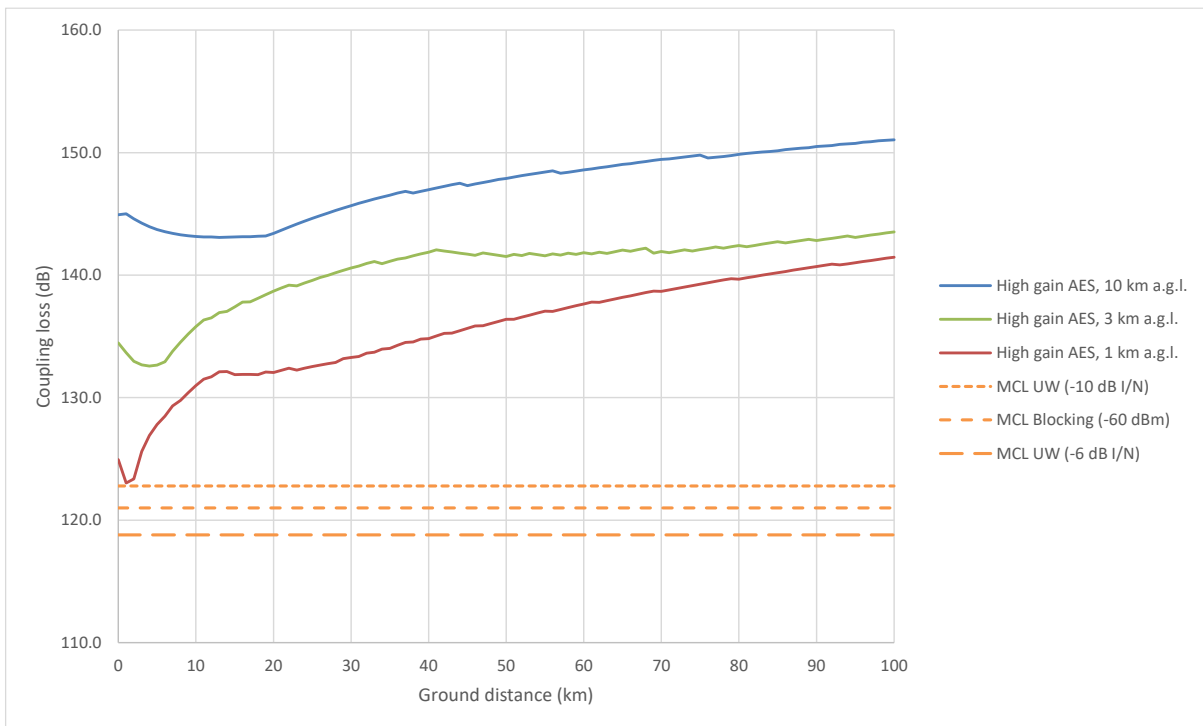


FIGURE A6-2  
**CL and MCL for interference from a rural IMT base station to a low gain AES at various altitudes**



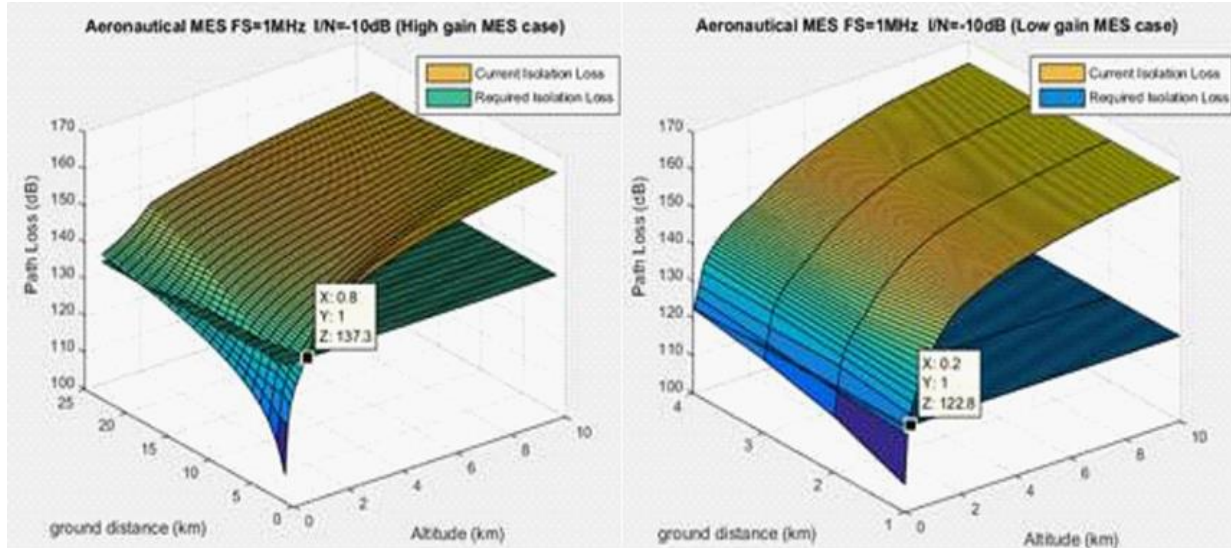
In all cases examined, the coupling loss exceeds the minimum coupling loss and hence interference would be below the criterion. Since the coupling loss exceeds the MCL values in the case of 1 MHz

frequency separation, the coupling loss would also exceed the MCL values for 3 MHz and 6 MHz frequency separation.

Among these different scenarios, the MCL worst case corresponds to the High Gain AES antenna for  $I/N = -10$  dB. It is therefore proposed to study it in this section.

FIGURE A6-3

Variation of current and required isolation loss with distance and altitude

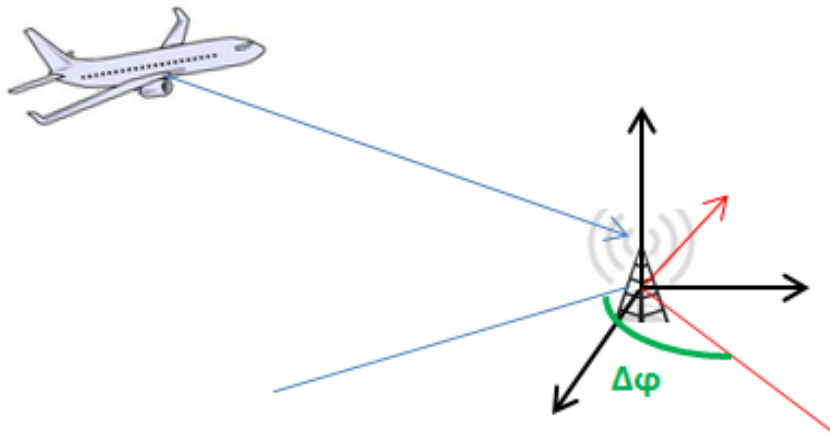


The left side figure exhibits the required isolation loss as well as the current isolation loss for varying altitude and distance (including antenna gain discriminations for aeronautical MES receiver and ground IMT BS interferer) for the worst case  $I/N = -10$  dB high gain MES antenna. As expected, the current isolation increases with altitude and distance. In addition, the shape of the curves shows that for 1 MHz frequency separation that required isolation loss is lower than current isolation loss (MES, BS) for altitude  $\geq 0.8$  km if  $I/N = -10$  dB and for the sake of comparison for altitude  $\geq 0.2$  km if  $I/N = -10$  dB for the low gain MES antenna<sup>7</sup>, resulting in no constraint in that case (since the required isolation loss is met). Note that this altitude = 0.8 km, called  $h_{\min}$  is derived for the scenario where IMT BS interferer and Aeronautical Earth Station antennas are facing each other. For the general case where these systems have a discrimination angle in horizontal (azimuthal) plan denoted  $\Delta\phi$  (depicted in Fig. A6-4), the value of  $h_{\min}$  is lower.

<sup>7</sup> The rationale for comparing the low and high gain MES antenna in the results of the study is based on the fact that the discrimination due to the antenna gain may facilitate the sharing for a high gain MES antenna depending on the location of the IMT BS with respect to the flying aircraft.



FIGURE A6-4  
Orientation of aeronautical MES in relation to IMT BS



For example:

FIGURE A6-5  
Variation of current and required isolation loss with distance and altitude,  
(left)  $\Delta\phi = 40^\circ$  then  $h_{\min} = 0.7$  km; (right)  $\Delta\phi = 90^\circ$  then  $h_{\min} = 0.5$  km

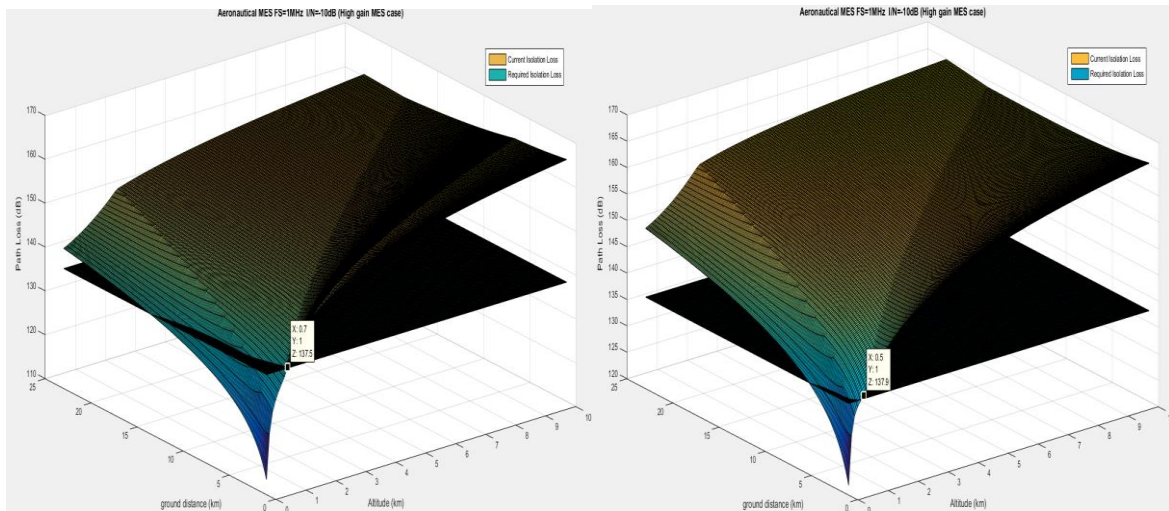
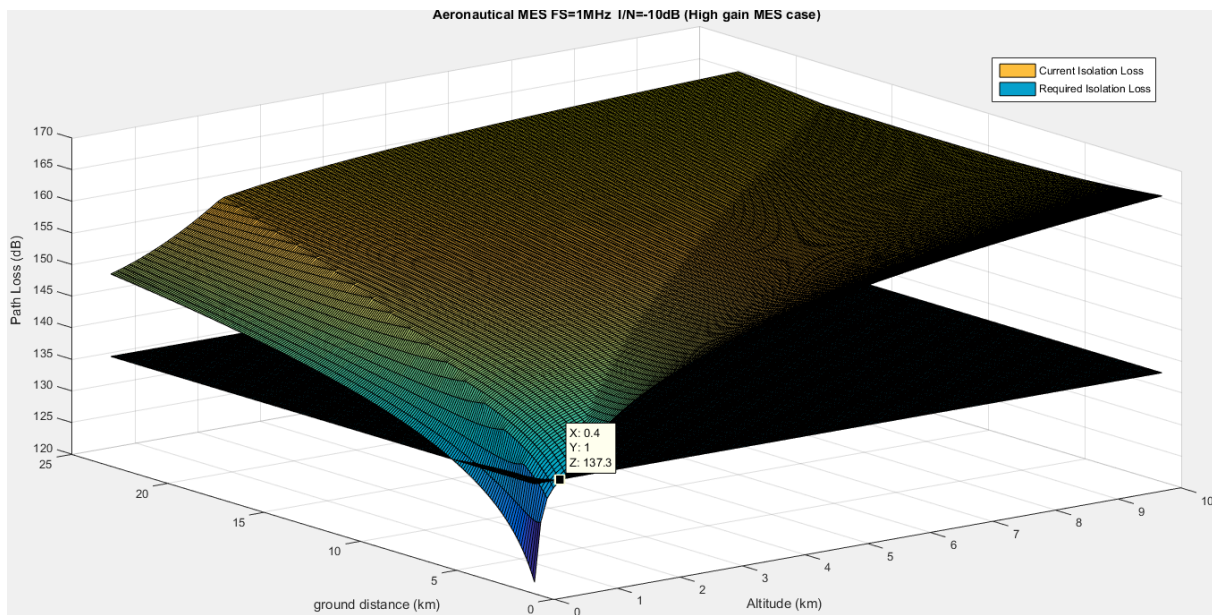


FIGURE A6-6

Variation of current and required isolation loss with distance and altitude,  
 $\Delta\phi = 180^\circ$  then  $h_{\min} = 0.4$  km (BS and MSS antennas are back-to-back)



Note that this study can be considered as conservative since no shielding loss due to fuselage was assumed. This leads to the conclusion that the probability of interference caused by IMT BS onto aeronautical MES in such case is null with 1 MHz, 3 MHz or 6 MHz frequency separation for an altitude of the aircraft higher than 800 m.

## A6.2 Study B1

### A6.2.1 Statistical analysis

In the following analysis, probabilistic simulations over a general area of IMT coverage are performed from a limited simulation area covered by a three sector IMT Base Station site, which has been simulated for cell radius of 0.5 km, 1 km and 5 km respectively for the different environments. For the land based simulation, the IMT base station transmits in all three sectors and the three service hexagons have been populated with MESs that are monitored for interference. The MESs are strictly limited to move within the assigned hexagon such that the model is equivalent to a full network.

The simulations investigate scenarios where IMT is deployed in urban areas and also for the less likely case where it may be deployed in suburban or even rural areas. Normal clutter is used for the three environments. Frequency separations of 1 MHz, 3 MHz and 6 MHz are included. A sensitivity analysis is included to additionally show the impact of  $I/N = -10$  dB for the MES. Further, an extreme situation where the clutter in a rural area is consistently below the standard 10 m is included, for this, clutter heights of 7 m and 4 m are used.

Simulations are also performed for the maritime environment with the IMT base stations located on land, the two relevant scenarios are as described in § 5.2.

### A6.2.2 Area impact on MES interference

The study results below contain an extension to the MCL, it covers an artificial situation where the MES is always allocated the 1st adjacent channel above the frequency separations (1 MHz, 3 MHz or 6 MHz), but moves randomly around in the area of IMT coverage.

## A6.2.2.1 Land based MES

TABLE A6-7

Area analysis results of interference from IMT base station unwanted emissions into a MES at a fixed frequency adjacent to frequency separation, in % interference probability (Land), normal environment, average IMT BS power, P.1546 propagation

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	I/N (dB)	Interference probability (%)		
			Rural (10 m clutter)	Suburban (10 m clutter)	Urban (20 m clutter)
1	3	-6	0.15	25.16	53.98
		-10	0.6	38.34	72.34
	17.5	-6	0	16.32	35.04
		-10	0.08	24.28	47.28
3	3	-6	0	0.31	1.37
		-10	0	0.63	4.21
	17.5	-6	0	0.26	1.31
		-10	0	0.53	2.35
6	3	-6	0	0.13	0.77
		-10	0	0.39	1.63
	17.5	-6	0	0.14	0.85
		-10	0	0.34	1.49

TABLE A6-8

Area analysis results of MES susceptibility to blocking from IMT transmitters, MES at a fixed frequency adjacent to frequency separation, in % interference probability (Land), normal environment, average IMT BS power, P.1546 propagation

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)		
			Rural (10 m clutter)	Suburban (10 m clutter)	Urban (20 m clutter)
1	3	-60	0.01	22.90	49.89
	17.5		0.00	14.79	32.62
3	3	-52	0.00	10.15	25.04
	17.5		0.00	6.03	17.28
6	3	-40	0.0	3.15	11.31
	17.5		0.0	1.75	6.48

TABLE A6-9

Sensitivity analysis of a more extreme rural scenario using lower clutter height and different propagation models for unwanted emissions into MES in % probability (Land)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	I/N (dB)	Interference probability (%)			
			Rural (P.1812, 4 m clutter)	Rural (P.452, 4 m clutter)	Rural (P.1812, 7 m clutter)	Rural (P.452, 7 m clutter)
1	3	-6	22.37	3.69	6	1.14
		-10	38.16	10.57	16.3	4.8
	17.5	-6	9.13	0.82	1.53	0.16
		-10	19.3	3.32	5.78	1.16
3	3	-6	0	0	0	0
		-10	0	0	0	0
	17.5	-6	0	0	0	0
		-10	0	0	0	0
6	3	-6	0	0	0	0
		-10	0	0	0	0
	17.5	-6	0	0	0	0
		-10	0	0	0	0

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

TABLE A6-10

Sensitivity analysis of a more extreme rural scenario using lower clutter height and different propagation models for MES susceptibility to blocking from IMT transmitters, in % interference probability (Land)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)			
			Rural (P.1812, 4 m clutter)	Rural (P.452, 4 m clutter)	Rural (P.1812, 7 m clutter)	Rural (P.452, 7 m clutter)
1	3	-60	19.55	2.85	4.65	1.11
	17.5		7.10	0.56	1.00	0.10
3	3	-52	2.20	0.08	0.15	0.00
	17.5		0.31	0.00	0.00	0.00
6	3	-40	0.00	0.00	0.00	0.00
	17.5		0.00	0.00	0.00	0.00

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

## A6.2.2.2 Sea based MES

TABLE A6-11

Area analysis results of interference from the IMT base station unwanted emissions into a MES at a fixed frequency adjacent to frequency separation in % probability (Sea)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Interference probability (%)	
			Two sectors rural IMT located on the coastline, 100% sea	One sector rural IMT pointing to sea 5 km from the coast
1	3	-6	1.67	0
		-10	11.44	55.1
	21	-6	1.75	0
		-10	6.61	9.19
3	3	-6	0	0
		-10	0	0
	21	-6	0	0
		-10	0	0
6	3	-6	0	0
		-10	0	0
	21	-6	0	0
		-10	0	0

TABLE A6-12

Area analysis results of MSS susceptibility to blocking from transmitters, MES at a fixed frequency adjacent to frequency separation, in % interference probability (Sea)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)	
			Two sectors rural IMT located on the coastline, 100% sea	One sector rural IMT pointing to sea 5 km from the coast
1	3	-60	0.84	0.00
	21		0.91	0.00
3	3	-52	0.00	0.00
	21		0.00	0.00
6	3	-40	0.00	0.00
	21		0.00	0.00

## A6.2.3 Area and frequency impact on MES interference

In addition to the area analysis above simulations have also been performed to include the effect of the MES using the full frequency band.

In the study results below, the impact on the user of MES is investigated, the parameters from above are used and the susceptibility of the MES is established by simulations over the entire IMT service area and over the full frequency range (1 518-1 559 MHz) available to MSS for downlink.

Whilst the results for MES Blocking in the following are of course the same as for the first adjacent channel above the results are provided for an easier comparison MES Blocking and unwanted emission interference under the same conditions.

#### A6.2.3.1 Land based MES

TABLE A6-13

**Area and frequency analysis results of interference from the IMT base station unwanted emissions into MSS in % probability (Land), normal environment, P.1546 propagation**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Interference probability (%)		
			Rural (10 m clutter)	Suburban (10 m clutter)	Urban (20 m clutter)
1	3	-6	0.01	1.19	2.62
		-10	0.02	1.87	3.88
	17.5	-6	0	0.76	1.82
		-10	0	1.19	2.44
3	3	-6	0	0.01	0.09
		-10	0	0.05	0.34
	17.5	-6	0	0.04	0.19
		-10	0	0.05	0.37
6	3	-6	0	0.01	0.02
		-10	0	0.02	0.11
	17.5	-6	0	0.03	0.1
		-10	0	0.04	0.26

TABLE A6-14

**Area and frequency analysis results of MES susceptibility to blocking from IMT transmitters, in % interference probability (Land), normal environment, P.1546 propagation**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)		
			Rural (10 m clutter)	Suburban (10 m clutter)	Urban (20 m clutter)
1	3	-60	0.01	22.90	49.89
	17.5		0.00	14.79	32.62
3	3	-52	0.00	10.15	25.04
	17.5		0.00	6.03	17.28
6	3	-40	0.00	3.15	11.31
	17.5		0.00	1.75	6.48

TABLE A6-15

Sensitivity analysis of a more extreme rural scenario using lower clutter height and different propagation models for unwanted emissions into MSS in % probability (Land)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Interference probability (%)			
			Rural (P.1812, 4 m clutter)	Rural (P.452, 4 m clutter)	Rural (P.1812, 7 m clutter)	Rural (P.452, 7 m clutter)
1	3	-6	1.04	0.12	0.23	0.06
		-10	1.77	0.45	0.75	0.04
	17.5	-6	0.44	0.04	0.07	0.01
		-10	0.89	0.15	0.25	0.1
3	3	-6	0	0	0	0
		-10	0	0	0	0
	17.5	-6	0	0	0	0
		-10	0	0	0	0
6	3	-6	0	0	0	0
		-10	0	0	0	0
	17.5	-6	0	0	0	0
		-10	0	0	0	0

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2

TABLE A6-16

Sensitivity analysis of a more extreme rural scenario using lower clutter height and different propagation models for MES susceptibility to blocking from IMT transmitters, in % interference probability (Land)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)			
			Rural (P.1812, 4 m clutter)	Rural (P.452, 4 m clutter)	Rural (P.1812, 7 m clutter)	Rural (P.452, 7 m clutter)
1	3	-60	19.55	2.85	4.65	1.11
	17.5		7.10	0.56	1.00	0.10
3	3	-52	2.20	0.08	0.15	0.00
	17.5		0.31	0.00	0.00	0.00
6	3	-40	0.00	0.00	0.00	0.00
	17.5		0.00	0.00	0.00	0.00

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

## A6.2.3.2 Sea-based MES

TABLE A6-17

Area and frequency analysis results of interference from the IMT base station unwanted emissions into MES, in % probability (Sea)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Interference probability (%)	
			Two-sector rural IMT located on the coastline, 100% sea	One-sector rural IMT pointing to sea 5 km from the coast
1	3	-6	0.09	0
		-10	0.58	2.57
	21	-6	0.06	0
		-10	0.21	0.42
3	3	-6	0	0
		-10	0	0
	21	-6	0	0
		-10	0	0
6	3	-6	0	0
		-10	0	0
	21	-6	0	0
		-10	0	0

TABLE A6-18

Area and frequency analysis results of MSS susceptibility to blocking from IMT transmitters in % probability (Sea)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)	
			Two-sector rural IMT located on the coastline, 100% sea	One-sector rural IMT pointing to sea 5 km from the coast
1	3	-60	0.84	0.00
	21		0.91	0.00
3	3	-52	0.00	0.00
	21		0.00	0.00
6	3	-40	0.00	0.00
	21		0.00	0.00

#### A6.2.4 Area impact on MES interference for the MES with increased blocking level than GMR-1/GMR-2 standards

Below are the results for the expected when using increased blocking level than GMR-1/GMR-2 standards of the MES receiver blocking performance, performed under exactly the same conditions as in the simulations above.



TABLE A6-19

Area analysis results of MES susceptibility to blocking from IMT transmitters, in % interference probability (Land), normal environment, P.1546 propagation

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)		
			Rural (10 m clutter)	Suburban (10 m clutter)	Urban (20 m clutter)
1	3	-55	0	13.66	32.71
		-45	0	4.35	13.47
	17.5	-55	0	8.75	22.4
		-45	0	2.28	8.45
3	3	-35	0	0.58	3.62
		-30	0	0.24	1.11
	17.5	-35	0	0.5	2.16
		-30	0	0.2	1.04
6	3	-30	0	0.41	1.74
		-25	0	0	0.62
	17.5	-30	0	0.36	1.57
		-25	0	0.13	0.81

TABLE A6-20

Sensitivity analysis of a more extreme rural scenario using lower clutter height and different propagation models

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	Interference probability (%)			
			Rural (P.1812, 4 m clutter)	Rural (P.452, 4 m clutter)	Rural (P.1812, 7 m clutter)	Rural (P.452, 7 m clutter)
1	3	-55	5.49	0.49	0.86	0.07
		-45	0.01	0	0	0
	17.5	-55	1.32	0	0.04	0
		-45	0	0	0	0
3	3	-35	0	0	0	0
		-30	0	0	0	0
	17.5	-35	0	0	0	0
		-30	0	0	0	0
6	3	-30	0	0	0	0
		-25	0	0	0	0
	17.5	-30	0	0	0	0
		-25	0	0	0	0

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

TABLE A6-21

**Area analysis results of MSS susceptibility to blocking from IMT transmitters in % probability (Sea)**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	Blocking level (dBm)	$I/N$ (dB)	Interference probability (%)	
				Two-sector rural IMT located on the coastline, 100% sea	One-sector rural IMT pointing to sea 5 km from the coast
1	3	-55	-6	0	0
		-45	-10	0	0
	21	-55	-6	0	0
		-45	-10	0	0
3	3	-35	-6	0	0
		-30	-10	0	0
	21	-35	-6	0	0
		-30	-10	0	0
6	3	-30	-6	0	0
		-25	-10	0	0
	21	-30	-6	0	0
		-25	-10	0	0

**A6.2.5 Comparison between IMT unwanted emissions and MES blocking (cases with increased blocking level than GMR-1/GMR-2 standards))**

**A6.2.5.1 Land based MES**

In the following are the simulations of the interference probability for future expected MES receiver overload characteristics compared to with the assumed IMT unwanted emission characteristics in order to see if these are of similar levels. The comparison simulations have been performed for the urban and suburban areas where the interference impact was greatest and is covering both the situation where the MES has use of the full frequency range and for completeness also the impact in the first adjacent channel to the frequency separation.

TABLE A6-22

**Comparison of interference experienced by a user in an urban area for blocking MES performance (cases with increased blocking level than GMR-1/GMR-2 standards), normal environment, P.1546 propagation with 20 m clutter**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	2.62	-45	13.47
		-10	3.88	-55	32.71
	17.5	-6	1.82	-45	8.45
		-10	2.44	-55	22.4
3	3	-6	0.09	-30	1.11
		-10	0.34	-35	3.62
	17.5	-6	0.19	-30	1.04
		-10	0.37	-35	2.16
6	3	-6	0.02	-25	0.62
		-10	0.11	-30	1.74
	17.5	-6	0.1	-25	0.81
		-10	0.26	-30	1.57

TABLE A6-23

**Comparison of interference experienced by the operator in the first channel above the frequency separation in an urban area, for blocking MES performance (cases with increased blocking level than GMR-1/GMR-2 standards), normal environment, P.1546 propagation with 20 m clutter**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	53.98	-45	13.47
		-10	72.34	-55	32.71
	17.5	-6	35.04	-45	8.45
		-10	47.28	-55	22.4
3	3	-6	1.37	-30	1.11
		-10	4.21	-35	3.62
	17.5	-6	1.31	-30	1.04
		-10	2.35	-35	2.16

TABLE A6-23 (end)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
6	3	-6	0.77	-25	0.62
		-10	1.63	-30	1.74
	17.5	-6	0.85	-25	0.81
		-10	1.49	-30	1.57

TABLE A6-24

**Comparison of interference experienced by a user in a suburban area for blocking MES performance (cases with increased blocking level than GMR-1/GMR-2 standards), normal environment, P.1546 propagation with 10 m clutter**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	1.19	-45	4.35
		-10	1.87	-55	13.66
	17.5	-6	0.76	-45	2.28
		-10	1.19	-55	8.75
3	3	-6	0.01	-30	0.24
		-10	0.05	-35	0.58
	17.5	-6	0.04	-30	0.2
		-10	0.05	-35	0.5
6	3	-6	0.01	-25	0
		-10	0.02	-30	0.41
	17.5	-6	0.03	-25	0.13
		-10	0.04	-30	0.36

TABLE A6-25

**Comparison of interference experienced by the operator in the first channel above the frequency separation in a suburban environment**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	25.16	-45	4.35
		-10	38.34	-55	13.66
	17.5	-6	16.32	-45	2.28
		-10	24.28	-55	8.75
3	3	-6	0.31	-30	0.24
		-10	0.63	-35	0.58
	17.5	-6	0.26	-30	0.2
		-10	0.53	-35	0.5
6	3	-6	0.13	-25	0
		-10	0.39	-30	0.41
	17.5	-6	0.14	-25	0.13
		-10	0.34	-30	0.36

### A6.3 Study B2

#### A6.3.1 Monte Carlo analysis results

In this section, the adjacent band compatibility between MSS above 1 518 MHz and IMT below 1 518 MHz has been investigated using Monte Carlo simulation to determine the probability of interference from IMT base station into MSS MES.

Two interference mechanisms are considered, the interference from IMT base station unwanted emissions into an MSS MES and the blocking of MES caused by high transmit power from IMT base station for the following cases:

- Scenarios: Rural, Suburban and Urban
- MES types: Omni (3 dBi) and directional (17.5 dBi)
- Interference Criteria (only for IMT unwanted emissions)  $I/N$ : -6 dB and -10 dB
- Frequency separation between IMT and MSS: 1 MHz, 3 MHz and 6 MHz
- Polarisation discrimination was taken into account in all cases.

#### A6.3.2 IMT base station OOB interference into MES simulations

In order to investigate the probability of interference from IMT base station unwanted emissions into MSS MES, simulations have been carried out with the following IMT base station unwanted emissions levels at different frequency separation as shown in Table A6-26.

TABLE A6-26

**IMT base station unwanted emissions e.i.r.p. limits**

<b>Frequency separation</b>	<b>1 MHz</b>	<b>3 MHz</b>	<b>6 MHz</b>
Rural	−0.8 dBm/MHz	−30 dBm/MHz	−33 dBm/MHz
Suburban/Urban	−2.8 dBm/MHz	−32 dBm/MHz	−35 dBm/MHz

For all the unwanted emission interference simulations, the IMT base station was set to operate at frequencies below 1 518 MHz while the MSS MES was operating at 1 518.1 MHz.

The IMT unwanted emission interference into MSS simulation has been performed for rural (with clutter height of 4 m and 7 m), suburban and urban IMT base station deployments for two MSS MES types with an Omni antenna gain of 3 dBi and directional antenna of 17.5 dBi, with the interference criteria set to  $I/N$  of −6 dB and −10 dB.

**A6.3.2.1 Propagation models**

The simulations were carried out using the following propagation models:

- Rural scenarios: ITU-R P.1812 with both 4 m and 7 m clutter heights<sup>8</sup>
- Suburban and Urban scenarios: ITU-R P.1546-5.

All the Monte Carlo simulations were run using SEAMCAT. SEAMCAT<sup>9</sup> does not implement Recommendation ITU-R P.1812 propagation model and only implements Recommendation ITU-R P.1546-4.

Therefore, it was necessary to develop and implement an appropriate and valid propagation models based on Recommendations ITU-R P.1812 and ITU-R P.1546-5 for use in the Monte Carlo simulations for the three scenarios.

In SEAMCAT the propagation models are implemented as plugins, and therefore it is possible to include a new propagation model and to add it to the list of existing pre-defined models. SEAMCAT propagation plugins of ITU-R P.1812 for the rural scenario and ITU-R P.1546-5 for suburban and urban scenarios were developed and implemented as a lookup table of distance gains propagation loss. The data for the lookup table were generated from ITU-R P.1812 and ITU-R P.1546-5 propagation models using the Visualyse simulation tool.

**A6.3.2.2 Simulation configuration**

The following study uses SEAMCAT (version 5.0.1 rev3543) where the F.1336-4 antenna used is not fully in accordance with § 3.1.1 due to its implementation in this software. The peak sidelobe antenna pattern is used for IMT base station. The simulation configuration was set up with seven IMT 3-sector base stations for each of the three deployment scenarios of rural, suburban and urban. The average IMT base station power was used. In each case, a simulation radius was determined and the MES was randomly placed around in the coverage area corresponding to the simulation radius. Simulation radius is set higher than inter-site distance (ISD) in accordance with macro cell parameters in § 3.1.1 and circular interference area is used (though deployment of the IMT network is based according to Report ITU-R M.2292). All these would lead to the increased interference probability compared to the assumptions in the Report.

<sup>8</sup> For more information on applicability of the Recommendation ITU-R P.1812-4, see Annex 2.

<sup>9</sup> Note from the BR: At the time of when the study was done.

**A6.3.2.3 SEAMCAT results of IMT Base station unwanted emission interference**

The SEAMCAT simulation results of the probability of interference from IMT base station into MES at frequency separation of 1 MHz, 3 MHz and 6 MHz are shown in Tables A6-27, A6-28 and A6-29 respectively.

TABLE A6-27

**Probability of interference (%) – Frequency separation: 1 MHz**

MES type	<i>I/N</i>	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	–10 dB	100	100	100	100
	–6 dB	100	100	100	50
Directional (17.5 dBi)	–10 dB	99	95	100	49.9
	–6 dB	74	52	81	21.4

TABLE A6-28

**Probability of interference (%) – Frequency separation: 3 MHz**

MES type	<i>I/N</i>	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	–10 dB	10.4	4.9	0.3	0
	–6 dB	6	1.2	0.01	0
Directional (17.5 dBi)	–10 dB	5.7	1.7	0.11	0
	–6 dB	2.4	0.15	0	0

TABLE A6-29

**Probability of interference (%) – Frequency separation: 6 MHz**

MES type	<i>I/N</i>	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	–10 dB	7.2	2.9	0.01	0
	–6 dB	3.6	0.5	0	0
Directional (17.5 dBi)	–10 dB	3.2	0.32	0	0
	–6 dB	0.4	0	0	0

Table A6-30 shows the impact on MES channels with a greater offset from the edge of the band when the IMT operates for the example case where the IMT upper band edge is 1 515 MHz. The MES receiver frequency is increased by 1 MHz and 2 MHz (i.e. carrier frequency at 1 519.1 MHz and 1 520.1 MHz). Only the urban and suburban cases are examined.

TABLE A6-30

**Probability of interference (%) – IMT upper band edge 1 515 MHz, MSS channel  
1 519.1 MHz and 1 520.1 MHz**

MES Type	$I/N$	MES at 1 519.1 MHz		MES at 1 520.1 MHz	
		Urban	Suburban	Urban	Suburban
Omni (3 dBi)	–10 dB	3.9	1.3	3.2	1.02
	–6 dB	2.3	0.4	1.9	0.2
Directional (17.5 dBi)	–10 dB	2.3	0.84	2.0	0.7
	–6 dB	1.3	0.21	1.2	0.2

The Monte Carlo method was also used to assess the impact of reducing the IMT unwanted emission level and to determine the level at which the probability of interference to MESs in the urban/suburban area is 1% and 0.1%. The simulations have modelled the average level of unwanted emissions, and the results are as shown in Table A6-31.

TABLE A6-31

**Unwanted emission level to meet 1% and 0.1% probability of interference**

Probability of interference	MES type	Unwanted emission level (dBm/MHz) for $I_{\max}/N = -6$ dB	Unwanted emission level (dBm/MHz) for $I_{\max}/N = -10$ dB
1%	Omni (3 dBi)	–37	–41
	Directional (17.5 dBi)	–34	–38
0.1%	Omni (3 dBi)	–43	–47
	Directional (17.5 dBi)	–42	–46

*Note:* The results are based on peak sidelobe antenna pattern, the simulation radius used is higher than inter-site distance (according to macro cell parameter indicated in § 3.1.1) and circular interference area is used (though deployment of the IMT network is based according to Report ITU-R M.2292).

### A6.3.3 MES blocking

In order to investigate the probability of MES blocking caused by high transmit power from IMT base stations in the adjacent band, simulations have been carried out with the following baseline MES blocking performances at different frequency separations as shown in Table A6-32.

TABLE A6-32

**Baseline MES blocking performance**

Frequency separation	1 MHz	3 MHz	6 MHz
MES receiver blocking	–60 dBm	–52 dBm	–40 dBm

For all the blocking simulations, the IMT base station was set to operate at frequencies below 1 518 MHz while the MSS MES was operating at 1 518.1 MHz.



The MES blocking simulation has been performed for rural (with clutter height of 4 m and 7 m), suburban and urban IMT base station deployments for two MSS MES types with an Omni antenna gain of 3 dBi and directional antenna of 17.5 dBi.

### A6.3.3.1 SEAMCAT simulation results of MES blocking

The SEAMCAT simulation results of the probability of MES blocking from high power IMT base stations into MES at frequency separation of 1 MHz, 3 MHz and 6 MHz are shown in Tables A6-33, A6-34 and A6-35 respectively. The IMT base station power was set to average power and not maximum transmit power. For frequency separations of 1 MHz and 3 MHz, in Tables A6-33 and A6-34 respectively, the IMT base station carrier bandwidth was 5 MHz while for frequency separations of 6 MHz, the IMT base station carrier was 10 MHz.

TABLE A6-33

#### Probability of interference (%) – IMT upper band edge at 1 517 MHz

MES type	MES blocking level (dBm)	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	-60	76.3	63.1	89.6	29.3
Directional (17.5 dBi)		56.3	39.3	43.1	15.3

TABLE A6-34

#### Probability of interference (%) – IMT upper band edge at 1 515 MHz

MES type	MES blocking level (dBm)	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	-52	46	25.8	16.3	5.3
Directional (17.5 dBi)		32.3	17.1	9.1	3

TABLE A6-35

#### Probability of interference (%) – IMT upper band edge at 1512 MHz

MES type	MES blocking level (dBm)	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	-40	21.2	9.5	3	0.5
Directional (17.5 dBi)		15.5	6.1	1.4	0.3

Table A6-36 shows the SEAMCAT simulation results of the probability of interference from IMT base station into an MES receiver (with increased blocking resilience than GMR-1/GMR-2 standards) at frequency separation of 6 MHz.

TABLE A6-36

**Probability of blocking interference (%) against MSS blocking levels (cases with increased blocking resilience than GMR-1/GMR-2 standards)**

MES type	MES blocking level (dBm)	Scenario			
		Urban	Suburban	Rural (4 m clutter)	Rural (7 m clutter)
Omni (3 dBi)	-30	8	3	0.1	0
Directional (17.5 dBi)		4	1.2	0.1	0
Omni (3 dBi)	-25	3.4	0.4	0	0
Directional (17.5 dBi)		2.2	0.7	0	0

## A6.4 Study B3

### A6.4.1 Land mobile satellite scenarios

#### A6.4.1.1 Considerations on assumptions for the analysis

Parameters required to derive the results of the current study are provided in § 3 of this Report. Regarding:

- The propagation model for the rural case: the agreed assumption for the rural case was to perform Recommendation ITU-R P.1812-4 with 50% percentage of time and location with 7 m clutter height at 100 m from the receiver. However, one could notice that the implementation of the clutter losses does not account the location of the clutter within the path making a conflict with the specific path that has been defined (no clutter except at 100 m from Rx). Other solutions are investigated, as discussed in Annex 2.
- The derivation of the probability of interference: the following analysis derives this metric by calculating the surface of the area (within an IMT cell with three hexagonal sectors) on which the protection criterion for the MSS (that can be  $I/N$  or blocking threshold) is not met over the IMT cell. Since the separation distance of a MES with respect of the IMT BS is dependent of the location of the MSS Receivers (discrimination angle of Rx/Tx with respect of the Tx/Rx position), a fine sampling of the location of the MES ( $1^\circ$  azimuth, 5 m distance (MES Rx, IMT BS)) is performed to estimate the surface of the exclusion zone. In that sense, the probability of interference is obtained by generating random positions of MES within the IMT cell.

#### A6.4.1.2 Statistical analysis with random MES location and fixed frequency

This section provides results of compatibility between MSS and IMT for MES at a fixed frequency adjacent to frequency separation, in terms of probability of interference (Land) for different scenarios (i.e. high/low gain antenna MES, blocking threshold and/or  $I/N$ , frequency separation, rural/urban).

TABLE A6-37  
Rural case (P.1812-4 with 7 m path profile)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	4.50	-63	5.40
		-10	5.90	-60	4.10
	17.5	-6	3.10	-63	3.50
		-10	3.90	-60	3.00
3	3	-6	0.30	-53	2.40
		-10	0.80	-52	2.20
	17.5	-6	0.20	-53	1.90
		-10	0.30	-52	1.80
6	3	-6	0.00	-53	2.40
		-10	0.40	-40	1.40
	17.5	-6	0.10	-53	1.90
		-10	0.20	-40	1.00

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

TABLE A6-38  
Rural case (P.452-16 with 7 m clutter losses)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	7.10	-63	11
		-10	15.90	-60	6.10
	17.5	-6	4.60	-63	6.90
		-10	9.60	-60	3.90
3	3	-6	0.30	-53	1.70
		-10	0.30	-52	1.40
	17.5	-6	0.10	-53	1.00
		-10	0.20	-52	0.90
6	3	-6	0.20	-53	1.70
		-10	0.30	-40	0.30
	17.5	-6	0.10	-53	0.40
		-10	0.10	-40	0.40

TABLE A6-39

Urban case (P.1546-5 with clutter height = 20 m)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	68.50	-63	82.10
		-10	95.60	-60	63.90
	17.5	-6	49.60	-63	59.00
		-10	67.20	-60	46.20
3	3	-6	1.60	-53	35.70
		-10	4.60	-52	32.80
	17.5	-6	2.20	-53	26.00
		-10	3.40	-52	23.80
6	3	-6	1.00	-53	35.70
		-10	1.60	-40	15.00
	17.5	-6	1.50	-53	26.00
		-10	2.40	-40	7.70

**A6.4.1.3 Statistical analysis with random MES location and random frequency**

This section provides results of compatibility between MSS and IMT for MES at a frequency within the full frequency band available to MES (1 518-1 559 MHz), in terms of probability of interference (Land) for different scenarios (i.e. high/low gain antenna MES, blocking threshold and/or  $I/N$ , frequency separation, rural/urban). The rationale not to only address the extension MSS frequency band 1 518-1 525 MHz (which is the one considered for the compatibility study with potential IMT systems operating in frequency band 1 492-1 518 MHz) is based on the fact that any satellite that enables MSS operation within the frequency band 1 518-1 525 MHz will also operate over frequency band 1 525-1 559 MHz, as with any current MSS satellites in orbit over this range.

TABLE A6-40

Rural case (P.1812-4 with 7 m path profile)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	0.20	-63	2.50
		-10	0.40	-60	4.10
	17.5	-6	0.20	-63	2.00
		-10	0.30	-60	3.00
3	3	-6	0.00	-53	2.30
		-10	0.10	-52	2.20

TABLE A6-40 (*end*)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
	17.5	-6	0.00	-53	1.80
		-10	0.10	-52	1.80
6	3	-6	0.00	-53	2.10
		-10	0.10	-40	1.40
	17.5	-6	0.00	-53	1.70
		-10	0.10	-40	1.00

For more information on applicability of Recommendation ITU-R P.1812-4, see Annex 2.

TABLE A6-41

**Rural case (P.452-16 with 7 m clutter losses)**

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	0.40	-63	2.20
		-10	0.90	-60	6.10
	17.5	-6	0.20	-63	1.30
		-10	0.50	-60	3.90
3	3	-6	0.10	-53	1.60
		-10	0.10	-52	1.40
	17.5	-6	0.00	-53	1.00
		-10	0.00	-52	0.90
6	3	-6	0.00	-53	1.50
		-10	0.10	-40	0.30
	17.5	-6	0.00	-53	0.90
		-10	0.00	-40	0.40

TABLE A6-42

Urban case (P.1546-5 with clutter height = 20 m)

Frequency separation $\Delta f$ (MHz)	MES antenna gain (dBi)	$I/N$ (dB)	Unwanted emissions interference probability (%)	Blocking level (dBm)	Blocking interference probability (%)
1	3	-6	3.70	-63	38.00
		-10	5.50	-60	63.90
	17.5	-6	2.80	-63	27.60
		-10	4.00	-60	46.20
3	3	-6	0.40	-53	34.00
		-10	0.80	-52	32.80
	17.5	-6	0.30	-53	24.70
		-10	0.70	-52	23.80
6	3	-6	0.30	-53	31.30
		-10	0.50	-40	15.00
	17.5	-6	0.20	-53	22.80
		-10	0.40	-40	7.70

### A6.5 Summary of Study B

The analysis has established the technical characteristics of the IMT and the MSS systems and determined the relevant scenarios to assess potential interference from IMT systems to MSS systems at 1 518 MHz.

Three different frequency separations between IMT and MSS were examined: 1 MHz, 3 MHz and 6 MHz. The analysis has, from the characteristics and parameters, developed an MCL analysis with the resulting required separation distances for the three different frequency separations. Interference due to out-of-band emissions from IMT base stations into the first MES channel above the frequency separation and due to blocking of the MES were considered separately. It is noted that the IMT block ends at 1 517 MHz in this study.

Furthermore, the analysis contains results from a number of Monte Carlo simulations of the impact on a user of a MES terminal in an area with IMT coverage for the 3 different frequency separations.

The results of the simulations show that there will be a degree of interference irrespective of the selected frequency separation.

With the assumed values for IMT e.i.r.p. and unwanted emissions and current values of MES receiver blocking, the interference at 1 MHz frequency separation is high from both IMT unwanted emissions and MES receiver blocking. However, at frequency separations of 3 MHz and 6 MHz the interference from IMT unwanted emissions is reduced but the interference due to receiver blocking remains high for current MESs.

The studies B1, B2 and B3 found that probability of interference from unwanted emissions for 1 MHz frequency separation is in the range from 0% to 100%, for 3 MHz frequency separation is in the range from 0% to 10.4% and for 6 MHz frequency separation is in the range from 0% to 7.2%. For blocking values ranging from -25 dBm to -60 dBm the interference probability is from 0% to 89.6%. The range of IMT BS unwanted emissions values used in the studies is from -0.8 to -80 dBm/MHz

depending on the frequency separation from the channel edge. The unwanted emission level to meet 1% and 0.1% probability of interference is within the range  $-47$  dBm/MHz up to  $-34$  dBm/MHz.

The analysis also examines the impact of a number of methods for mitigation of interference including a reduction in the IMT unwanted emissions and a future expectation for the MES receiver blocking characteristics. When the future expectations for MES receiver blocking is also taking into consideration, the interference due to receiver blocking is reduced to similar levels as for IMT unwanted emissions interference (for frequency separations of 3 MHz and 6 MHz).

There may be a need to provide protection for MES at seaports and airports, and hence there may be a need to apply other mitigation techniques to IMT BSs in the vicinity of seaports and airports for the frequencies at the top end of the 1 492-1 518 MHz frequency band to avoid interference to MESs.

Based on the final results of this compatibility studies, this study concludes that:

- The minimum in-band blocking characteristic for land mobile earth stations receivers from a 5 MHz broadband signal interferer (IMT) operating below 1 518 MHz should be  $-30$  dBm above 1 520 MHz<sup>10</sup>.
- The base station unwanted emission limits e.i.r.p. for a broadband signal interferer (IMT) operating below 1 518 MHz should be  $-30$  dBm/MHz above 1 520 MHz.
- The maximum in-block e.i.r.p. for base stations operating in 1 512-1 517 MHz should be 58 dBm per cell<sup>11</sup>.

## Annex 7

### Study C

The following results for this study are based on protection criteria of  $I/N = -6$  dB and  $-10$  dB.

#### A7.1 Analysis for interference from UE to MES

Technical characteristics of IMT user terminal (UE) are provided in Table A7-1.

TABLE A7-1  
IMT terminal characteristics

Parameter	Unit	Values
Transmit frequency	MHz	1 492-1 518
Cell Bandwidth	MHz	10
Deployment	–	Macro (urban, suburban)
Average base station activity		50%
Maximum transmitter power	dBm	23
Average user terminal output power	dBm	2 dBm for rural, $-9$ dBm for urban and suburban

<sup>10</sup> When the MES operates above 1 520 MHz.

<sup>11</sup> In a multi-sector site, the value per 'cell' corresponds to the value for one of the sectors.

TABLE A7-1 (*end*)

Parameter	Unit	Values
Maximum antenna gain	dBi	-3
Body loss	dB	4
Antenna height	m	1.5
Polarization	dB	Linear
Antenna pattern	-	Recommendation ITU-R F.1336-4 OMNI
Macro cell radius	km	5 km in rural, 1 km (suburban), 0.5 km (urban)
User terminal density in active mode		3/5 MHz/km <sup>2</sup> for urban 2.16/5 MHz/km <sup>2</sup> for suburban

### A7.1.1 Land analysis

Interference probabilities from the IMT UEs into MSS (Land) are provided in this section:  
unwanted emissions of -20 dBm/MHz case:

TABLE A7-2

#### Interference probability from IMT UE unwanted emissions (-20 dBm/MHz case)

System	MES antenna gain (dBi)	Interference probability (%)			
		Urban scenario		Suburban scenario	
		$I/N = -6$	$I/N = -10$	$I/N = -6$	$I/N = -10$
MSS 1	3	8.8	12	2.4	3.8
	17.5	4.8	5.6	2.6	3.2
MSS 2	1	9	12.6	3.6	4.2
	6	9.6	11.8	4.2	6.2
	12	8	9	1.8	3.2
MSS 3	1	7.6	10	3	3.8
	6	7.6	10.4	3.2	4.8
	12	6	8.2	1.8	2.4

The following Figures show different CDF for the case of MSS 2 which appears to be the worst case among the three MSS terminals evaluated.



FIGURE A7-1  
 CDF graph of Urban MSS2 –20 dBm/MHz unwanted emissions case

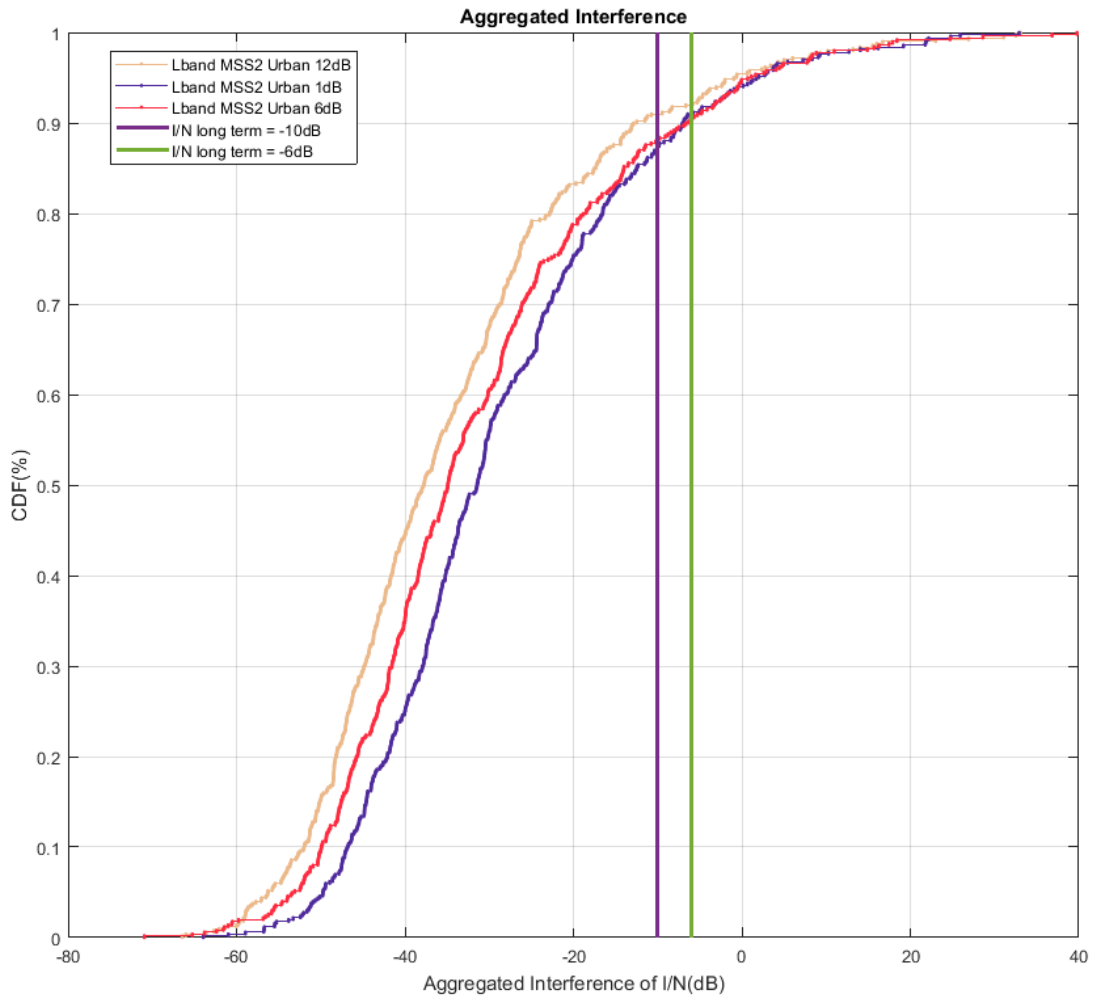
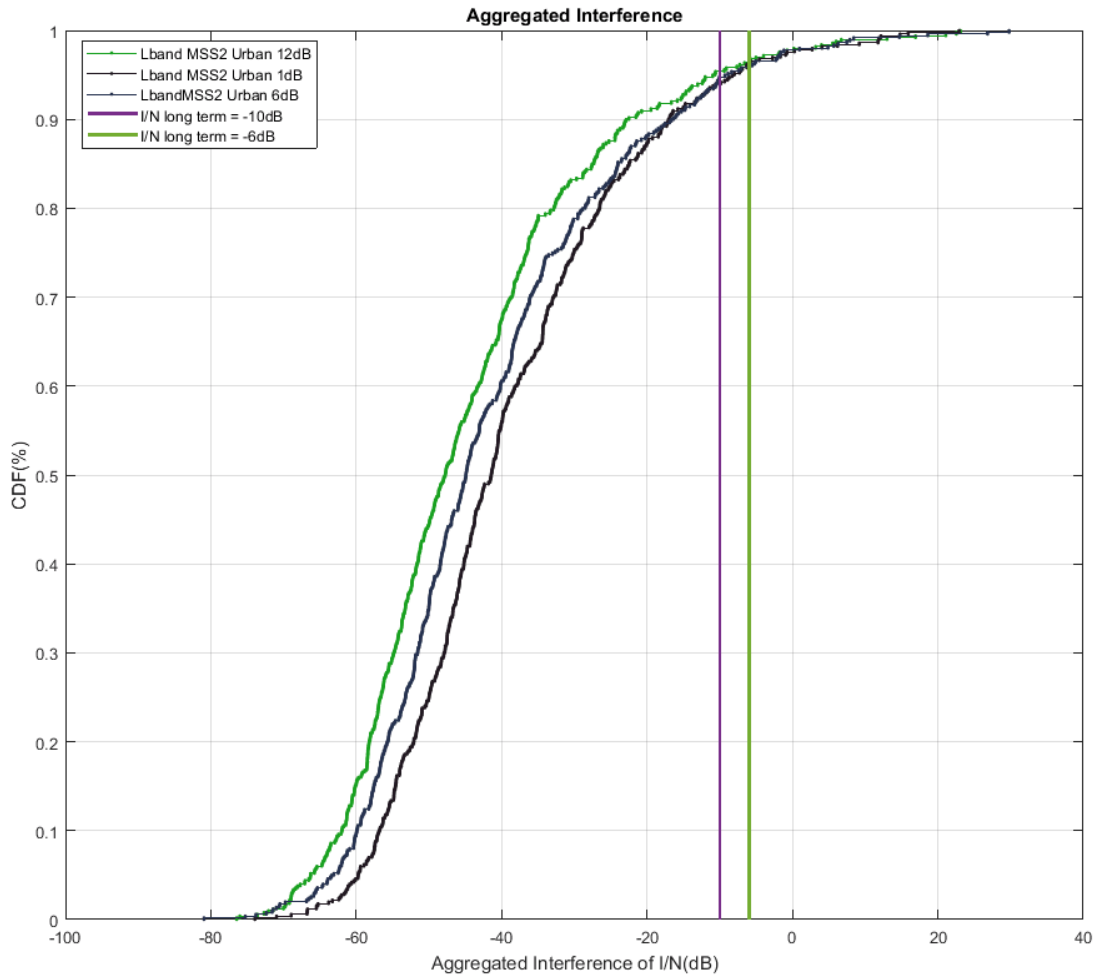


TABLE A7-3

**Interference probability from IMT UE unwanted emissions (–30 dBm/MHz case)**

System	MES antenna gain (dBi)	Interference probability (%)			
		Urban scenario		Suburban scenario	
		<i>I/N</i> = –6	<i>I/N</i> = –10	<i>I/N</i> = –6	<i>I/N</i> = –10
MSS 1	3	3	3.6	1.4	1.8
	17.5	3.4	5.4	1.8	2.2
MSS 2	1	3.8	6	1.6	2.2
	6	4.2	5.2	2.2	2.8
	12	3.6	4.6	1	1.6
MSS 3	1	3.2	4.4	1	1.6
	6	3.4	4.2	1.8	2.2
	12	2.8	3.8	1	1

FIGURE A7-2  
 CDF graph of Urban MSS2 –30 dBm/MHz unwanted emissions case

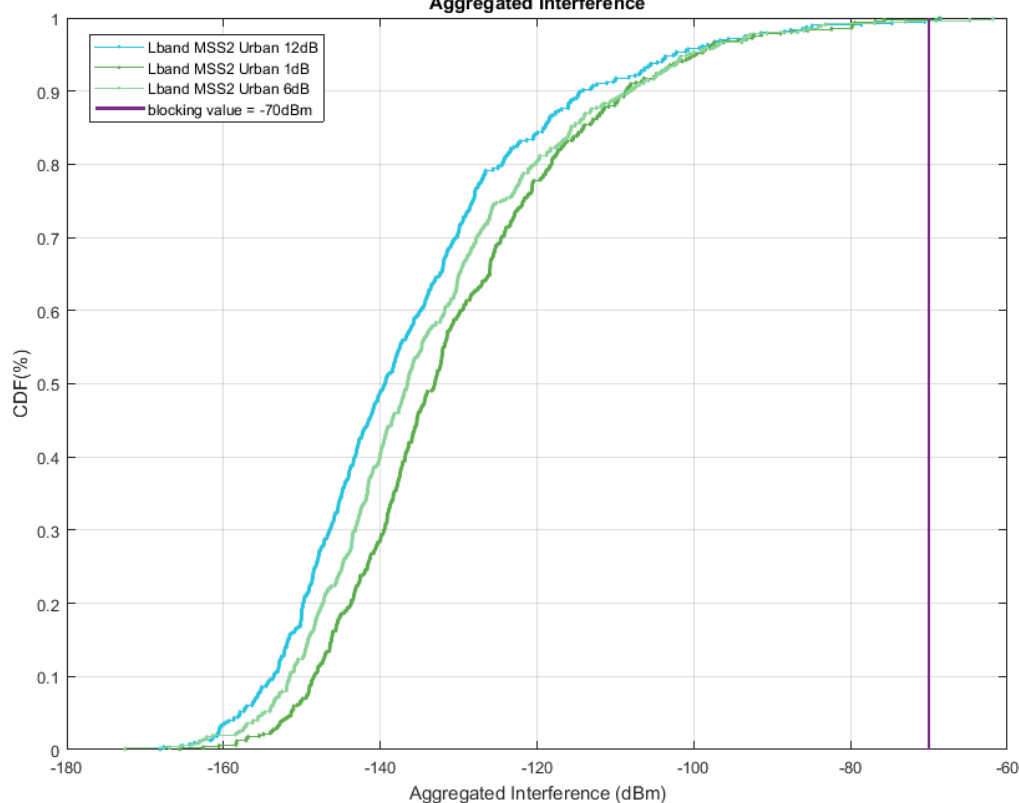


Evaluation of MES Blockage probability within 1 518-1 525 MHz:

TABLE A7-4  
 Probability of MES blocking

System	MES antenna gain (dBi)	Interference probability (%)	
		Urban scenario	Suburban scenario
MSS 1 (-43 dBm, 200 K reference bandwidth)	3	0	0
	17.5	0	0
MSS 2 (-70 dBm, 31.25 K reference bandwidth)	1	0.2	0
	6	0.4	0
	12	0.6	0.2
MSS 3 (-70 dBm, 156.25 K reference bandwidth)	1	1.4	0.4
	6	0.8	0.2
	12	1	0.4

FIGURE A7-3  
CDF graph of blocking  
Aggregated Interference



### A7.1.2 Impact of IMT terminal unwanted emission on MES receiver in land environment

The study results below contain an extension to the MCL. It covers an artificial situation where the MES is always allocated the first adjacent channel above the frequency separations (1 MHz, 3 MHz or 6 MHz), but moves randomly around in the area of IMT coverage.

### A7.1.3 Land-based MES

TABLE A7-5

Area and frequency analysis results of interference from the IMT UEs unwanted emissions into MSS in % probability (Land), normal environment

Adjacent emission level above 1 520 MHz	MES antenna gain (dBi)	$I/N$ (dB)	Non-interference probability (%)		
			Rural scenario	Suburban scenario (P.1546 model)	Urban scenario (P.1546 model)
-10 dBm/MHz	3	-6	100	98.2	93.5
		-10	100	96.8	88.6
	17.5	-6	100	> 98.2	> 93.5
		-10	100	> 96.8	> 88.6
-20 dBm/MHz	3	-6	100	99.5	98
		-10	100	99.1	96.5
	17.5	-6	100	> 99.5	> 98

TABLE A7-5 (*end*)

Adjacent emission level above 1 520 MHz	MES antenna gain (dBi)	<i>I/N</i> (dB)	Non-interference probability (%)		
			Rural scenario	Suburban scenario (P.1546 model)	Urban scenario (P.1546 model)
		-10	100	> 99.1	> 96.5
-30 dBm/MHz	3	-6	100	100	99.1
		-10	100	99.9	98.6
	17.5	-6	100	100	> 99.1
		-10	100	> 99.9	> 98.6

### A7.2 Summary of Study C

Interference probabilities from the IMT UEs unwanted emissions into MSS (Land) are provided in this study.

Three MSS systems are considered as victim, where MSS 2 was found to be the worst case among the 3 MSS terminals evaluated. Two unwanted emission values were considered for the analysis assuming *I/N* protect criterion ratio of -6 / -10 dB.

For unwanted emissions of -20 dBm/MHz case:

Interference probabilities which exceed *I/N* protect criterion ratio of -6 / -10 dB is almost 0% for rural scenario, less than 2-9.6% / 3.5-12.6% in urban scenario and less than 0.5-4.2% / 0.9-6.2% in suburban scenario.

For unwanted emissions of -30 dBm/MHz case:

Interference probabilities which exceed *I/N* protect criterion ratio -6 / -10 dB is almost 0% for rural scenario, less than 0.9-4.2% / 1.4-5.2% in urban scenario and less than 0-2.2% / 0.1-2.8% in suburban scenario.

The results of analysis for unwanted emissions of -10 dBm/MHz has shown that interference probabilities which exceed *I/N* protect criterion ratio of -6 / -10 dB showed almost 0% interference probability for rural scenario, less than 6.5% / 11.4% in urban scenario and less than 1.8% / 3.2% in suburban scenario.

For the evaluation of MES Blockage probability within 1 518-1 525 MHz:

Interference probabilities which exceed the tolerable blockage level of -70 dBm is around 0% to 1.4% in urban scenario and around 0% to 0.4% in suburban scenario.

## Annex 8

### Study D

#### A8.1 Protection of MSS terminal receivers from overload/blocking from IMT BS

MSS terminals are designed to receive relatively weak signals from geostationary satellites ~36 000 km above earth, while in motion. As such, they have to be extremely sensitive in order to receive such a weak signal. High power IMT base stations deployed geographically much closer to these terminals in adjacent spectrum can cause an overload/blocking in the MSS terminal receivers, blocking the terminals from being able to connect to the satellite network.

The susceptibility of the terminals to overload interference varies across different devices (see different blocking performances in § A8.1.1.3). While next generation devices will be designed to better withstand this interference, in order to provide continued operation of currently deployed MSS terminals, regulators can implement IMT in a way that ensures co-existence between IMT and current MSS services.

This could be accomplished by adopting a phased approach, with phase 1 dealing with measures to ensure continued operation of currently deployed terminals while phase 2 would involve more relaxed measures to ensure compatibility with next generation terminals which are expected to have increased blocking level than current terminals standards.

##### A8.1.1 Land MESs

Current MSS land terminals were designed in compliance to the standards that were applicable at the time they were deployed for operation; examples of these standards are ETSI standards TS 101 376-5-5 (which defines blocking requirements as  $-70$  dBm) and TS 101 377-5-5 (which defines blocking requirement as  $-43$  dBm). In these standards, the blocking test signal is defined as a CW signal.

##### A8.1.1.1 Derivation of IMT BS maximum e.i.r.p. limits required to protect current and next generation land MESs

To protect MESs operating in the same area as the IMT deployment, the protection against MES receiver overload/blocking caused by IMT BS could be achieved by limiting the maximum IMT BS e.i.r.p.

In order to ensure continued operation of currently deployed MSS terminals operating in the adjacent band as well as next generation terminals, it is necessary to derive the maximum BS e.i.r.p. limits at different frequency offsets that would be required to protect MESs from blocking interference.

In order to determine the maximum BS e.i.r.p. required to protect current MESs in the field and next generation terminals, it is necessary to consider the following:

- IMT BS deployment scenario (Rural, suburban, Urban).
- The deployment scenario that results in the highest blocking signal at the MES.
- MESs blocking performance at frequency offsets of 0, 1, 3, 6, 8, 11 and 16 MHz from 1 518 MHz.

##### A8.1.1.2 IMT deployment scenarios

Generally, three deployment scenarios can be considered, and these are listed with their relevant parameters in Table A8-1.

TABLE A8-1

**IMT BS deployment scenarios and their associated technical and deployment parameters**

Deployment scenario	IMT BS max e.i.r.p. (dBm)	Antenna height (m)	Antenna down tilt (deg)
Rural	61	30	3
Suburban	59	30	6
Urban	59	25	10

Taking into account the parameters from the above deployment scenarios (Rural, Suburban and Urban), propagation losses associated with each of these deployment scenarios and representative MES characteristics, the maximum blocking interference level that can be received at the MES from IMT BSs can be calculated for each deployment scenario as shown in Table A8-2.

TABLE A8-2

**IMT BS deployment scenarios and the maximum receiver signal level at the MES**

Deployment scenario	Max interfering signal received at MES antenna connector (dBm)	Distance at which the max interfering signal is received at the MES (m)
Rural	-21.5	40
Suburban	-11.0	40
Urban	-9.5	40

From Table A8-2, the worst case with respect to blocking interference is urban deployment scenario which results in a received blocking interference level of -9.5 dBm.

**A8.1.1.3 Measured blocking performance of current and next generation land MESs**

In order to determine the IMT BS e.i.r.p. reduction required to ensure protection of land MESs from IMT deployment at different frequency offsets from 1 518 MHz, it is necessary to determine the blocking performance of MESs at different frequency offsets from 1 518 MHz. The tables are shown in this matter to give highest flexibility to administrations in deploying IMT, depending on the terrestrial IMT channel arrangement and IMT base station deployment scenario. The blocking performance of the most susceptible current terminals available for testing and next generation land MESs are as shown in Table A8-3 and Table A8-4 respectively.

TABLE A8-3

**Current land portable MES blocking performance at different frequency offsets**

Frequency offset	0 MHz Offset	1 MHz Offset	3 MHz Offset	6 MHz Offset	8 MHz Offset	11 MHz Offset	16 MHz Offset
Blocking (dBm/5 MHz)	-63	-63	-60	-56	-53	-49	-41

TABLE A8-4

**Next generation land portable MES blocking performance at different frequency offsets**

Frequency offset	0 MHz Offset	1 MHz Offset	3 MHz Offset	6 MHz Offset	8 MHz Offset	11 MHz Offset	16 MHz Offset
Blocking (dBm/10 MHz)	-50	-33	-27	-18	-15	-14	N/A

By considering the blocking performances of current and next generation terminals given above, and the results of Table A8-2, the IMT BS maximum e.i.r.p. limits that ensure protection of current and next generation terminals is derived as shown in Table A8-5 and Table A8-6 respectively.

TABLE A8-5

**Proposed e.i.r.p. limits required to protect current MESs from IMT BS deployment at difference frequency offsets from the 1 518 MHz when MESs are operated in the same area as terrestrial IMT deployment (separation distance of 40 m)**

Deployment scenario	IMT BS maximum e.i.r.p. (dBm)	Required e.i.r.p. limit for IMT BS deployed with 0 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 1 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 3 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 6 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 8 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 11 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 16 MHz Offset (dBm)
Rural	61	19.5	19.5	22.5	26.5	29.5	33.5	41.5
Suburban	59	7.0	7.0	10.0	14.0	17.0	21.0	29.0
Urban	59	5.5	5.5	8.5	12.5	15.5	19.5	27.5

TABLE A8-6

**Proposed e.i.r.p. limits required to protect next generation MESs from IMT BS deployment at difference frequency offsets from the 1 518 MHz when MESs are operated in the same area as terrestrial IMT deployment (separation distance of 40 m)**

Deployment scenario	IMT BS maximum e.i.r.p. (dBm)	Required e.i.r.p. limit for IMT BS deployed with 0 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 1 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 3 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 6 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 8 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 11 MHz Offset (dBm)	Required e.i.r.p. limit for IMT BS deployed with 16 MHz Offset (dBm)
Rural	61	32.5	49.5	55.5	64.5	67.5	68.5	N/A
Suburban	59	20.0	37.0	43.0	52.0	55.0	56.0	N/A
Urban	59	18.5	35.5	41.5	50.5	53.5	54.5	N/A

These e.i.r.p. values apply to IMT base stations deployed outdoors. Based on the above analysis, to provide sufficient protection to land-based MESs, IMT base station e.i.r.p. should be limited according to the values contained in Tables A8-5 and A8-6. Indoor deployment scenarios have not been considered in this study, and for such deployments, the e.i.r.p. values may be exceeded by an amount equal to building penetration loss, such that the same protection would be afforded to MESs.

### A8.1.2 Maritime and aeronautical MESs

The risk of interference for maritime and aeronautical MESs is when the MESs are located in and around ports and airports respectively and when the IMT base stations are deployed in the same areas.

Since the studies contained in Annex 6 were developed, additional results of blocking performance for aeronautical and maritime terminals have been obtained. The CEPT compatibility studies only considered blocking interference resulting from a single 5 MHz LTE block at 1 512-1 517 MHz, however, in real deployment scenarios, more than one LTE carrier/channel transmissions from an IMT BS below 1 517 MHz can occur, for which the resulting blocking effect on MESs is worse than when only one LTE carrier/channel is considered. This is due to the multicarrier LTE channels causing intermodulation effect inside the receiver which degrades the receiver performance further.

The blocking performance of different types of current maritime and aeronautical terminals was measured against single and multiple LTE channels. The terminal blocking performance resulting from a single LTE channel was measured by simulating an IMT BS transmitting a single 5 MHz LTE channel at 1 512-1 517 MHz, while the terminal blocking performance resulting from multiple LTE channels was measured by simulating an IMT BS transmitting simultaneously combinations of the following LTE channels: (1) a 5 MHz LTE channel at 1 512-1 517 MHz, (2) a 10 MHz LTE channel at 1 502-1 512 MHz and (3) a 10 MHz LTE channel at 1 492-1 502 MHz.

The expected blocking performances of next generation maritime and aeronautical terminals (based on simulated receiver modelling by manufacturers), were also estimated against single and multiple LTE channels.

#### A8.1.2.1 Blocking performances of current Maritime and aeronautical MESs

The blocking performances (most susceptible) of current maritime and aeronautical terminals against single and multiple LTE channels at different frequencies for 1 dB receiver sensitivity loss were measured and the results are given in Tables A8-7 and A8-8.

TABLE A8-7

**Measured blocking performance of current maritime and aeronautical current terminals from a single LTE channel at different frequencies**

Terminal type	Frequency range (MHz)		
	1 492-1 502	1 502-1 512	1 512-1 517
Maritime (dBm)	-53	-68	-76
Aeronautical (dBm)	-21	-35	-50.3



TABLE A8-8

**Measured blocking performance of current maritime and aeronautical MESs  
from aggregate multiple LTE channels**

<b>Terminal Type/Model</b>	<b>Aggregate blocker power level at MES RX input from LTE channels in 1 492-1 512 MHz (dBm)</b>	<b>Blocker power level at MES RX input from an LTE channel at 1 512-1 517 MHz (dBm)</b>
Maritime	-67	-78
Aeronautical	-45.6	-55.5

### A8.1.2.2 Blocking performances of next generation maritime and aeronautical MESs

The expected blocking performances of next generation maritime and aeronautical terminals (based on simulated receiver modelling by manufacturers), were also estimated against single and multiple LTE channels, and the results are given in Tables A8-9 and A8-10 respectively.

TABLE A8-9

**The expected blocking performances of next generation maritime and aeronautical terminals  
resulting from a single LTE block at different frequencies**

<b>Blocking signal</b>	<b>Frequency range</b>	<b>Blocking level at the antenna connector of MSS terminal</b>
LTE signal	1 492-1 512 MHz	-20 dBm
	1 512-1 517 MHz	-30 dBm

TABLE A8-10

**The expected blocking performances of next generation maritime and aeronautical terminals  
resulting from multiple LTE channels**

<b>Maximum aggregate blocker power at MES antenna connector from LTE blocks in 1 492-1 512 MHz</b>	<b>Maximum blocker power at MES antenna connector from LTE block at 1 512-1 517 MHz</b>
-23 dBm	-33 dBm

### A8.1.2.3 Blocking values to be used for calculation of pfd limits on IMT BS

In order to ensure protection of maritime and aeronautical terminals at seaports and airports, it is proposed to apply a protection measure based on pfd limits on the IMT BS transmission. The pfd limits to protect maritime operations would be applied to the boundary of the areas where ships use MES terminals, which means ports, coastal areas, and some inland waterways. The pfd limits to protect aeronautical operations would be applied to the boundary of the areas where aircraft operate on the ground, which means most international airports and some maintenance facilities.

The pfd limits should be applied in two phases. For phase 1, the pfd limits presented below are based on the measured blocking performance of the most susceptible current maritime and aeronautical terminals. Administrations could also develop pfd values based on different blocking performance

values. Phase 2 would involve more relaxed constraints on IMT BSs as the pfd limits presented below are based on next generation terminals, which are expected to be more resilient to blocking.

Two sets of pfd limits would be defined for IMT BS depending on single or multiple LTE channel transmissions for both phase 1 and phase 2 based on the blocking performances given Tables A8-11 and A8-12.

TABLE A8-11

**Blocking values to be used for pfd calculation for IMT BS transmitting single channel at different frequencies**

Phase	Phase 1			Phase 2		
LTE frequency range (MHz)	1 492-1 502	1 502-1 512	1 512-1 517	1 492-1 502	1 502-1 512	1 512-1 517
Ports and inland waterways (blocking level dBm)	-53	-68	-76	No limit required	-20	-30
Airports (blocking level dBm)	-21	-35	-50.3	No limit required	-20	-30

TABLE A8-12

**Blocking values to be used for pfd calculation for IMT BS transmitting multiple channels**

Phase	Phase 1		Phase 2	
Frequency range (MHz)	1 492-1 512	1 512-1 517	1 492-1 512	1 512-1 517
Ports and inland waterways (blocking level dBm)	-67	-78	-23	-33
Airports (blocking level dBm)	-45.6	-55.5	-23	-33

#### A8.1.2.4 Proposed IMT base station PFD Limits to protect maritime and aeronautical MESS

Taking the blocking values from Tables A8-11 and A8-12, the corresponding pfd limits on IMT BS transmitting a single and multiple channels for both phase 1 and phase 2 can be derived using the methodology given in Annex 3, and the results are as shown in Table A8-13 and Table A8-14 for IMT BS transmitting single and multiple channels respectively.

TABLE A8-13

**pfd limits on IMT BS transmitting a single channel**

Phase	MSS terminal antenna gain (dBi)	Phase 1			Phase 2		
		pfd limit for BS emissions in the band 1 492-1 502 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )
Ports and inland waterways	3	-60.9	-75.9	-83.9	No limit required	-27.9	-37.9
	19	-76.9	-91.9	-99.9	No limit required	-43.9	-53.9
Airports	3	-28.9	-42.9	-58.2	No limit required	-27.9	-37.9
	17	-42.9	-56.9	-72.2	No limit required	-41.9	-51.9

These pfd values are based on an MES with a range of antenna gain values. There are some cases where the antenna gain towards the horizon can exceed 3 dBi, in particular where high gain aeronautical MES antennas (maximum 17 dBi) and high gain maritime MES antennas (maximum 19 dBi) are used with a low elevation angle towards the satellite. pfd values for these cases are included in the Table.

TABLE A8-14

**pfd limits on IMT BS transmitting multiple channels**

Phase	MSS terminal antenna gain (dBi)	Phase 1		Phase 2	
		pfd limit for emissions in the band 1 492-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )	pfd limit for emissions in the band 1 492-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )
Ports and inland waterways	3	-74.9	-85.9	-30.9	-40.9
	19	-90.9	-101.9	-46.9	-56.9
Airports	3	-53.5	-63.4	-30.9	-40.9
	17	-67.5	-77.4	-44.9	-54.9

There are some cases where the antenna gain towards the horizon can exceed 3 dBi, in particular where high gain aeronautical MES antennas (maximum 17 dBi) and high gain maritime MES antennas (maximum 19 dBi) are used with a low elevation angle towards the satellite. pfd values for these cases are included in the Table.

Administrations may be needed to adjust the pfd values according to the particular circumstances of their country taking into account the satellite location, including elevation and azimuth, within their country and the consequential antenna discriminations.

**A8.2 Summary of Study D**

This study addresses the protection of MESs from blocking interference, taking into account MESs currently operating in the field, and the anticipated blocking performance of next generation MESs. Base station e.i.r.p. limits are developed that would protect land MSS operations, when MESs are operated in the same area as terrestrial IMT deployment (Tables A8-5 and A8-6 based on the separation distance of 40 m).

Measured blocking performance data shows that maritime and aeronautical MESs are typically more sensitive to blocking interference than land MESs, but require protection only at a limited set of locations where IMT base stations might be deployed close to those MESs (e.g. near to port and airports). For these cases, pfd limits are developed that would be applied to IMT operations in the areas where maritime and aeronautical MESs operate (Tables A8-13 and A8-14).

## Annex 9

### Study E

#### A9.1 Analysis for interference from UE to MES

##### A9.1.1 Compatibility scenarios

This study evaluates compatibility between IMT in L-Band 1 427-1 518 MHz and MSS in the frequency band (1 518-1 559 MHz), in accordance with Resolution **223 (Rev.WRC-15)**, considering the following:

- Impact of IMT terminals unwanted emission on MES receiver in land environment.

##### A9.1.2 Methodology

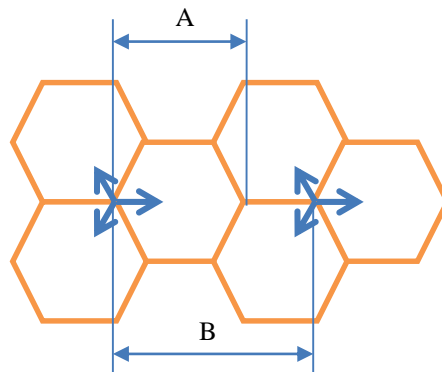
This study considers statistical analysis based on Monte Carlo simulations instead of MCL calculation. Monte Carlo simulations have been developed to provide information about what the risk of interference is to a user when both the interferer and the victim system are operating in close to normal conditions as possible.

In the performed Monte Carlo analysis, it is assumed that the MES may be located at any location within the IMT coverage area. By randomising the location of the MESs and determining the interference at each location, the probability of interference can be assessed.

This addresses the interference probability for a mobile (MES) user and is also taking into account that the MSS system will allocate a channel from within the MSS band to that user.

The deployment of the IMT network is based on the information in Report ITU-R M.2292. The typical macro cell coverage is formed of three hexagons, as illustrated in Fig. A9-1.

FIGURE A9-1  
Macro cell geometry (A is the cell radius and B is the inter-site distance)



##### A9.1.3 Technical characteristics of IMT terminal

According to Report ITU-R M.2292, find Table A9-1 about “IMT Terminal characteristics”.

TABLE A9-1  
**IMT terminal characteristics**

Parameter	Unit	Value
Transmit frequency	MHz	1 492-1 518
Cell Bandwidth	MHz	10
Deployment	–	Macro (urban, suburban)
Average base station activity		50%
Indoor user terminal usage		70%
Indoor user terminal penetration loss	dB	20
Maximum transmitter power	dBm	23
Average user terminal output power	dBm	2 dBm for rural, –9 dBm for urban and suburban
Maximum antenna gain	dBi	–3
Body loss	dB	4
Antenna height	m	1.5
Polarization	dB	Linear
Antenna pattern	–	Rec. ITU-R F.1336-4 OMNI
Macro cell radius	km	5 km in rural, 1 km (suburban), 0.5 km (urban)
User terminal density in active mode	MHz/km <sup>2</sup>	3/10 for urban 2.16/5 for suburban

The IMT cell radius is configured to be 5 km for rural, 1 km for suburban scenario and 0.5 km for urban scenario.

The IMT terminals are distributed uniformly, the number of active terminals is set to three terminals in rural, two terminals in suburban and one terminal in urban per cell per 5 MHz.

#### **A9.1.4 IMT UE unwanted emission values**

IMT UE unwanted emission values that cause interference less than 0.1% of time are evaluated. Due to the power control of IMT UE, the average in band UE output power is considered based on Report ITU-R M.2292.

#### **A9.1.5 Technical characteristics of MSS**

Recommendation ITU-R M.1184 contains a range of characteristics of MSS systems operating in these bands. MSS terminal's characteristics considered in this study are provided in Table 1 of this Report with protection criteria of  $I/N = -15.2$  and  $-20$  dB and the antennae patterns are in Table 2.

#### **A9.1.6 Propagation models and environments**

- 1 Rural case – Recommendation ITU-R P.1546-5 with 4 m clutter height.
- 2 Suburban case – Recommendation ITU-R P.1546-5 with 10 m clutter height.
- 3 Urban case – Recommendation ITU-R P.1546-5 with 20 m clutter height.

### A9.1.7 Results and summary

#### A9.1.7.1 Land analysis

IMT UEs unwanted e.i.r.p. into MSS (Land) for less than 1% of interference are provided in this section.

TABLE A9-2  
IMT UEs unwanted e.i.r.p. into land MSS

System	MES antenna gain (dBi)	Less than 1% of time					
		Urban		Suburban		Rural	
		$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$	$I/N = -20$	$I/N = -15.2$
MSS 1	3	-66	-61	-69	-65	-45	-40
	17.5	-61	-57	-66	-61	-39	-33
MSS 2	1	-69	-65	-74	-70	-48	-43
	6	-66	-62	-72	-67	-45	-40
	12	-60	-56	-65	-61	-40	-36
	32	-55	-50	-60	-56	-30	-25
MSS 3	1	-69	-64	-73	-69	-47	-43
	6	-67	-63	-71	-68	-48	-43
	12	-61	-55	-66	-61	-34	-35
	32	-55	-50	-61	-55	-31	-25

### A9.2 Summary of Study E

This study is based on a Monte Carlo analysis using fixed MES frequency channel to assess the interference from IMT UE into land MES. It considered the MSS protection criteria of  $I/N = -15.2$  and  $-20$  dB, for different MSS systems in urban and suburban scenarios. The results in order to achieve availability of 99% for all of the MES systems under different scenarios the unwanted emissions should be less than  $-74$  dBm/MHz.

## Annex 10

### Study F

#### A10.1 Deterministic analysis for interference from UE to MES

##### A10.1.1 Compatibility scenarios

This study evaluates compatibility between IMT in L-Band 1 427-1 518 MHz and MSS considering the impact of IMT UE unwanted emissions on MES receivers. The analysis is applicable to MESs used in the land environment based on a maximum level of interference and a minimum separation distance between the UE and MES of 10 m. The analysis method also addresses potential interference

from IMT UEs to aircraft earth stations. Although the separation distance between aircraft passengers and the AES can be less than 10 m, the additional fuselage shielding should ensure adequate isolation between the cabin passengers and the AES. The analysis method also addresses potential interference from IMT UE to a ship earth station, provided that any passengers and crew using the IMT UE on the ship maintain at least 10 m separation from the ship earth station.

### A10.1.2 Methodology

A deterministic analysis is performed to analyse the impact of interference from the UE to MES. For a given set of parameter values for the UE and MES, the required separation distance is determined, and this is compared with the minimum acceptable separation distance of 10 m. The impact of UE in-band emissions to the MES is determined based on criteria of the blocking of the MES receiver. Separately, and the impact of UE unwanted emissions on the MES is separately determined for different criteria for the maximum level of interference from unwanted emissions.

### A10.1.3 Technical characteristics of IMT terminal and MES

Technical characteristics of the IMT terminal are given in § 3.2 and for the MES are given in § 3.1. The study determines the acceptable level of UE unwanted emissions to provide compatibility with MSS operations. To reduce the number of variables involved, and noting that MES receiver characteristics are similar, the MES characteristics are for “MSS-1” and the antenna gain is assumed to be fixed at 3 dBi.

Assessment of the acceptable level of UE in-band emissions requires criteria for the blocking of the MES. The acceptable blocking levels used in Annex 4 are used here, with one set of criteria for current generation land MESs and another set of criteria for next generation land MESs with improved receiver performance.

### A10.1.4 Results

#### A10.1.4.1 Results for UE in-band emissions

Results for the consideration of UE in-band emissions are shown in Table A10-1 for current generation MESs and Table A10-2 for next generation MESs at different frequency offsets.

TABLE A10-1

#### Interference from in-band UE emissions to current generation land terminals

Offset	MHz	0	1	3	6	8	11	16
Maximum user terminal output power	dBm	23	23	23	23	23	23	23
Typical antenna gain for user terminals	dBi	-3	-3	-3	-3	-3	-3	-3
Body loss	dB	4	4	4	4	4	4	4
UE e.i.r.p. towards MES	dBm	16	16	16	16	16	16	16
MES antenna gain	dBi	3	3	3	3	3	3	3
MES receiver max interference	dBm	-63	-63.0	-60.0	-56.0	-53.0	-49	-41
Minimum coupling loss	dB	82.0	82.0	79.0	75.0	72.0	68.0	60.0
Separation distance to meet the blocking levels of MES receivers (FSL)	m	198.0	198.0	140.2	88.4	62.6	39.5	15.7

TABLE A10-2

**Interference from in-band UE emissions to next generation land terminals**

Offset	MHz	0	1	3	6	8	11	16
Maximum user terminal output power	dBm	23	23	23	23	23	23	23
Typical antenna gain for user terminals	dBi	-3	-3	-3	-3	-3	-3	-3
Body loss	dB	4	4	4	4	4	4	4
UE e.i.r.p. towards MES	dBm	16	16	16	16	16	16	16
MES antenna gain	dBi	3	3	3	3	3	3	3
MES receiver max interference	dBm	-50	-33.0	-27.0	-18.0	-15.0	-14	N/A
Minimum coupling loss	dB	69.0	52.0	46.0	37.0	34.0	33.0	N/A
Separation distance to meet the blocking levels of MES receivers (FSL)	m	44.3	6.3	3.1	1.1	0.8	0.7	N/A

These results show that with regard only to in-band interference from UE to land MES, transmitting UEs are not compatible with the current generation of land terminals if deployed in the same area (minimum separation distance of 10 m), but are compatible with next generation land MESs provided the UE operates below 1 517 MHz. As next generation aircraft earth stations and ship earth stations will have similar blocking capabilities as land MESs, this conclusion is also applicable to those earth stations.

**A10.1.4.2 Results for UE unwanted emissions**

For the analysis of unwanted emissions, this analysis examines interference with respect to the *I/N* criteria -20 dB, -15.2 dB, -10 dB and -6 dB. Table A10-3 shows the minimum coupling loss and distance for an unwanted emission e.i.r.p. of -80 dBm/MHz.

TABLE A10-3

**Interference from UE unwanted emissions to land/ship/aircraft MESs**

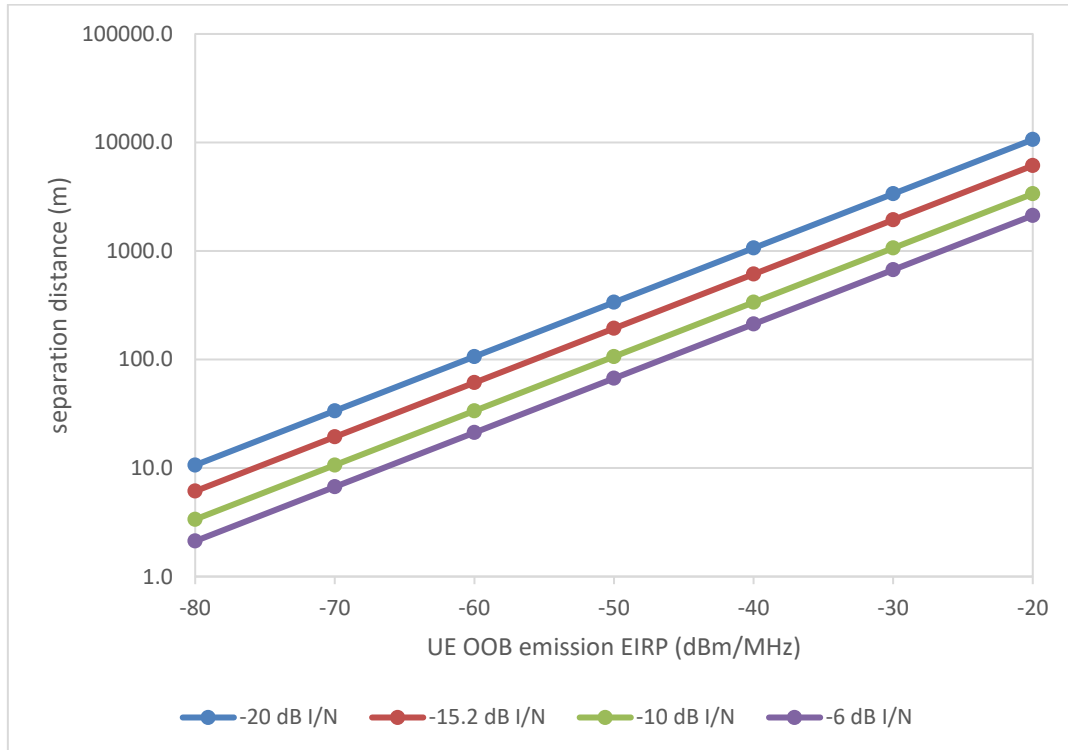
		Unwanted emission 1 (-20 dB)	Unwanted emissions 2 (-15.2 dB)	Unwanted emissions 3 (-10 dB)	Unwanted emissions 4 (-6 dB)
UE e.i.r.p. towards MES	dBm	-80	-80	-80	-80
MES antenna gain	dBi	3	3	3	3
MES reference bandwidth	kHz	1 000	1 000	1 000	1 000
MES noise temperature	K	316	316	316	316
MES noise power	dBm	-113.6	-113.6	-113.6	-113.6
MES max unwanted <i>I/N</i>	dB	-20	-15.2	-10	-6
MES receiver max interference	dBm	-133.6	-128.8	-123.6	-119.6
Minimum coupling loss	dB	56.6	51.8	46.6	42.6
Distance (FSL)	m	10.6	6.1	3.4	2.1



The results show that for a UE unwanted emission level of  $-80$  dBm/MHz, the separation distance ranges from 10.6 m to 2.1 m for the four  $I/N$  criteria.

A similar calculation can be made for other values of UE unwanted emissions of  $-70$  dBm/MHz to  $-20$  dBm/MHz. Figure A10-1 shows the corresponding distances for each of the four criteria in each case.

FIGURE A10-1  
Required separation distance to meet  $I/N$  criterion, for UE unwanted emission e.i.r.p. from  $-80$  dBm/MHz to  $-20$  dBm/MHz



It can be seen that a UE unwanted emission e.i.r.p. in the range  $-80$  to  $-66$  dBm/MHz is necessary to meet the MES UE protection criteria for a separation distance of 10 m.

## A10.2 Summary of Study F

This study considers the case of a transmitting UE operating below 1 517 MHz, as would be the case for IMT frequency arrangements for the band 1 427-1 518 MHz which use TDD. The study is based on the characteristics of land MESs operating in the same area as terrestrial IMT systems and is applicable to protection of aircraft earth stations and ship earth stations.

Considering first the compatibility with MES operation due to the in-band emissions from the UE causing potential blocking of the MES receiver, it can be seen that the UE operation is not compatible with current generation land MES if they are deployed in the same area (minimum separation distance of 10 m), but is compatible with next generation land MESs, provided the UEs operate below 1 517 MHz. As next generation aircraft earth stations and ship earth stations will have similar blocking capabilities as land MESs, this conclusion is also applicable to those earth stations.

Considering second the compatibility with MES operation due to unwanted emissions from the UE, received by the MES, each of the four *I/N* criteria (−20 dB, −15.2 dB, −10 dB, −6 dB) have been used, along with a minimum separation distance of 10 m between UE and MES. This leads to a maximum UE unwanted emission e.i.r.p. level of −80 to −66 dBm/MHz which is applicable for protection of land, aircraft and ship earth stations.

## Annex 11

### Study G

#### A11.1 IMT UE interference into MES Analysis

The unwanted emission interference into MSS MES 1 for the deployment scenarios of suburban and urban are considered in this study.

##### A11.1.1 Technical characteristics

###### A11.1.1.1 Technical characteristics of IMT UE

The relevant parameters for the IMT UE according to Report ITU-R M.2292 are shown in Table A11-1.

TABLE A11-1  
IMT UE characteristics

Parameter	Unit	Value
Transmit frequency	MHz	1 492-1 518
Bandwidth	MHz	5
Deployment	–	suburban and urban
Maximum transmitter power	dBm	23
Average user terminal output power	dBm	−9 (for urban and suburban)
UE unwanted emission e.i.r.p.	dBm/MHz	−20 (for suburban and urban)
Maximum antenna gain	dBi	−3
Body loss	dB	4
Antenna height	m	1.5 m
Polarization	dB	Linear
Antenna pattern	–	Rec. ITU-R F.1336-4 OMNI
User terminal density in active mode	MHz/km <sup>2</sup>	2.16/5 for suburban 3/5 for urban

### A11.1.1.2 Technical characteristics of MES

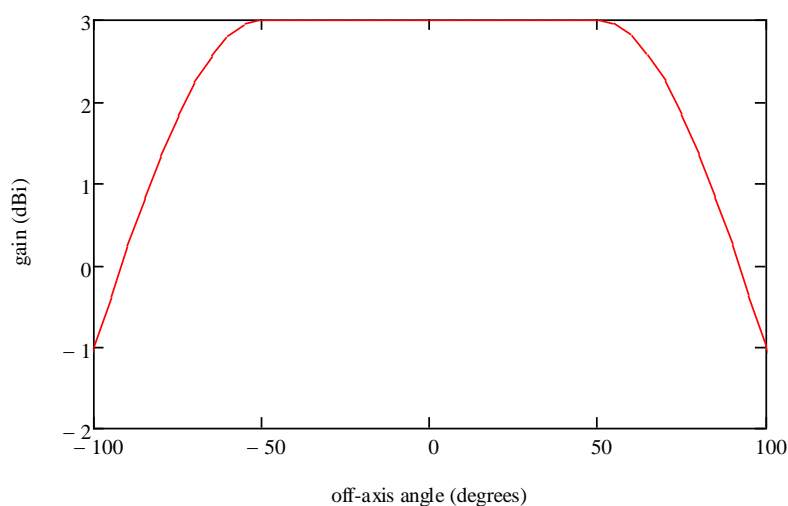
The relevant parameters for the MES “MSS 1” are shown in Table A11-2.

TABLE A11-2  
MES terminal characteristics

Parameter	Unit	Value
Receiver frequency	MHz	1 518
Bandwidth	kHz	200
Maximum antenna gain	dBi	3
Antenna height	m	1.5
Polarization	dB	RHCP
Antenna pattern	–	(See Plot in Fig. A11-1)
MES receiver system noise temp (K)	K	316
Blocking value	dBm	–43

FIGURE A11-1

MES antenna radiation pattern with 3 dBi peak gain



### A11.1.2 Methodology

In order to determine the probability of interference a statistical analysis was carried out based on Monte-Carlo methodology.

The Visualyse simulation tool was used for the Monte-Carlo analysis, where the simulation was set up with the MES located at the centre of the analysis area pointing at 90-degree elevation relative to the horizon. The analysis area is determined based on the user terminal density in active mode given in Table A11-1 and the number of UEs considered for the simulation in suburban and urban deployment scenarios; the IMT UEs are assumed to transmit in 5 MHz bandwidth. 10 UEs uniformly distributed in an area of 3.3 km<sup>2</sup> were considered for the urban case and 21 UEs uniformly distributed in an area of 10 km<sup>2</sup> for the suburban case.

### A11.1.3 MSS MES Protection criteria

Protection criteria of  $I/N$  of  $-6$  dB,  $-10$  dB are used.

### A11.1.4 Propagation models and environments

The propagation model that was used in this analysis was Recommendation ITU-R P.1546-5 in Suburban and urban scenario as follows:

- Suburban case: ITU-R P.1546-5 with 10 m clutter height placed at the MES receiver.
- Urban case: ITU-R P.1546-5 with 20 m clutter height placed at the MES receiver.

Both of these scenarios are carried out with 50% location variability and 50% time percentage.

### A11.1.5 Results of Monte-Carlo analysis

The results of the Monte-Carlo analysis using the assumptions and characteristics outlined above, to assess the probabilities of interference from the IMT UEs unwanted emissions into MES are shown in Table A11-3.

TABLE A11-3  
Probability of UE unwanted emission interference results

Result \ Scenario	Urban		Suburban	
	$I/N = -6$	$I/N = -10$	$I/N = -6$	$I/N = -10$
-20 dBm/MHz emission limit	14.4%	18.4%	13.3%	20.3%

The veracity of the results of the analysis carried out in this study using a Monte-Carlo simulation can be corroborated using simple probabilistic interference analysis using the same assumptions and technical characteristics. The corroborating statistical analysis is given in the sections below.

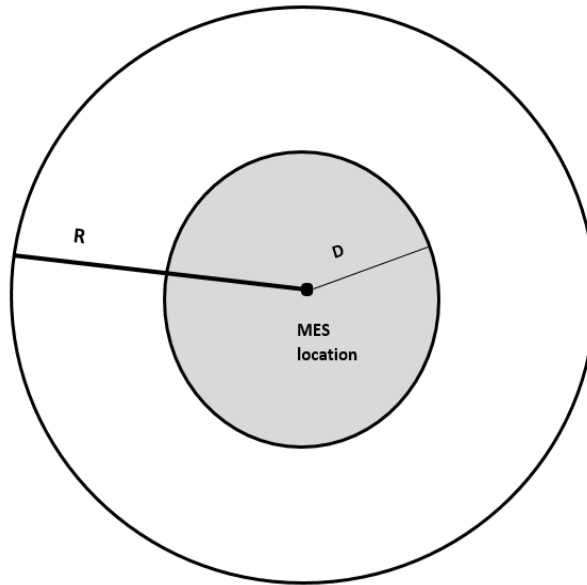
### A11.1.6 Probabilistic interference analysis

For the unwanted emission interference from IMT UE into the MES, a separate probabilistic analysis was used to determine the probability of interference exceeding the protection criteria. The methodology used was as follows:

- 1 An analysis area is considered for each of the deployment scenarios (suburban and urban) where the MES is located at the centre of the analysis area and one IMT UE is randomly placed anywhere within the analysis area.
- 2 The analysis area is determined based on the user terminal density in active mode given in Table A11-1 for each deployment scenarios (suburban and urban) and one IMT UE transmitting in 5 MHz bandwidth.
- 3 For each scenario, an interference area can be determined by calculating the minimum separation distance required ( $D$ ) between the MES which is located at the centre of the analysis area and the UE to meet the protection criterion. When the UE is within a circular area of radius  $D$  from the location of the MES, then there is an occurrence of interference and when the UE is outside of this area, there is no occurrence of interference. This is illustrated in the diagram in Fig. A11-2.
- 4 The probably of interference is determined by comparing the area where the interference from the IMT UE into the MES exceeds the protection criteria to the total analysis area (radius  $R$ ), and from this, the probability of interference is calculated.

FIGURE A11-2

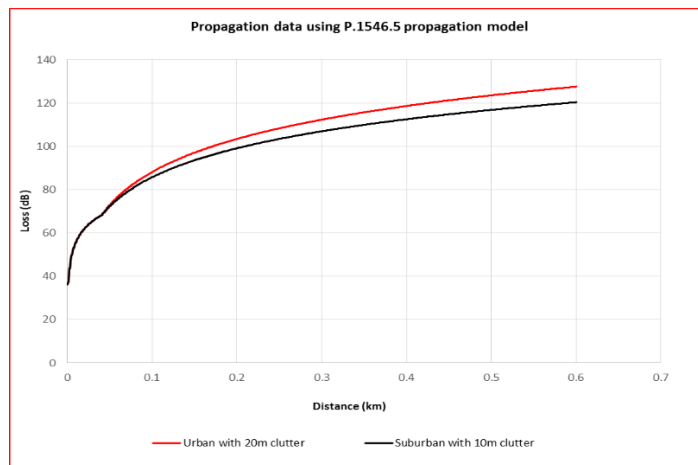
Showing big circle with radius R (interference analysis area) and small circle with radius D (an area within which there is an interference)



Visualyse simulation tool was used to generate the propagation loss data for the above two deployment scenarios as shown in the plot in Fig. A11-3.

FIGURE A11-3

Propagation data for suburban and urban cases with 50% location variability and 50% time percentage



**A11.1.7 Probabilistic interference analysis results**

Table A11-4 shows the probabilistic unwanted emission interference analysis from IMT UE into MES. The same assumptions and technical characterises as the Monte-Carlo simulation were used to obtain the results for the suburban and urban cases with the protection criteria of  $I/N$  of  $-6$  dB and  $-10$  dB.

TABLE A11-4

**Statistical unwanted emission interference analysis for suburban and urban cases with  $I/N$  of  $-6$  dB and  $-10$  dB**

Parameter	Unit	$I/N = -10$ dB		$I/N = -6$ dB	
		Suburban	Urban	Suburban	Urban
MES frequency	MHz	1 520.2	1 520.2	1 520.2	1 520.2
UE BW	MHz	5.0	5.0	5.0	5.0
UE unwanted emissions e.i.r.p.	dBm/MHz	-20.0	-20.0	-20.0	-20.0
UE unwanted emissions e.i.r.p.	dBm/Hz	-80.0	-80.0	-80.0	-80.0
UE Omni antenna gain	dBi	-3.0	-3.0	-3.0	-3.0
Body loss	dB	4.0	4.0	4.0	4.0
Polarisation loss	dB	3.0	3.0	3.0	3.0
MES receiver noise temperature	K	316.0	316.0	316.0	316.0
MES receiver noise temperature	dBK	25.0	25.0	25.0	25.0
MES 3 dBi peak gain in the direction of UE	dBi	0.0	0.0	0.0	0.0
MES noise PSD	dBm/Hz	-173.6	-173.6	-173.6	-173.6
$I/N$ protection criteria	dB	-10.0	-10.0	-6.0	-6.0
Allowable interference PSD	dBm/Hz	-183.6	-183.6	-179.6	-179.6
Minimum link loss required to meet protection criteria	dB	96.6	96.6	92.6	92.6
Separation distance assuming P.1546-5 model	km	0.175 8	0.147 0	0.142 2	0.121 8
Exclusion area	km <sup>2</sup>	0.097	0.068	0.064	0.047
UE density in active mode	/5 MHz/km <sup>2</sup>	2.16	3.00	2.16	3.00
Analysis area with 1 UE and 5 MHz	km <sup>2</sup>	0.46	0.33	0.46	0.33
Ratio of exclusion area to analysis area	%	21.0	20.4	13.7	14.0
<b>Probability of interference</b>	<b>%</b>	<b>21.0</b>	<b>20.4</b>	<b>13.7</b>	<b>14.0</b>

Comparing the results in Table A11-4 obtained using a simple probabilistic analysis with the results of the Monte-Carlo simulation given in Table A11-3, clearly show that the two sets of results are very close, corroborating the results of the Monte-Carlo simulation.

TABLE A11-5

**Summary of results**

Result \ Scenario	Urban		Suburban	
	$I/N = -6$	$I/N = -10$	$I/N = -6$	$I/N = -10$
Monte-Carlo analysis	13.9%	21.4%	13.7%	22.2%
Simple probabilistic analysis	14.0%	20.4%	13.7%	21.0%

### A11.2 Summary of Study G

This study is based on a Monte Carlo statistical analysis to assess the impact of IMT UE unwanted emissions interference into MESs. The analysis performed probabilities of interference for urban and suburban deployment scenarios, considering  $I/N$  protection ratio of  $-6$  dB and  $-10$  dB for each deployment scenario.

For the case of suburban deployment scenario, the results of probability of interference into MES for  $I/N$  of  $-6$  dB was 13.3% and for  $I/N$  of  $-10$  dB was 20.3%.

For the case of urban deployment scenario, the results of probability of interference into MES for  $I/N$  of  $-6$  dB was 14.4% and for  $I/N$  of  $-10$  dB was 18.4%.

## Annex 12

### Study H

#### **Measures to address potential blocking of MES operating in bands adjacent to 1 518 MHz (including 1 525-1 559 MHz) at seaports and airports**

##### A12.1 Introduction

This study considers possible measures to protect MES terminals in airports, ports and inland waterways. It is based upon ECC Report 299 developed by the CEPT in order to assess the issue of ensuring protection to aeronautical and maritime terminals at airports and seaports.

As shown by studies in this Report, the dominant interference effect is blocking.

The study considers a scenario when administrations will adopt a two-phased approach.

- During a phase 1 they will ensure the protection of MES terminals at seaports and airports considering the blocking level of terminals currently on the market. To this regard, it has to be noted that, as it can be seen from the measurements, in general, the blocking response of current terminals is not adapted to the presence of IMT in adjacent bands (see Nos. 3.2 and 3.3 of Article 3 of the Radio Regulations). This is due to the fact that these terminals were designed prior to the identification of the 1 452-1 518 MHz band to the IMT. It is assumed that the blocking responses for MES terminals will improve in the future. Phase 1 is supposed to last for a number of years, sufficient to allow the update of MES terminals.
- During a second phase, based on ECC Report 263 and ECC Report 299, it is assumed that terminals in CEPT countries will have to comply with a blocking level of  $-30$  dBm (for a frequency separation of 3 MHz). Therefore, a new set of pfd values is derived, more relaxed with respect to the ones in phase 1.

In order to ensure an efficient usage of the spectrum, and similarly to application of a cross-border coordination procedure, the pfd limits described could be treated as pfd coordination thresholds for base stations at the boundary where MSS terminals may operate and may need protection. Hence indoor installations at the harbour/airport could then be allowed as long as the pfd value outside the building is lower than the coordination threshold.

The reference height for pfd threshold at the “fence” should be calculated having in mind the height of a vessel/plane above ground level.

As long as pfd at the “fence” is kept under the coordination threshold, usage of the 1 492-1 517 MHz should not have any other restrictions.

The study is structured as follows. First it is provided a set of measurements on current MES available on the market. Then the pfd thresholds are derived.

### A12.2 Blocking level of existing aeronautical terminals

The blocking performance levels for a number of current aeronautical earth stations (AES) – Classic Aero and Swift Broadband (SB) terminals – have been measured. The list of terminal types tested is shown in Table A12-1. The AES terminal types E, F, G and H are the most widely deployed for air transport.

TABLE A12-1  
Types of aeronautical terminals tested

Aeronautical terminal types	Service	Operational band (MHz)
AES A	Classic Aero and SB	1 525-1 559
AES B	Classic Aero and SB	1 525-1 559
AES C	Classic Aero and SB	1 525-1 559
AES D	Classic Aero and SB	1 525-1 559
AES E	Classic Aero and SB	1 525-1 559
AES F	Classic Aero and SB	1 525-1 559
AES G	Classic Aero	1 530-1 559
AES H	Classic Aero	1 530-1 559

Summaries of the measured blocking performance results against single and multiple LTE channels are given in the sections below.

#### A12.2.1 Blocking performance results from a single LTE channel transmission

The blocking performance for each of the AESs terminals listed above in Table A12-1 above was measured against a single 5 MHz LTE channel at 1 512-1 517 MHz, and a summary of the results for the most susceptible terminals Classic Aero (AES E) and SB (AES B) are presented in TABLE A12-2

TABLE A12-2

#### Measured blocking performance levels for Classic aero (AES E) and SB (AES B) resulting from a single LTE channel

Terminal type	Blocking performance (dBm)	Wanted carrier frequency (MHz)
Classic Aero (AES E)	-50.3	1 555.1
SB (AES B)	-40.8	1 525.1



It is important to note that transmissions from LTE channels below 1 512 MHz also cause blocking of the terminals. To illustrate this, the blocking performance levels for Classic Aero (AES E) and SB (AES B) were also measured against an LTE channel at different channels below 1 512 MHz and the results are shown in Table A12-3.

TABLE A12-3

**Measured blocking performance levels for the most susceptible Classic aero (AES E) and SB (AES B) from a single 5 MHz LTE channel at different frequency centres**

LTE centre frequency (MHz)	Blocking performance of Classic aero (AES E) (dBm)	Blocking performance of SB (AES B) (dBm)
1 514.5	-50.3	-40.8
1 509.5	-35	-25.7
1 504.5	-35	> -20
1 499.5	-25	> -20

### A12.2.2 Blocking performance results from multiple LTE channel transmissions

The blocking performance levels for each of the AESs listed in Table **Error! Reference source not found.** A12-1 have also been measured against multiple LTE channels simultaneously transmitting, and the results for the most susceptible Classic aero (AES E) are shown in Table A12-4 for two cases: (1) the three uppermost LTE channels in use; and (2) the two uppermost LTE channels in use.

TABLE A12-4

**Measured blocking performance levels for Classic Aero (AES E) (most susceptible AES) from multiple LTE channels**

Case	Measured blocking performance from LTE channel at 1 492-1 502 MHz (dBm)	Measured blocking performance from LTE channel at 1 502-1 512 MHz (dBm)	Measured blocking performance from LTE channel at 1 512-1 517 MHz (dBm)
(1)	-48.4	-48.4	-55.5
(2)	Not tested*	-45.6	-55.5

\* For case (2), there was no signal generated in the channel 1 492-1 502 MHz.

## A12.3 Blocking performance Levels for Current maritime MES terminals

### A12.3.1 Blocking performance results from a single LTE channel transmission

Three different models of Inmarsat C and Fleet Broadband (FB) have been measured against a single 5 MHz LTE channel at various LTE centre frequencies between 1 512 MHz and 1 517 MHz, and the results are presented in TABLE A12-5

. Also presented are the approximate number and the year of production of each model, and the frequency at which the blocking test was carried out.

TABLE A12-5

**Measured blocking performance levels for models of current Inmarsat C and FB maritime terminals from a single LTE channel**

<b>Terminal type</b>	<b>Measured blocking performance (dBm)</b>	<b>Approx. numbers of terminals</b>	<b>% models within type</b>	<b>Production year</b>	<b>Wanted carrier test frequency (MHz)</b>
Inmarsat C Model 1	-76 to -71	59 000	37%	1995–2005	1 537
Inmarsat C Model 2	-63 to -57	24 000	15%	1992–1995	1 537
Inmarsat C Model 3	-34 to -30	77 000	48%	2005–2018	1 537
FB Model-1	-62	17 000	30%	2005–2013	1 525.1
FB Model-2	-38	8 000	14%	2007–2014	1 525.1
FB Model-3	-30	31 000	55%	2012–2018	1 525.1

TABLE A12-6

and

TABLE A12-7

7 show the impact of interference from additional (lower frequency) LTE channels below 1 517 MHz to Inmarsat C Model 1 and Inmarsat C Model 2, respectively.

TABLE A12-6

**Measured Inmarsat C (Model 1) blocking performance resulting from a single LTE channel at three different frequencies**

<b>Terminal</b>	<b>Measured blocking performance levels from LTE channel at 1 492-1 502 MHz (dBm)</b>	<b>Measured blocking performance levels from LTE channel at 1 502-1 512 MHz (dBm)</b>	<b>Measured blocking performance levels from LTE channel at 1 512-1 517 MHz (dBm)</b>
Model 1	-53	-68	-76

TABLE A12-7

**Measured blocking performance levels for Inmarsat C model-2 from a single 5 MHz LTE channel at different frequency centres**

LTE centre frequency (MHz)	Measured blocking performance from LTE channel (dBm)	Test frequency (MHz)
1 509.5	-50	1 537
1 504.5	-41	1 537
1 499.5	-36	1 537
1 494.5	-32	1 537
1 489.5	-24	1 537
1 484.5	-20	1 537

### A12.3.2 Blocking performance results from multiple LTE channel transmissions

The blocking performance levels for the most susceptible models, Inmarsat C Model 1, Inmarsat C Model 2 and FB Model 1, have also been measured against multiple LTE channels transmitting simultaneously from one MFCN BS for two cases: (1) the three uppermost LTE channels in use; and (2) the two uppermost LTE channels in use, and the results are presented in TABLE A12-8

TABLE A12-8

**Measured blocking performance levels for Inmarsat C Model-1, Inmarsat C Model-2 and FB Model-1 from multiple LTE channels**

Case	Terminal type/model	Measured blocking performance from LTE channel at 1 492-1 502 MHz (dBm)	Measured blocking performance from LTE channel at 1 502-1 512 MHz (dBm)	Measured blocking performance from LTE channel at 1 512-1 517 MHz (dBm)
(1)	FB Model-1	-57	-57	-64
(2)		Not tested*	-55	-65
(1)	Inmarsat C Model 1	-70	-70	-77
(2)		Not tested*	-67	-78
(1)	Inmarsat C Model 2	-55	-55	-63
(2)		Not tested*	-52	-63

\* For case (2), there was no signal generated in the channel 1 492-1 502 MHz

### A12.4 Pfd values

In order to ensure protection of maritime and aeronautical terminals at selected seaports and airports respectively, one option is to apply a protection measure based on pfd limits for IMT BS and this methodology is described in this section. Two phases are proposed with a transition period as described in § A12-1.

To minimise any potential blocking of next generation MES receivers, CEPT concluded in ECC Report 263 that the minimum out-of-band blocking characteristic for land mobile earth stations receivers from a 5 MHz broadband signal interferer (LTE) operating below 1 518 MHz shall be  $-30$  dBm for the band above 1 520 MHz, noting that the IMT block ends at 1 517 MHz. The same blocking level value will be used for next generation maritime and aeronautical MESs. The value of the pfd limit for Phase 2 could be derived based on the  $-30$  dBm blocking requirement above 1 520 MHz.

The value of the PFD limit for Phase 1 (i.e. during the transition period) could be derived by considering a more stringent (lower) value of blocking than  $-30$  dBm. This value could be based on either:

- (a) Measurements conducted by the FCC in 2004:
- or
- (b) blocking measurements performed by some manufacturers (see § A12-2 for aeronautical receivers and § A12-3 for maritime receivers).

Regarding option (a), the pfd levels for this option are derived with reference to measurements of MSS terminals conducted by the United States FCC in 2004. The measurements considered interference from terrestrial mobile equipment transmitting on frequencies in the band 1 525-1 559 MHz to the MSS terminals operating on separated frequencies in the frequency band above 1 525 MHz. FCC document FCC 05-30<sup>12</sup> records testing based on CDMA-2000, GSM/TDMA 800 and GSM 1 800 mobile system architecture. It showed that CDMA-2000 corresponds to a  $-52$  dBm blocking level for 1-2 MHz frequency separation. The blocking level used for this option is  $-50$  dBm for IMT in the band 1 512-1 517 MHz and  $-35$  dBm for the frequencies below. Currently used maritime and aeronautical terminals (e.g. Inmarsat-C and Inmarsat aeronautical terminals) were not included in the tests performed back in 2004. It is noted that IMT-2020 and IMT-Advanced signals could have wider bandwidth than the CDMA-2000 signal used. Hence PFD limits derived from these receiver blocking measurements may not be suitable for protecting currently operating maritime and aeronautical MSS systems.

The FCC in its 2020 Order<sup>13</sup> introduced new measures for mobile equipment, including setting a new e.i.r.p. limit of 9.8 dBW (from 32 dBW) for base stations operating in the band 1 526-1 536 MHz, to reduce the interference impact to other systems and services.

When selecting a MES blocking requirement, it is possible to derive the maximum pfd limit using the following equation:

$$pfd_{max} = I_{max} - Ae_{iso} - G_{MES}$$

where:

- $pfd_{max}$ : maximum power flux-density
- $I_{max}$ : maximum interferer level (i.e. blocking requirement)
- $Ae_{iso}$ : effective aperture area of an isotropic antenna ( $= \frac{\lambda^2}{4\pi}$ )
- $G_{MES}$ : gain of MES in the direction of the BS.

<sup>12</sup> FCC 05-30: "Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands – Memorandum Opinion and Order and Second Order on Reconsideration", February 2005. See <https://docs.fcc.gov/public/attachments/FCC-05-30A1.pdf>

<sup>13</sup> FCC 20-48: "In the Matter of LightSquared Technical Working Group Report – Order and Authorization," 22 April 2020, <https://docs.fcc.gov/public/attachments/FCC-20-48A1.pdf>

The areas in which maritime earth stations and aeronautical earth stations are protected through the application of these pfd limits, as well as the methods applied to achieve these limits, will be defined by administrations.

### Examples of pfd limits based on regulation outside CEPT (option (a))

The pfd limits in this section are based on measurements of MSS terminals conducted by FCC described above.

TABLE A12-9  
pfd limits on MFCN BS transmitting a single channel

Phase	Phase 1			Phase 2		
	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBm/m <sup>2</sup> )
Ports and inland waterways <sup>(1)</sup>	-12.9	-12.9	-27.9	No limit required	2.1	-7.9
Airports <sup>(2)</sup>	-12.9	-12.9	-27.9	No limit required	2.1	-7.9

<sup>(1)</sup> These blocking values assume IMT is CDMA2000; Maritime terminals excluding Inmarsat-C terminals.

<sup>(2)</sup> These blocking values assume IMT is CDMA2000; No Inmarsat aeronautical terminals considered.

TABLE A12-10  
Pfd limits on MFCN BS transmitting multiple channels

Phase	Phase 1			Phase 2		
	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBm/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBm/m <sup>2</sup> )
Ports and inland waterways <sup>(1)</sup>	-12.9	-12.9	-27.9	No limit required	2.1	-7.9
Airports <sup>(2)</sup>	-12.9	-12.9	-27.9	No limit required	2.1	-7.9

<sup>(1)</sup> These blocking values assume IMT is CDMA2000; Maritime terminals excluding Inmarsat-C terminals.

<sup>(2)</sup> These blocking values assume IMT is CDMA2000; No Inmarsat aeronautical terminals considered.

### Examples of pfd limits based on blocking measurements performed by some manufacturers (option (b))

For phase 1, the pfd limits in this section are based on the blocking measurements of the most susceptible terminal performed by some Satcom manufacturers which were presented in §§ A12.2 and A12.3. For phase 2, the pfd limits in Table A12-11 are based on -20 dBm and -30 dBm blocking levels resulting from the band 1 502-1 512 MHz and the band 1 512-1 517 MHz respectively; and the pfd limits in Table A12-12 are based on -23 dBm and -33 dBm blocking levels resulting from the band 1 492-1 512 MHz and the band 1 512-1 517 MHz, respectively.

TABLE A12-11

**Pfd limits on MFCN BS transmitting a single channel**

Phase	Phase 1			Phase 2		
	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )
Ports and waterways	-60.9	-75.9	-83.9	No limit required	-27.9	-37.9
Airports	-32.9	-42.9	-58.2	No limit required	-27.9	-37.9

TABLE A12-12

**Pfd limits on MFCN BS transmitting multiple channels**

Phase	Phase 1		Phase 2	
	pfd limit for BS emissions in the band 1 492-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 492-1 512 MHz (dBW/m <sup>2</sup> )	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m <sup>2</sup> )
Ports and waterways	-74.9	-85.9	-30.9	-40.9
Airports	-53.5	-63.4	-30.9	-40.9