Radiocommunication Study Groups

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IAFI[1]

UPDATE TO WORKING DOCUMENT TOWARDS A PDNR ITU-R M.[CONDITIONS 1.1]

This contribution proposes further updates to IAFI's study on basic transmission loss, specifically, in Section 8.2.1 and Section 8.4 that is:

a) Text added to include the observation that the lowest pfd value for AMS systems using omni-directional antenna is – 116.57 dB(W/(m^2 · MHz)) and – 114.7 dB(W/(m^2 · MHz)) for MMS systems employing omni-directional antenna.

b) In Section 8.2.1.1 the pfd value of -113.7 is replaced with -116.57 and consequential changes made in the section and following section (8.2.1.2).

c) In Section 8.2.1.2 a chart plotting radio horizon distances against altitude is added to provide additional information.

d) In Section 8.4 – Conclusion, text is added with reference to study in section 8.2

The proposed updates/changes are marked up in light grey in below attachment.

[1] ITU-APT Foundation of India (IAFI) is a sector member of ITU

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Annex 4.8 to
Document 5D/1361-E
30 June 2022
English only

Annex 4.8 to Working Party 5D Chairman's Report

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ITU-R M.[CONDITIONS 1.1]

WORKING DOCUMENT RELATED TO WRC-23 AGENDA ITEM 1.1

Technical and regulatory conditions for the protection of stations of the Aeronautical Mobile Service (AMS) and Maritime Mobile Service (MMS) located in international airspace or waters (i.e. outside national territories) and operating in the frequency band 4 800-4 990 MHz

NOTE: The content of this document is very lengthy. On the other hand there is high priority to finalize the CPM text before the deadline of 21 October 2022. On the other hand this document contains elements which is useful for inclusion in the CPM draft report. Consequently, utmost effort to be made to concentrate and focus on the areas which would serve as elements/candidates for consideration and eventual inclusion in the CPM text. After the CPM deadline, efforts would be made to complete this report as soon as possible for timely submission to SG 5.

Editor's note: This document is work in progress and is subject to further scrutiny and improvement by the co-responsible groups, namely WP 5D and WP 5B. Input/comments are being sought from WP 5B, which is the responsible group for AMS and MMS, on the conditions of protection for AMS and MMS stations and the development of the analysis.

1 Introduction

WRC-19 approved WRC-23 agenda item 1.1 calling upon WRC-23 "to consider, based on the results of ITU-R studies, possible measures to address, in the frequency band 4 800-4 990 MHz, protection of stations of the aeronautical and maritime mobile services located in international airspace and waters from other stations located within national territories, and to review the power flux-density criteria in RR No. **5.441B** in accordance with Resolution **223 (Rev.WRC-19)**".

Resolution **223 (Rev.WRC-19)**:

– *invites the ITU Radiocommunication Sector* to study the technical and regulatory conditions for the protection of stations of the AMS and the maritime mobile service

(MMS) located in international airspace or waters (i.e. outside national territories) and operated in the frequency band 4 800-4 990 MHz;

– *invites the 2023 World Radiocommunication Conference* to consider, based on the results of the studies referred to in *invites the ITU Radiocommunication Sector* above, possible measures to address, in the frequency band 4 800-4 990 MHz, protection of stations of the AMS and MMS located in international airspace and waters from other stations located within national territories and to review the pfd criteria in RR No. **5.441B**.

This Report focuses on studies of technical and regulatory conditions for the protection of AMS and MMS stations located in international airspace or in international waters (i.e. outside national territories) and operating in the frequency band 4 800-4 990 MHz.

The term *operation of vessels and aircrafts in international waters and international airspace*, respectively, referred to in WRC-23 agenda item 1.1, is understood to mean that such operation would take place in an area which is outside the territory under jurisdiction of any administration.

Editor's note: the text in square brackets below presents a new approach to the definition of international waters and airspace. Both the proposed approach and the text have not been exhaustively discussed. The text was therefore placed in square brackets. At the June WP 5D meeting a contribution 5D/1205 proposed to delete this text. Decision on this proposal is pending further consideration.

2 Relevant ITU-R Recommendations and Reports

Recommendation ITU-R M.2116	*Technical characteristics and protection criteria for the aeronautical mobile service systems operating within the 4 400-4 990 MHz frequency range*
Report ITU-R M.2286	*Operational characteristics of aeronautical mobile telemetry*
Report ITU-R M.2119	*Sharing between aeronautical mobile telemetry systems for flight testing and other systems operating in the 4 400-4 940 and 5 925-6 700 MHz bands*
Recommendation ITU-R P.528	*A propagation prediction method for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands*
Recommendation ITU-R P.617	*Propagation prediction techniques and data required for the design of trans-horizon radio-relay systems*

[TBD]

3 General description of systems of the aeronautical mobile service operated in international airspace in the frequency band 4 800-4 990 MHz

TBD

4 General description of systems of the maritime mobile service operated in international waters in the frequency band 4 800-4 990 MHz

TBD

5 System characteristics and protection criteria

Editor's note: Information under sub-sections 5.1 and 5.2 may need to be revised following further input from WP 5B

5.1 System characteristics and protection criteria of aeronautical mobile service systems in international airspace in the frequency band 4 800-4 990 MHz

5.1.1 Technical characteristics of aeronautical mobile systems

Technical characteristics for aeronautical mobile stations can be found in Table 1.

TABLE 1

Typical technical characteristics of representative systems operating in the aeronautical mobile service in the frequency range 4 400-4 990 MHz

<table>
<tr><th>Parameter</th><th>Units</th><th>System 1
Airborne</th><th colspan="3">System 1
Ground</th><th>System 2
Airborne</th><th colspan="3">System 2
Ground</th></tr>
<tr><td colspan="10">Transmitter</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td>4 400-4 990(1)</td><td colspan="3">4 400-4 990(1)</td><td>4 400-4 990(1)</td><td colspan="3">4 400-4 990(1)</td></tr>
<tr><td>Power output</td><td>dBm</td><td>45</td><td colspan="3">45</td><td>35-39</td><td colspan="3">30-39</td></tr>
<tr><td>Bandwidth (3 dB)</td><td>MHz</td><td>1</td><td colspan="3">1</td><td>6 / 10 / 20</td><td colspan="3">6 / 10 / 20</td></tr>
<tr><td colspan="10">Receiver</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td>4 400-4 990(1)</td><td colspan="3">4 400-4 990(1)</td><td>4 400-4 990(1)</td><td colspan="3">4 400-4 990(1)</td></tr>
<tr><td>Selectivity (3 dB)</td><td>MHz</td><td>1</td><td colspan="3">1</td><td>6 / 10 / 20</td><td colspan="3">6 / 10 / 20</td></tr>
<tr><td>Noise figure</td><td>dB</td><td>3.5</td><td colspan="3">3</td><td>3.5</td><td colspan="3">3</td></tr>
<tr><td>Thermal noise level</td><td>dBm</td><td>−110.5</td><td colspan="3">−111</td><td>−102.5 to −97.5</td><td colspan="3">−103 to −98</td></tr>
<tr><td colspan="10">Antenna</td></tr>
<tr><td>Antenna type</td><td></td><td>Omnidirectional</td><td>Omni-directional</td><td colspan="2">Directional</td><td>Omnidirectional</td><td>Omni-directional</td><td colspan="2">Directional</td></tr>
<tr><td>Antenna gain</td><td>dBi</td><td>3</td><td>3</td><td>19</td><td>31</td><td>3</td><td>6</td><td>19</td><td>31</td></tr>
<tr><td>1st sidelobe</td><td>dBi</td><td>N/A(2)</td><td>N/A(2)</td><td>6</td><td>11</td><td>N/A(2)</td><td>N/A(2)</td><td>6</td><td>11</td></tr>
<tr><td>Polarization</td><td></td><td>Vertical</td><td>Vertical</td><td colspan="2">Vertical</td><td>Vertical</td><td>Vertical</td><td colspan="2">Vertical</td></tr>
<tr><td>Antenna pattern</td><td></td><td>N/A(2)</td><td>N/A(2)</td><td colspan="2">Uniform distribution(3)</td><td>N/A(2)</td><td>N/A(2)</td><td colspan="2">Uniform distribution(3)</td></tr>
<tr><td>Horizontal beamwidth</td><td>Degrees</td><td>360</td><td>360</td><td>16</td><td>3.3</td><td>360</td><td>360</td><td>16</td><td>3.3</td></tr>
<tr><td>Vertical beamwidth</td><td>Degrees</td><td>90</td><td>90</td><td>16</td><td>3.3</td><td>90</td><td>90</td><td>16</td><td>3.3</td></tr>
</table>

TABLE 1 (*continued*)

<table>
<tr><th>Parameter</th><th>Units</th><th colspan="2">System 3
Airborne</th><th colspan="2">System 3
Ground [and shipborne]</th><th colspan="2">System 4
Airborne</th><th colspan="2">System 4
Ground</th></tr>
<tr><td colspan="10">Transmitter</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td></tr>
<tr><td>Power output</td><td>dBm</td><td colspan="2">42-50</td><td colspan="2">42</td><td colspan="2">43</td><td colspan="2">37</td></tr>
<tr><td>Bandwidth (3 dB)</td><td>MHz</td><td colspan="2">0.158 / 0.97 / 1.23 / 4.0</td><td colspan="2">0.158 / 0.97 / 1.23 / 4.0</td><td colspan="2">0.158 / 2.4 / 4.8 / 9.6</td><td colspan="2">0.158 / 2.4 / 4.8 / 9.6</td></tr>
<tr><td colspan="10">Receiver</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td><td colspan="2">4 400-4 940(1)</td></tr>
<tr><td>Selectivity (3 dB)</td><td>MHz</td><td colspan="2">0.2 / 1 / 1.5 / 4.5</td><td colspan="2">0.2 / 1 / 1.5 / 4.5</td><td colspan="2">0.2 / 2.6 / 5.0 / 10</td><td colspan="2">0.2 / 2.6 / 5.0 / 10</td></tr>
<tr><td>Noise figure</td><td>dB</td><td colspan="2">2.5</td><td colspan="2">2.5 (ground) / [6 (shipborne)]</td><td colspan="2">2.5</td><td colspan="2">3</td></tr>
<tr><td>Thermal noise level</td><td>dBm</td><td colspan="2">−118.5 to −105.0</td><td colspan="2">−118.5 to −105.0</td><td colspan="2">−118.5 to −101.5</td><td colspan="2">−118 to −101</td></tr>
<tr><td colspan="10">Antenna</td></tr>
<tr><td>Antenna type</td><td></td><td>Omni-directional</td><td>Directional</td><td>Omni-directional</td><td>Directional</td><td>Omni-directional</td><td>Directional</td><td>Omni-directional</td><td>Directional</td></tr>
<tr><td>Antenna gain</td><td>dBi</td><td>3.5</td><td>16</td><td>3</td><td>30</td><td>4.5</td><td>16</td><td>4</td><td>30</td></tr>
<tr><td>1st sidelobe</td><td>dBi</td><td>N/A(2)</td><td>9</td><td>N/A(2)</td><td>17</td><td>N/A(2)</td><td>9</td><td>N/A(2)</td><td>17</td></tr>
<tr><td>Polarization</td><td></td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td></tr>
<tr><td>Antenna pattern</td><td></td><td>N/A(2)</td><td>Uniform distribution(3)</td><td>N/A(2)</td><td>Uniform distribution(3)</td><td>N/A(2)</td><td>Uniform distribution(3)</td><td>N/A(2)</td><td>Uniform distribution(3)</td></tr>
<tr><td>Horizontal beamwidth</td><td>degrees</td><td>360</td><td>33</td><td>360</td><td>4.4</td><td>360</td><td>33</td><td>360</td><td>4.4</td></tr>
<tr><td>Vertical beamwidth</td><td>degrees</td><td>35</td><td>33</td><td>40</td><td>4.4</td><td>35</td><td>33</td><td>60</td><td>4.4</td></tr>
</table>

TABLE 1 (*continued*)

Parameter	Units	System 5 Airborne		System 5 Ground [and shipborne]		
Transmitter						
Tuning range	MHz	4 400-4 990[1]		4 400-4 990[1]		
Power output	dBm	45		45		
Bandwidth (3 dB)	MHz	0.4 / 3 / 8.5		0.4 / 3 / 8.5		
Receiver						
Tuning range	MHz	4 400-4 990[1]		4 400-4 990[1]		
Selectivity (3 dB)	MHz	0.4 / 3 / 17		0.4 / 3 / 17		
Noise figure	dB	3.5		3.5 (ground) / [6 (shipborne)]		
Thermal noise level	dBm	–118.5 to –105.0		–118.5 to –105.0		
Antenna						
Antenna type		Omni-directional	Directional	Omni-directional	Directional	
Antenna gain	dBi	3	19	3	19	31
1st sidelobe	dBi	N/A[2]	6	N/A[2]	6	11
Polarization		Vertical	Vertical	Vertical	Vertical	
Antenna pattern		N/A[2]	see equation in [4]	N/A[2]	[see equation in [4] [5] /Uniform distribution[3]]	
Horizontal beamwidth	degrees	360	16	360	16	3.3
Vertical beamwidth	degrees	90	16	360	16	3.3

Notes:

[1] RR No. **5.442** applies.

[2] N/A – Not applicable.

[3] Refer to Recommendation ITU-R M.1851.

[4] For antenna gain 19 dBi: $G(\psi) = 20.\log_{10}(|sinc(3.19\pi \sin(\psi))|) + 19.0 \ \forall\psi \in [-68.43°, 68.43°]$ and $G(\psi) = -20$ otherwise. Here, $\mathrm{sinc}(x) = \frac{\sin(x)}{x} \ \forall \ x \neq 0$ (x in radians) and $\mathrm{sinc}(0) = 1$.

(5) For antenna gain 31 dBi: $G\psi = 20.\log10 \, sinc \, 15.5\pi \sin\psi + 31.0 \;\; \forall\psi \in -64.25°, 64.25°$ and $G(\psi) = -20$ otherwise. Here, $\mathrm{sinc}(x) = \frac{\sin(x)}{x} \;\; \forall \, x \neq 0$ (x in radians) and $\mathrm{sinc}(0) = 1$.

[Editor's note: The need of this equation should be confirmed. One possible solution is to keep using footnote (3) in case of uniform distribution]

In the Table "-" means range of values, and "/" means discrete values.

[Editor's note: The noise figure in some parts of Table 1 needs to be further clarified]

TABLE 1 (*continued*)

<table>
<tr><th>Parameter</th><th>Units</th><th>System 6
Airborne 1</th><th>System 6
Airborne 2</th><th colspan="2">System 6
Ship borne</th><th colspan="2">System 6
Ground</th></tr>
<tr><td colspan="8">Transmitter</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td>4 800-4 990</td><td>4 800-4 990</td><td colspan="2">4 800-4 990</td><td colspan="2">4 800-4 990</td></tr>
<tr><td>Power output</td><td>dBm</td><td>27-33</td><td>27-33</td><td colspan="2">35</td><td colspan="2">35</td></tr>
<tr><td>Bandwidth (3 dB)</td><td>MHz</td><td>5/10/20/40 (software configurable)</td><td>5/10/20/40 (software configurable)</td><td colspan="2">5/10/20/40 (software configurable)</td><td colspan="2">5/10/20/40 (software configurable)</td></tr>
<tr><td colspan="8">Receiver</td></tr>
<tr><td>Tuning range</td><td>MHz</td><td>4 800-4 990</td><td>4800-4 990</td><td colspan="2">4 800-4 990</td><td colspan="2">4 800-4 990</td></tr>
<tr><td>Selectivity (3 dB)</td><td>MHz</td><td>5/10/20/40</td><td>5/10/20/40</td><td colspan="2">5/10/20/40</td><td colspan="2">5/10/20/40</td></tr>
<tr><td>Noise figure</td><td>dB</td><td>6</td><td>6</td><td colspan="2">6</td><td colspan="2">4</td></tr>
<tr><td>Thermal noise level</td><td>dBm</td><td>−101 to -92</td><td>−101 to -92</td><td colspan="2">−103 to −94</td><td colspan="2">−103 to −94</td></tr>
<tr><td colspan="8">Antenna</td></tr>
<tr><td>Antenna type</td><td></td><td>Omnidirectional</td><td>Omnidirectional</td><td>Omni-directional</td><td>Directional</td><td>Omni-directional</td><td>Directional</td></tr>
<tr><td>Antenna gain</td><td>dBi</td><td>4.7</td><td>4.7</td><td>6</td><td>11.8</td><td>6</td><td>11.8</td></tr>
<tr><td>1st sidelobe</td><td>dBi</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Note 2</td><td>N/A</td><td>Note 2</td></tr>
<tr><td>Polarization</td><td></td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td><td>Vertical</td></tr>
<tr><td>Antenna pattern</td><td></td><td>N/A</td><td>N/A</td><td>Note 1</td><td>Note 2</td><td>Note 1</td><td>Note 2</td></tr>
<tr><td>Horizontal beamwidth</td><td>Degrees</td><td>360</td><td>360</td><td>360</td><td>30</td><td>360</td><td>30</td></tr>
<tr><td>Vertical beamwidth</td><td>Degrees</td><td>90</td><td>90</td><td>28</td><td>18</td><td>28</td><td>18</td></tr>
</table>

TABLE 1 (*continued*)

Parameter	**Units**	**System 7 Airborne 1**	**System 7 Airborne 2**
Transmitter			
Tuning range	MHz	4 400-4 990	4 400-4 990
Power output	dBm	30-43	30-43
Bandwidth (3 dB)	MHz	5 / 0.008	5 / 0.008
Receiver			
Tuning range	MHz	4 400-4 990	4 400-4 990
Selectivity (3 dB)	MHz	5 / 0.008	5 / 0.008
Noise figure	dB	[6]	6
Thermal noise level	dBm	-103 / −131	-103/ −131
Antenna			
Antenna type		Directional	Directional
Antenna gain	dBi	14	14
1st sidelobe	dBi	-1	-1
Polarization		Vertical	Vertical
Antenna pattern		Uniform distribution (Refer to Rec. ITU-R M.1851)	Uniform distribution (Refer to Rec. ITU-R M.1851)
Horizontal beamwidth	Degrees	24	28
Vertical beamwidth	Degrees	24	28

TABLE 1 *(end)*

Parameter	Units	System 8 Airborne	System 8 Ground	System 8 Shipborne
Transmitter				
Tuning range	MHz	4 800-4 990	4 800-4 990	4 800-4 990
Power output	dBm	26	46	46
Bandwidth (3 dB)	MHz	40/50/60/80/100 (software configurable)	40/50/60/80/100 (software configurable)	40/50/60/80/100 (software configurable)
Receiver				
Tuning range	MHz	4 800-4 990	4 800-4 990	4 800-4 990
Selectivity (3 dB)	MHz	40/50/60/80/100	40/50/60/80/100	40/50/60/80/100
Noise figure	dB	9	5	5
Thermal noise level	dBm	−89 … -85	−93 … -89	−93 … -89
Antenna				
Antenna type		Omnidirectional	Directional (steerable, MIMO)	Directional (steerable, MIMO)
Antenna gain	dBi	0	15	15
1^{st} sidelobe	dBi	N/A	N/A	N/A
Polarization		Vertical	Vertical	Vertical
Antenna pattern		N/A	Rec ITU-R F.1336	Rec ITU-R F.1336
Horizontal beamwidth	Degrees	360	65	65
Vertical beamwidth	Degrees	90	90	90

5.1.2 Protection criteria for aeronautical mobile systems

An increase in receiver effective noise of 1 dB would result in significant degradation in communication range.

Such an increase in effective receiver noise level corresponds to an $(I + N)/N$ ratio of 1.26, or an I/N ratio of about −6 dB. This represents the required protection criterion for the AMS systems referenced herein from interference due to another radiocommunication service. If multiple potential interference sources are present, protection of the AMS and MMS systems requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

5.2 System characteristics and protection criteria of maritime mobile service systems in international waters in the frequency band 4 800-4 990 MHz

5.2.1 Technical characteristics of maritime mobile systems

Technical characteristics for aeronautical mobile stations can be found in Table 2.

TABLE 2

Typical technical characteristics of representative systems operating in the maritime mobile service in the frequency range 4 400-4 990 MHz

Parameter	Units	System 1 Shipborne			System 1 Ground			System 2 Shipborne	System 2 Ground
Transmitter									
Tuning range	MHz	4 400-4 940			4 400-4 940			4 800-4 990	4 800-4 990
Power output	dBm	39			39			46	46
Bandwidth (3 dB)	MHz	5.6/11.3/22.6			5.6/11.3/22.6			40/50/60/80/100 (software configurable)	40/50/60/80/100 (software configurable)
Receiver									
Tuning range	MHz	4 400-4 940			4 400-4 940			4 800-4 990	4 800-4 990
Selectivity (3 dB)	MHz	5.6/11.3/22.6			5.6/11.3/22.6			40/50/60/80/100	40/50/60/80/100
Noise figure	dB	6			6			5	5
Thermal noise level	dBm	-100.5 to -94.5			-100.5 to -94.5			−93 … -89	−93 … -89
Antenna									
Antenna type		Omnidirectional			Omni-directional			Directional (steerable, MIMO)	Directional (steerable, MIMO)
Antenna gain	dBi	6	4.2	2.5	6	4.2	2.5	15	15
1st sidelobe	dBi	N/A[(1)]			N/A[(1)]			N/A[(1)]	N/A[(1)]
Polarization		Vertical			Vertical			Vertical	Vertical
Antenna pattern		N/A[(1)]			N/A[(1)]			Rec ITU-R F.1336	Rec ITU-R F.1336
Horizontal beamwidth	Degrees	360			360			65	65
Vertical beamwidth	Degrees	30	37	69	30	37	69	90	90

Notes:

(1) N/A – Not applicable.

5.2.2 Protection criteria for maritime mobile systems

An increase in receiver effective noise of 1 dB would result in significant degradation in communication range.

Such an increase in effective receiver noise level corresponds to an $(I + N)/N$ ratio of 1.26, or an I/N ratio of about −6 dB. This represents the required protection criterion for the MMS systems referenced herein from interference due to another radiocommunication service. If multiple potential interference sources are present, protection of the MMS systems requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

5.3 System Characteristics of IMT systems operated in the band 4 800-4 990 MHz

Tables 3 and 4 provide the deployment-related parameters of IMT systems for the frequency bands between 3 and 6 GHz. Implementation of AAS (see Table 5) as well as antenna characteristics in Recommendation ITU-R F.1336 are considered for IMT base stations in these frequency bands. For IMT user equipment / mobile stations, implementation of AAS is not considered.

Note A to Table 3 and Table 4 below:
For the 3-6 GHz range, contiguous coverage is not expected in this frequency range in rural areas, and any such base stations that may exist in small numbers will be isolated installations at specific locations, and therefore, the rural deployment environment may or may not be included in the sharing and compatibility studies, depending on the area of study.

TABLE 3

Deployment-related parameters for bands between 3 and 6 GHz

	Rural (optional, see Note A below)	**Urban/suburban macro**	**Small cell (outdoor)/Micro cell**	**Indoor (small cell)**
Base station characteristics/Cell structure				
Cell radius / Deployment density (non-AAS)	1.2 km / isolated BSs or a cluster of four BSs with the density of 0.001-0.006 BSs/km^2 (Note 2)	Typical cell radius 0.3 km urban / 0.6 km suburban	1-3 per urban macro cell <1 per suburban macro site	Depending on indoor coverage/ capacity demand
Cell radius / Deployment density (AAS)	1.6 km / isolated BSs or a cluster of four BSs with the density of 0.001-0.006 BSs/km^2 (Note 2)	Typical cell radius 0.4 km urban / 0.8 km suburban (10 BSs/km^2 urban / 2.4 BSs/km^2 suburban (Note 2))	1-3 per urban macro cell <1 per suburban macro site	Depending on indoor coverage/ capacity demand
Antenna height	35 m	20 m urban / 25 m suburban	6 m	3 m
Sectorization	3 sectors	3 sectors	Single sector	Single sector
Non-AAS BS downtilt (Note 1)	3 degrees	10 degrees urban / 6 degrees suburban	n.a.	n.a.
Frequency reuse	1	1	1	1
Non-AAS BS antenna pattern (Note 1)	Rec. ITU-R F.1336 (*recommends* 3.1) $ka = 0.7$ $kp = 0.7$ $kh = 0.7$	Rec. ITU-R F.1336 (*recommends* 3.1) $ka = 0.7$ $kp = 0.7$ $kh = 0.7$	Rec. ITU-R F.1336 (omni: *recommends* 2)	

	Rural (optional, see Note A below)	**Urban/suburban macro**	**Small cell (outdoor)/Micro cell**	**Indoor (small cell)**
	kv = 0.3 Horizontal 3 dB beamwidth: 65 degrees Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Rec. ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.	*kv* = 0.3 Horizontal 3 dB beamwidth: 65 degrees Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Rec. ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.		
Non-AAS BS antenna polarization	Linear/±45 degrees	Linear/±45 degrees	Linear	Linear
Indoor base station deployment	n.a.	n.a.	n.a.	100%
Indoor base station penetration loss	n.a.	n.a.	n.a.	Rec. ITU-R P.2109
Below rooftop base station antenna deployment	0%	Urban: 50% Suburban: 0%	100%	n.a.
Non-AAS BS feeder loss (Note 1)	3 dB	3 dB	3 dB	3 dB
Typical channel bandwidth	40 or 80 or 100 MHz	40 or 80 or 100 MHz	40 or 80 or 100 MHz	40 or 80 or 100 MHz
Maximum Non-AAS BS output power (Note 1)	52 dBm in 40 MHz 55 dBm in 80 MHz 56 dBm 100 MHz	49 dBm in 40 MHz 52 dBm in 80 MHz 53 dBm in 100 MHz	24 dBm in 40 or 80 or 100 MHz	24 dBm in 40 or 80 or 100 MHz
Maximum Non-AAS BS antenna gain (Note 1)	18 dBi	18 dBi	5 dBi	0 dBi
Maximum Non-AAS BS output power/sector (e.i.r.p.) (Note 1)	67 dBm in 40 MHz 70 dBm in 80 MHz 71 dBm in 100 MHz	64 dBm in 40 MHz 67 dBm in 80 MHz 68 dBm in 100 MHz	29 dBm in 40 or 80 or 100 MHz	24 dBm in 40 or 80 or 100 MHz
Network loading factor (base station load probability X%) (see section 3.4 below and Rec. ITU-R M.2101 Annex 1, section 3.4.1 and 6)	50%	20%, 50%	20%, 50%	20%, 50%
Average Non-AAS BS power/sector (e.i.r.p.) taking into account activity factor (Note 1)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)	Use Rec. ITU-R M.2101 (see section 3.4 below)
TDD / FDD	TDD	TDD	TDD	TDD
BS TDD activity factor	75%	75%	75%	75%

Note 1: This parameter is only applicable for non-AAS base stations. Antenna characteristics for AAS base stations (for frequency bands above 1710 MHz) are provided in Table 9.

	Rural (optional, see Note A below)	**Urban/suburban macro**	**Small cell (outdoor)/Micro cell**	**Indoor (small cell)**

Note 2: "1 BS" = 1 sector in 3-sector cell.

TABLE 4

UE parameters for bands between 3 and 6 GHz

	Rural (optional, see Note A above)	**Urban/suburban macro**	**Small cell (outdoor)/Micro cell**	**Indoor (small cell)**
User terminal characteristics				
Indoor user terminal usage	50%	70%	70%	100%
Indoor user terminal penetration loss	Rec. ITU-R P.2109 (traditional building)	Rec. ITU-R P.2109	Rec. ITU-R P.2109	Rec. ITU-R P.2109
User equipment density for terminals that are transmitting simultaneously (Note 1)	3 UEs per sector	3 UEs per sector	3 UEs per sector	3 UEs per sector
UE height (Note 2)	1.5 m	1.5 m	1.5 m	1.5 m
Average user terminal output power	Use transmit power control	Use transmit power control	Use transmit power control	Use transmit power control
Typical antenna gain for user terminals	−4 dBi	−4 dBi	−4 dBi	−4 dBi
Body loss	4 dB	4 dB	4 dB	4 dB
UE TDD activity factor	25%	25%	25%	25%
Transmit power control				
Power control model	Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1			
Maximum user terminal output power, PCMAX	23 dBm	23 dBm	23 dBm	23 dBm
Power (dBm) target value per RB, P0_PUSCH (Note 3)	−92.2	−92.2	−87.2	−87.2
Path loss compensation factor, α (same as "balancing factor" mentioned in Rec. ITU-R M.2101)	0.8	0.8	0.8	0.8

Note 1: UEs share equally the channel bandwidth, i.e. each UE is allocated 1/3 of the channel bandwidth (see Rec. ITU-R M.2101, Section 3.4.1, item 1e-f.). In sharing studies, it is assumed that the AAS BS beamforms towards each UE using the entire array.

Note 2: In principle, indoor UEs are distributed over different floors of the building. It should be noted that the number of floors of buildings vary within the environment and among the countries. Moreover, the number of floors of buildings is not related to Macro BS antenna height (parameter given in the Table). In particular in small cities, sub-urban and rural areas, many or most of antennas are installed on masts. Therefore, for outdoor BSs, indoor UEs are assumed to be modelled on the ground floor for the sharing study.

Note 3: The target power is defined per Resource Block (RB), considering 180 kHz RB bandwidth corresponding to 15 kHz subcarrier spacing.

TABLE 5

Beamforming antenna characteristics for IMT in 1 710-4 990 MHz

		Rural macro	**Suburban macro**	**Urban macro**	**Urban small cell (outdoor)/Micro cell**	**Indoor (small cell)**
1	**Base station antenna characteristics**					
1.1	Antenna pattern	Refer to the extended AAS model in Table A of Annex 3			Refer to section 5 of Rec. **Error! Hyperlink reference not valid.**	N/A
1.2	Element gain (dBi) (Note 1)	6.4	6.4	6.4	6.4	N/A
1.3	Horizontal/vertical 3 dB beam width of single element (degree)	90º for H 65º for V	90º for H 65º for V	90º for H 65º for V	90º for H 65º for V	N/A
1.4	Horizontal/vertical front-to-back ratio (dB)	30 for both H/V	30 for both H/V	30 for both H/V	30 for both H/V	N/A
1.5	Antenna polarization	Linear ±45º	Linear ±45º	Linear ±45º	Linear ±45º	N/A
1.6	Antenna array configuration (Row × Column) (Note 2)	4 × 8 elements	4 × 8 elements	4 × 8 elements	8 × 8 elements	N/A
1.7	Horizontal/Vertical radiating element/sub-array spacing, d_h /d_v	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 2.1 of wavelength for V	0.5 of wavelength for H, 0.7 of wavelength for V	N/A
1.7a	Number of element rows in sub-array, M_{sub}	3	3	3	N/A	N/A
1.7b	Vertical radiating element spacing in sub-array, $d_{v,sub}$	0.7 of wavelength of V	0.7 of wavelength of V	0.7 of wavelength of V	N/A	N/A
1.7c	Pre-set sub-array down-tilt, $\theta_{subtilt}$ (degrees)	3	3	3	N/A	N/A
1.8	Array Ohmic loss (dB) (Note 1)	2	2	2	2	N/A
1.9	Conducted power (before Ohmic loss) per antenna element/sub-array (dBm) (Note 5, 6)	28	28	28	16	N/A
1.10	Base station horizontal coverage range (degrees)	±60	±60	±60	±60	N/A
1.11	Base station vertical coverage range (degrees) (Notes 3, 4, 7)	90-100	90-100	90-100	90-120	N/A
1.12	Mechanical downtilt (degrees) (Note 4)	3	6	6	10	N/A
1.13	Maximum base station output power/sector (e.i.r.p.) (dBm)	72.28	72.28	72.28	61.53	N/A

Note 1: The element gain in row 1.2 includes the loss given in row 1.8 and is per polarization. This means that this parameter in row 1.8 is not needed for the calculation of the BS composite antenna gain and e.i.r.p.

Note 2: For the small/micro cell case, 8 × 8 means there are 8 vertical and 8 horizontal radiating elements. For the extended AAS model case, 4 × 8 means there are 4 vertical and 8 horizontal radiating sub-arrays.

Note 3: The vertical coverage range is given in global coordinate system, i.e. 90° being at the horizon.

Note 4: The vertical coverage range in row 1.11 includes the mechanical downtilt given in row 1.12.

Note 5: The conducted power per element assumes 8 × 8 × 2 elements for the micro/small cell case, and 4 × 8 × 2 sub-arrays for the macro case (i.e. power per H/V polarized element).

Note 6: In sharing studies, the transmit power calculated using row 1.9 is applied to the typical channel bandwidth given in Table 5-1 and 6-1 respectively for the corresponding frequency bands.

Note 7: In sharing studies, the UEs that are below the base station vertical coverage range can be considered to be served by the "lower" bound of the electrical beam, i.e. beam steered towards the max. coverage angle. A minimum BS-UE distance along the ground of 35 m should be used for urban/suburban and rural macro environments, 5 m for micro/outdoor small cell, and 2 m for indoor small cell/urban scenarios.

6 Propagation models

Regarding propagation, one approach used in *some studies* is to assume free space propagation above clutter. Recommendation ITU-R P.2108 (§ 3.2 for MMS and § 3.3 for AMS) has been used to implement a clutter layer in urban areas, with p-factor as a random variable of uniform law between 0 *and* 100%. Clutter has not been applied in suburban areas considering that IMT antenna height is 25 m and buildings are assumed to be typically 10 m height. It has been applied on half of the urban sites considering the assumption that half of IMT base stations are above the clutter.

In the studies for clutter loss estimation Recommendation ITU-R P.2108 may be used. In many countries, typical urban and suburban clutter may reach heights higher than 20-25 meters. Therefore, depending on the reviewed area, the clutter can be applied to urban and suburban areas.

To estimate the pathloss level at the sea path, Recommendation ITU-R P.452 may be used.

Recommendation ITU-R P.528 contains a method for predicting basic transmission loss in the frequency range 100 MHz to 30 GHz for aeronautical services: for air-to-air, ground-to-air, and air-to-ground paths. It provides a step-by-step method to compute the basic transmission loss for time percentages of 1 to 99%. The only data needed for this method are the distance between antennas, the heights of the antennas above mean sea level, the frequency, the polarization, and the time percentage. According to *recommends* 1 of Recommendation ITU-R P.528, the integral software in the Recommendation should be used to generate basic transmission loss values and curves for terminal heights, frequencies, and time percentages likely to be encountered in the aeronautical services.

Basic transmission loss is defined in recommends 1.2 of Recommendation ITU-R P.341 as follows:

Basic transmission loss (of a radio link) (symbols: Lb or Ab): The ratio, usually expressed in decibels, for a radio link between the power radiated by the transmitting antenna and the power that would be available at a conjugately matched receiver antenna input if the antennas were replaced by isotropic antennas with the same polarization as the real antennas, including the attenuation effects on the propagation path, but with the effects of obstacles close to the antennas being disregarded.

$$Lb = Lbf + Lm \qquad \text{dB,}$$

where Lm is the loss relative to free space (symbols: Lm or Am).

Editor's note: There is a consideration to swap Sections 8 and 9

7 Technical studies

[TBD]

Editor's note: Elements of Section 8 suitable for further discussion with the view to be included in the CPM text should be identified and worked on – Iran

Editor's note: Section 8 may be further split into several subsections based on different approaches.

Editor's note: This Section should be reviewed after the regulatory studies are concluded.

Editor's Note: Irrespective of any results obtained from theoretical calculations of the value of pfd which is required at the receiver of AMS/MMS it is understood that every possible effort wis to be made to agree on a workable pfd which allows both systems, AMS/MMS on one hand and IMT on the other hand, to function satisfactorily.

8 General considerations on the reference distance from the costal baseline for deriving technical conditions

Editor's note: further discussion on UNCLOS is required (ref. documents 5D/1094 and 5D/1300)

[As mentioned in the Introduction, the United Nations Convention on the Law of the Sea (the UNCLOS) establishes that a costal state has jurisdiction and sovereign rights for the various activities related to the economic exploitation and exploration in its so called "*exclusive economic zone*" (EEZ) defined as an area beyond and adjacent to the territorial sea. The EEZ can extend up to 200 nautical miles (370.4 km) from the baselines from which the breadth of the territorial sea is measured.

It is therefore appropriate to constrain the discussion in the context of AI 1.1 of WRC-23 on the possible protection of operations of vessels and aircraft in international waters and international airspace respectively by the area beyond the boundary of the costal state's exclusive economic zone. Such an approach does not imply that the UNCLOS regulates in some sense the international aspects of using radio frequency spectrum (which is the subject for the ITU Radio Regulations) but it is used solely as a widely recognized reference for defining the boundaries of the various maritime zones in the context of AI 1.1 of WRC-23.

Therefore, the curve on the water surface which should be used as reference for deriving the technical conditions for protection of AMS/MMS applications (at the heights typical for their operations respectively) should correspond to the external boundary of the costal state's "exclusive economic zone" having a maximum breadth. Such a reference curve would be located 370.4 km away from the costal baseline but could be closer in certain geographical situations. In such situations, the technical conditions defined at the reference curve corresponding to the maximum breadth of the costal state's EEZ (i.e. at 370.4 km away from the costal baseline) would be scaled to correspond to the actual length of the EEZ in question.

If the actual breadth of the costal state's EEZ is larger than the maximum distance from the costal baseline at which technical studies show that AMS and MMS systems would be protected without any restrictions on IMT systems of the costal state, then no conditions on the operation of the mentioned IMT systems with respect to the protection of the AMS and MMS applications in international airspaces and waters respectively would be required.

Finally, the results of the technical studies provided in the following sub-sections could be scaled to correspond to the same heights but at the distance corresponding to the external boundary of the costal state's EEZ having a maximum breadth, i.e. to the distance of 370.4 km from the costal baseline.]

8.1 Methodology to derive a pfd limit

This section provides a method calculating the power flux density at the AMS/MMS receiver. The following equation provides the calculation required to convert the interference to noise ratio (*I/N*) to the pfd at the AMS/MMS receiver:

$$pfd_{agg} \leq 10log_{10}(kTB) + NF + \frac{I}{N} - 10log_{10}(\frac{\lambda^2}{4\pi}) - G_r + L_f \text{ dB(W/}(m^2\text{*MHz))} \quad (1)$$

Where:

Pfd_{agg}: power flux density at the receiving antenna surface of the AMS/MMS system[2] dB(W/(m^2*MHz);

B: reference bandwidth (1 MHz);

k: Boltzmann's constant;

T: noise temperature of receiver (300 K);

NF: noise figure of the AMS/MMS system (dB);

I/N: interference to noise ratio protection criterion (-6 dB);

G_r: gain of AMS/MMS in the direction of source of interference (dBi);

L_f: feeder loss (dB) .

Table 6 provides the calculations for the pfd required to protect AMS systems when the interferer located in the maximum receiving antenna gain direction based upon the characteristics provided in Table 1. It should be noted that some of the AMS systems contain a shipborne component and therefore will be considered in Table 6. Table 7 provides the calculations for the pfd required to protect MMS systems based upon the characteristics provided in Table 2. These calculations assume a wavelength of 0.0612m (corresponding to a frequency of 4 900 MHz) which yield an effective aperture constant ($(\frac{\lambda^2}{4\pi})$ of 0.000298. These calculations also assume the AMS/MMS systems are pointing towards the interferer with their maximum gain. Both Tables 6 and 7 assume a *I/N* protection criteria of –6 dB.

[Editor's note: The conversion from I/N to PFD needs to take into account all losses between receiver antenna and receiver input (e.g. feeder loss). Future contributions will need to consider such factors.]

TABLE 6

Calculated pfd required to protect AMS systems for maximum receiving antenna gain direction

Parameter (Unit)	AMS Receiver Antenna Gain (dBi)		Power Flux Density (dB(W/m^2*MHz))	
System 1 Airborne	3		-114.07	
System 2 Airborne	3		-114.07	
System 3 Airborne	3.5 (omni)	16 (directional)	-115.57 (omni)	-128.07 (directional)
System 3 Shipborne	3 (omni)	30 (directional)	-111.57 (omni)	-138.57 (directional)
System 4 Airborne	4.5	16	-116.57	-128.07

[2] The pfd in Eq. (1) does not account for polarization loss at the AMS/MMS receiver antenna

Parameter (Unit)	**AMS Receiver Antenna Gain (dBi)**		**Power Flux Density (dB(W/m^2*MHz))**	
	(omni)	(directional)	(omni)	(directional)
System 5 Airborne	3 (omni)	19 (directional)	-114.07 (omni)	-130.07 (directional)
System 5 Shipborne	3 (omni)	31 (directional)	-111.57 (omni)	-139.57 (directional)
System 6 Airborne 1	4.7		-113.27	
System 6 Airborne 2	4.7		-113.27	
System 6 Shipborne	6 (omni)	11.8 (directional)	-114.57 (omni)	-120.37 (directional)
System 7 Airborne 1	14		-122.57	
System 7 Airborne 2	14		-122.57	
System 8 Airborne	0		-105.57	
System 8 Shipborne	15		-124.57	

TABLE 7

Calculated pfd required to protect MMS systems for maximum receiving antenna gain direction

Parameter (Unit)	**MMS Receiver Antenna Gain (dBi)**	**Power Flux Density (dB(W/m^2*MHz))**
System 1 Shipborne	6	-114.57
System 2 Shipborne	15	-124.57

8.1.2 Methodology to derive a pfd limit per station (for low gain AMS/MMS antenna)

This methodology assumes that MMS/AMS receiver antenna has a low gain in order to define pfd_{single} based on the aggregate pfd limit pfd_{agg}. Assuming NF+L_f=4 dB, this leads to

$$pfd_{agg} = -113.7 \frac{dBW}{MHz.m^2}$$

For the case where M Base stations with isotropic antenna (e.g. indoor small cells) deployed in the area of interest whose size ensures that distances between each hotspot and the MMS/AMS receiver are similar:

$$pfd_{single} = \frac{pfd_{agg}}{M^*} \quad (2)$$

For the general case where BSs high gain antenna (passive and active sectors) are deployed in a simulation area with varying distances (between BS and the MMS/AMS receiver), it is not possible to define a proper aggregation factor because all sources of interference do not have the same influence on the MMS/AMS victim receiver due to varying parameters (antenna gain towards the victim, distance from the victim, visibility elevation angle towards the AMS/MMS receiver). It is then necessary to define an ***equivalent*** number of sources M^* by considering aggregate and single interference distributions. The wording "equivalent" is given to this parameter because it is not (in general) equal to the number of active base-stations. To define M^*, let us notice:

– That the number of active BSs $NbactiveBSs$ within the simulation area is (assumed to be) given in the table of IMT parameters[3] as an average value. This means that this number is a variable of the event *i*, denoted $NbactiveBSs(i)$.

– That the aggregate and single interferences are defined at the receiver antenna and can be expressed as (in linear scale) follows:

$$I_{single\ i,j} = \frac{P.G_{BS\ i,j}}{PL_{i,j}.CL_{i,j}} G_r \text{ and } I_{agg\ i} = \sum_{j=1}^{NbactiveBSs(i)} I_{single\ i,j}$$

Where *P* relates to the conducted power at each BS, $G_{BS\ i,j}$ defines the gain of the active BS #*j* at snapshot #*i*, $PL_{i,j}, CL_{i,j}$ respectively correspond to the free-space-loss and clutter loss (>0) between active BS #*j* and MMS/AMS receiver at snapshot #*i* and G_r refers to the AMS/MMS receiver antenna gain.

– If it is obvious that the interference from a single BS spatially and timely varies, the aggregate interference from all active BSs in the simulation area also does at every event *i* because the number and the locations of the most influencing BSs (within the simulation area) vary at every snapshot.

A way to define an equivalent number of sources M^* would be to divide at each snapshot *i* the aggregate interference over a X^{th} percentile of the single interference (still at snapshot #*i*). The choice of this X^{th} percentile is explained below:

– An average value would result in achieving $NbactiveBSs$ as the aggregation factor (in linear scale) as showed in developing

$$M(i) = \frac{I_{agg\ i}}{\frac{1}{Nbactive\ BSs(i)} \sum_{j=1}^{Nbactive\ BSs(i)} I_{single\ i,j}} = Nbactive\ BSs(i)$$

Such assumption would lead to linear dependency of the pfd per station with the number of active BSs in the simulation area (whatever Ra/Rb, BS activity factors are applied on large zone). Indeed, such trend contradicts the slower growth of any practical aggregation factor compared to the number of active BSs when extending the simulation area because interference from remote BSs decrease much faster due to larger distance than its discrimination antenna gain rises up.

– This means that the slope of the M^* parameter as a function of the simulation area needs to be as soft as the evolution of the aggregation interference, probably because closer BSs have likely more impact on the MMS/AMS receiver than remote ones. Such rationale is equivalent to consider higher/highest percentile of the interference of a single active BS in the calculation of $M(i)$.

To illustrate this idea, consider the following example: if there are two active BSs within the simulation area and one of them has always (for every snapshot *i*) dominant impact over the other then: $pfd_{single\ (most\ dominant)} \approx pfd_{agg}$ and $M = 1$.

$M(i)$ is a random variable whose sample is given at every snapshot *i*. Its expression is given:

$$M(i) = \frac{I_{agg\ i}}{I_{single\ i(X\%)}} \text{where } X \text{ could be equal to } 90\%$$

By taking the same X^{th} percentile of the $M(i)$ *cumulative density function (cdf)*, we get: $M_{X\%}(i) \triangleq M^*$, the equivalent number of sources is obtained, and formula (2) can be applied for the general case

[3] Featured as a network load or a base-station activity.

of AAS BSs deployment. Consequently, the pfd per station formula can be established for AMS/MMS receiver operating with low gain:

$$pfd_{single} = \frac{I_{max}\frac{4\pi}{\lambda^2.G_r}}{M^*} \quad (3)$$

8.1.3 Study to derive a pfd limit per station

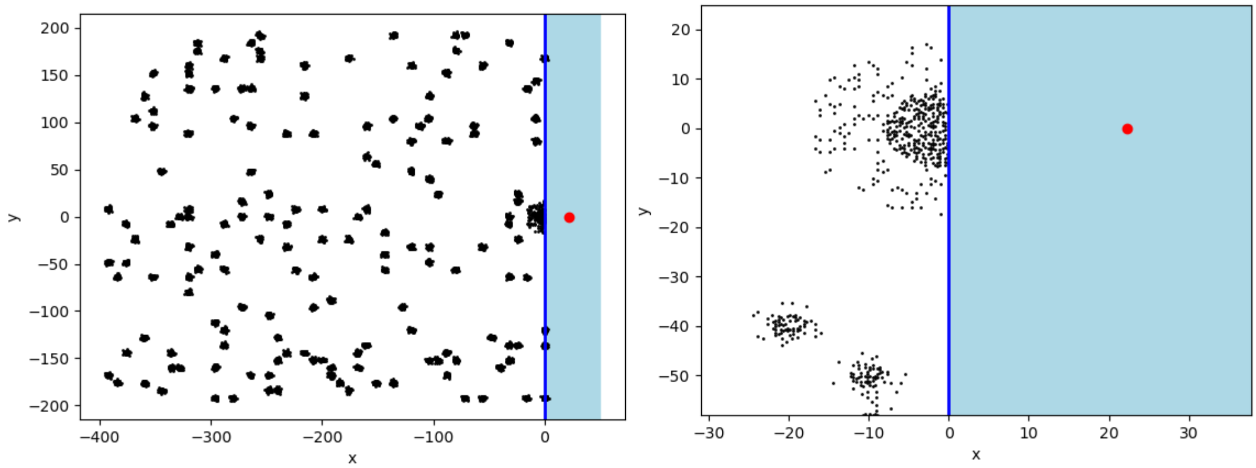
The methodology described in section 8.1 has been used in this study for the case of the protection of an AMS receiver

8.1.3.1 Assumptions

Assumptions for IMT

FIGURE 1

Distribution of AAS BS (x and y in km, before filtering those outside of LOS)



IMT AAS Base Stations sectors are generated as clusters in suburban/urban areas ("cities") that are randomly distributed around a terrain (with the exception of a "main" city with coordinates (0,0)). Cities are generated with a random radius both for the suburban and urban parts (and a maximum area of 1 000 km² for the suburban part and 200 km² for the urban part). The whole simulation area is 400 km x 400 km, and therefore the following values are used: Ra_urban=45%, Ra_suburban=20% and Rb=5%. For all cities except the "main" one, the urban part has half the radius of the suburban part. The seaside is materialized by the line x=0, with terrestrial part on x<0 locations and waters on x>0 areas.

Generated IMT base stations have 3 AAS sectors (0°, 120° and 240° azimuth relative to north, mechanical tilt of −10° for urban, −6° for suburban) and use parameters as agreed (Recommendation ITU-R M.2101 extended pattern with sub-arrays, relevant mechanical tilt depending on urban/suburban areas, 3 UEs per sector, network load of 20%, etc).

A spherical earth model was assumed i.e. only IMT base stations that can be in visibility with the victim receiver are kept in the simulation, taking into account earth curvature and the antenna height of both the IMT station and the AMS/MMS receiver.

Assumptions for AMS

For AMS, the victim receiver (red dot on figure above) is assumed to be located at 10 km altitude in international waters in front of the main city (i.e. $x = +22.5$ km, $y = 0$, $z = 10$ km). It is for the moment assumed to have an omnidirectional antenna with 3 dBi gain.

Considering the IMT and AMS antenna heights, the maximum distance for LOS is 375 km. With those parameters above, this leads to approximately 7 000 IMT sectors in the simulation in total.

With regards to the clutter layer, the ITU-R P.2108 § 3.3 was applied (both current recommendation and the update under consideration were implemented).

Assumptions for MMS

For MMS, the victim receiver (same red dot on figure above) is assumed to be located at 30 m altitude in international waters in front of the main city (i.e. $x = +22.5$ km, $y = 0$, $z = 30$ m as the draft revision of ITU-R M.2116 states "*The shipborne antenna height as described for Systems 3 5, 6, and 8 in Table 1 is in the range of 10 to 30 metres*"). It is for the moment assumed to have an omnidirectional antenna with 3 dBi gain.

Considering the IMT and AMS antenna heights, the maximum distance for LOS is 39 km. With those parameters above, this leads to approximately 350 IMT sectors in the simulation in total.

With regards to the clutter layer, the ITU-R P.2108 § 3.2 was applied, using the distance between the IMT base station and the coastline.

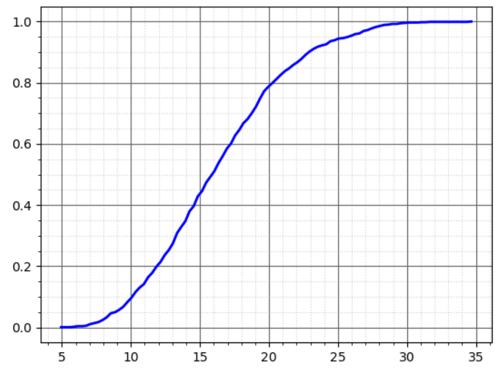
Propagation assumptions

For each generated terrain, a Monte-Carlo simulation is performed (where UEs and clutter layer are refreshed). The clutter is considered using Recommendation ITU-R P.2108 in urban areas, with *p*-factor as a random variable of uniform law between 0..100% (clutter has not been applied in suburban areas considering that IMT antenna height is 25 m and buildings are assumed to be typically 10m height). It has been applied on half of the urban sites considering the assumption that half of IMT base stations are above the clutter). Free space loss is assumed above the clutter.

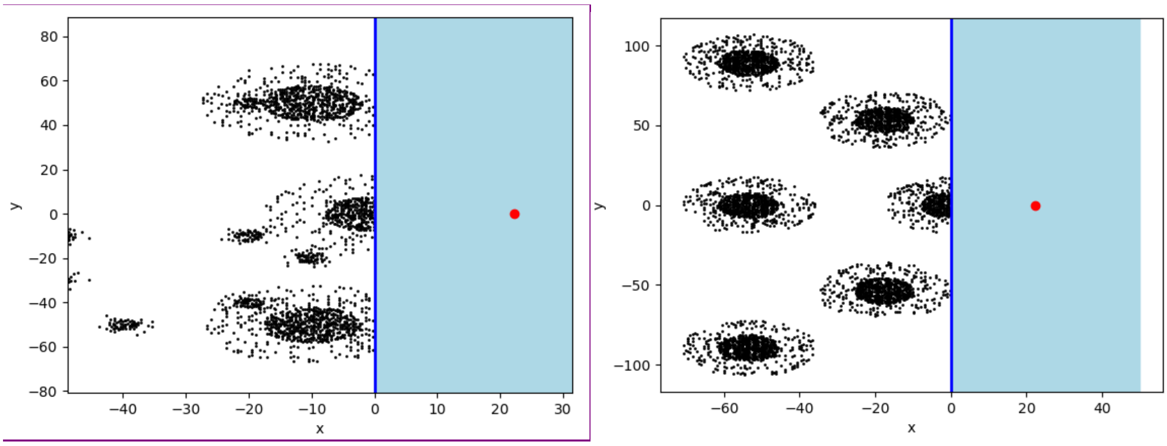
8.1.3.3 Results

Results for AMS

With the parameters above (N=1000 iterations), the average value for M* is [22.8 in linear scale i.e. 13.5 dB]. The graph below shows an illustration of the CDF for M(i).



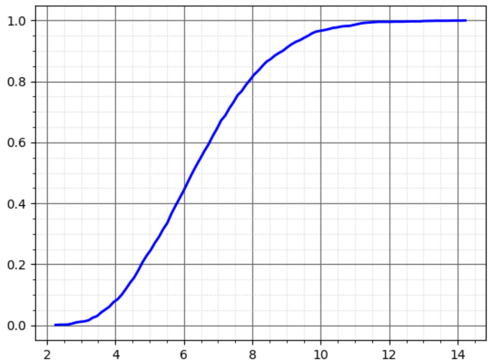
Sensitivity analysis



When forcing the deterministic generation of other large cities in the surroundings of the victim (e.g. see figures above) while keeping all things equal, the mean value for M* becomes 35.6 in linear scale i.e. 15.51 dB.

Results for MMS

With the parameters above (*N* = 1 000 iterations), the average value for *M** is [10 in linear scale i.e. 10 dB]. The graph below shows an illustration of the CDF for *M*(i).



8.2 Study on basic transmission loss between air borne station of the aeronautical mobile service and terrestrial base station.

The objective of this study is to provide an understanding of how the basic transmission loss between an airborne station and a terrestrial station changes with the altitude of the airborne station and its distance from the terrestrial station.

There are three modes of transmission: line of sight within the radio horizon; diffraction near and beyond the radio horizon and; scattering beyond the radio horizon.

The radio horizon[4] is the locus of points at which direct rays from an antenna are tangential to the surface of the Earth. Note: If the Earth were a perfect sphere and there were no atmospheric anomalies, the radio horizon would be a circle. In practice, the distance to the radio horizon is affected by the height of the transmitting antenna, the height of the receiving antenna, atmospheric conditions, and the presence of obstructions, e.g., mountains.

The transmission mode from an airborne station to a region before its radio horizon is the line-of-sight mode, consisting of atmospheric absorption and the transmission loss corresponding to free-

[4] https://www.its.bldrdoc.gov/fs-1037/dir-030/_4378.htm.

space conditions. For radio paths extending only slightly over the horizon, or for paths extending over an obstacle or over mountainous terrain, diffraction will generally be the propagation mode determining the field strength. Attenuation for diffracted signals increases very rapidly with distance and with frequency, and the anomalous propagation probability is relatively small, eventually the long-term principal mechanism is that of tropospheric scatter. These mechanisms may be used to establish “trans-horizon” radiocommunication[5].

According to *recommends* 1 of Recommendation ITU-R P.528, the integral software in the Recommendation should be used to generate basic transmission loss values and curves for terminal heights, frequencies, and time percentages likely to be encountered in the aeronautical services.

In this study, basic transmission losses were generated based on the following parameters:

TABLE 8.2-1

Input to P.528 software	**Value used in study**
Great-circle distance between the stations, d (km)	Vary
Height of terrestrial station above mean sea level, h1 (m)	25m
Height of air borne station above mean sea level, h2 (m)	Vary
Frequency (MHz)	4 800 MHz
Polarization (1=Vertical, 0=Horizontal)	1
Time percentage (%)	5%

Figure 8.2-1 provide plots of basic transmission loss against the distances between stations for different altitudes of the airborne station.

[5] Recommendation ITU-R P.617-5 Propagation prediction techniques and data required for the design of trans-horizon radio-relay systems.

Frequency (MHz)	4800	4800	4800	4800	4800
h1 (m)	25	25	25	25	25
h2 (m)	1000	2400	5000	7500	10000
Polarization	1 (vertical)	1 (vertical)	1 (vertical)	1 (vertical)	1 (vertical)
p (Time percentage)	5%	5%	5%	5%	5%
d (km)	P.528 BT loss (dB) at h2 = 1000 m	P.528 BT loss (dB) at h2 = 2400 m	P.528 BT loss (dB) at h2 = 5 000 m	P.528 BT loss (dB) at h2 = 7 500 m	P.528 BT loss (dB) at h2 = 10 000 m
50	135.1	135.7	136.5	137.2	137.7
100	140.5	140.7	141.4	141.5	141.6
150	145.3	144.0	143.5	143.9	143.9
200	180.6	147.5	146.3	145.6	146.4
250	191.2	175.2	149.3	148.4	147.8
300	199.9	188.6	151.7	150.9	150.3
350	207.3	197.9	181.5	153.0	152.4
400	213.8	205.8	192.7	177.8	154.3
450	219.8	212.5	201.6	191.1	177.5
500	225.5	218.6	209.1	200.4	191.4
550	230.9	224.4	215.6	208.2	200.7
600	235.9	229.9	221.6	214.9	208.6
650	240.5	235.1	227.2	221.0	215.3

FIGURE 8.2-1

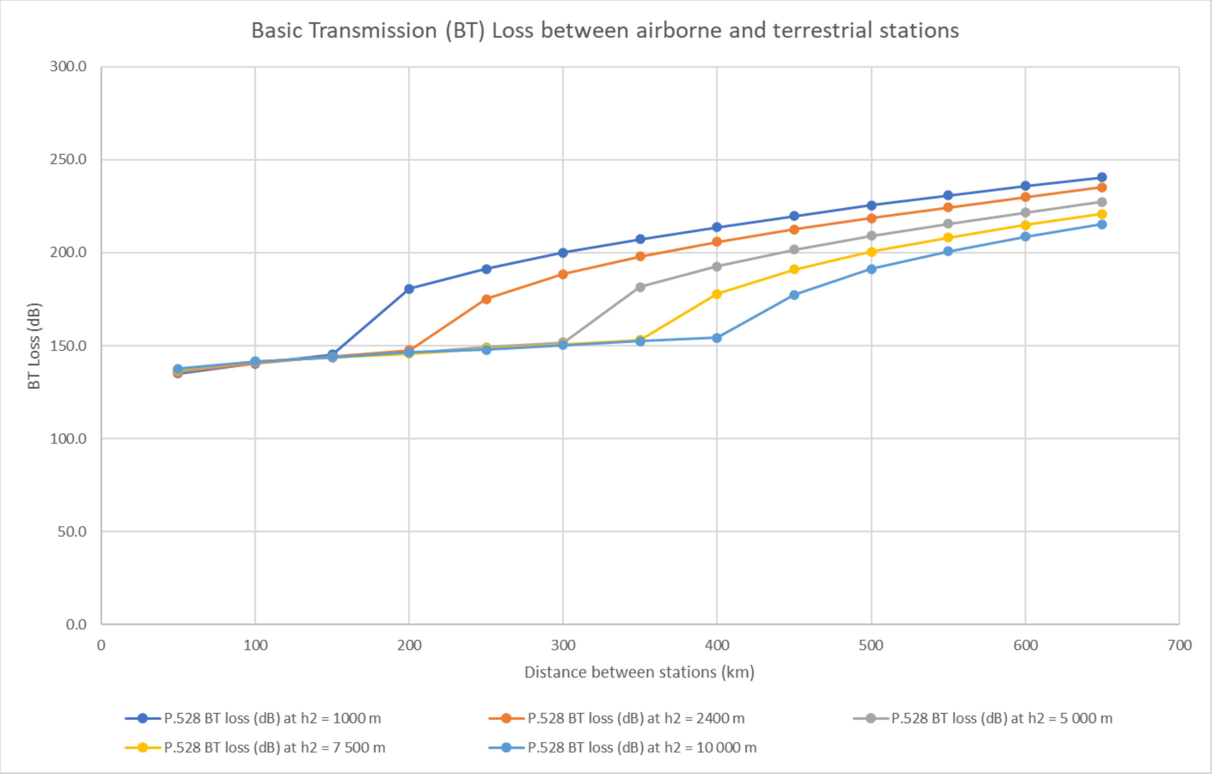


Figure 8.2-2 below shows how basic transmission loss change with altitude at particular distances between stations.

Frequency (MHz)	4 800.0
Distance, d	370, 450 km
h1 (m)	25.0
h2 (m)	Vary
Polarization	1 (vertical)
p (Time percentage)	5.0%

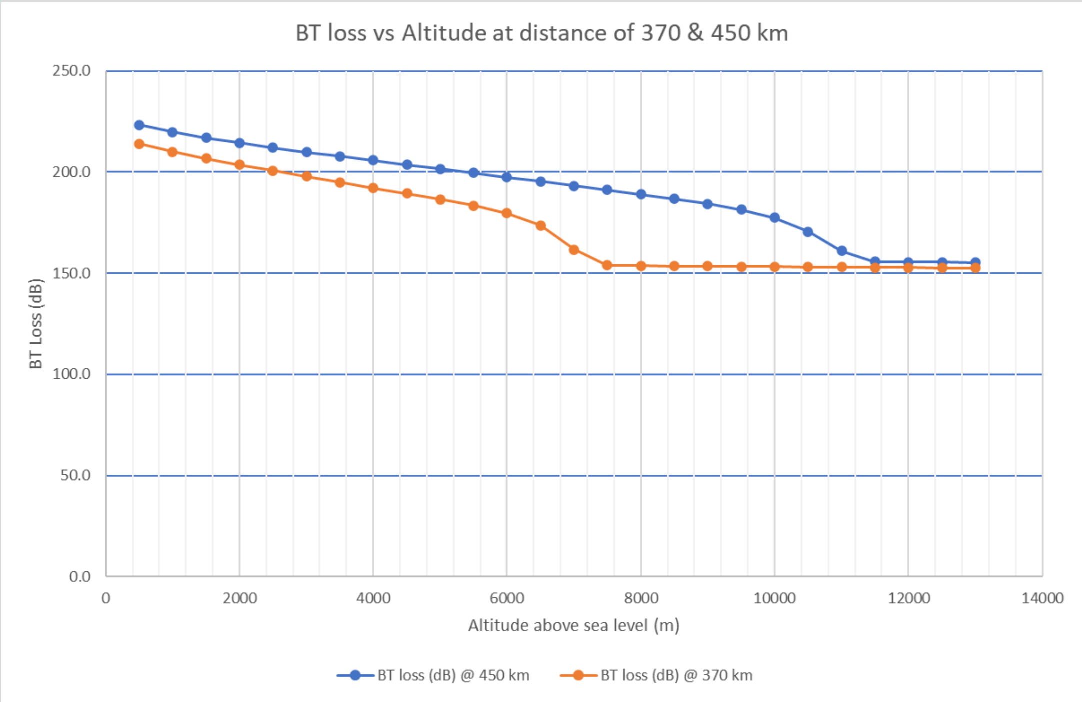
The distances of 450 km is selected due to bullet point number 6 of *resolves* 1 of Resolution **416 (WRC-07)** and *resolves* 3 of Resolution **223 (Rev.WRC-19)**

The distance of 370 km is approximately 200 nautical miles, which is the breadth of the exclusive economic zone of a coastal state. (Refer Article 57 of United Nations Convention on the Law of the Sea)

h2 (m)	BT loss (dB) @ 450 km	BT loss (dB) @ 370 km
500	223.4	214.0
1000	219.8	210.0
1500	216.9	206.6
2000	214.4	203.6
2500	212.1	200.6
3000	209.9	197.8
3500	207.8	194.9
4000	205.7	192.1
4500	203.6	189.3
5000	201.6	186.6
5500	199.5	183.5
6000	197.4	179.7
6500	195.3	173.7
7000	193.2	161.8
7500	191.1	153.8
8000	189.0	153.7
8500	186.8	153.6
9000	184.4	153.4
9500	181.4	153.3
10000	177.5	153.2
10500	170.5	153.1
11000	161.0	153.0
11500	155.6	152.9
12000	155.5	152.7
12500	155.4	152.6
13000	155.3	152.6

FIGURE 8.2-2

Basic Transmission Loss against altitudes



8.2.1 Observation

At specific minimum separation distances and maximum altitudes the basic transmission loss is high enough to provide the isolation needed to comply with a pfd limit.

In Table 6 of section 8.1, the lowest pfd value for systems using omni-directional antenna is that of System 4 (airborne), at – 116.57 dB(W/(m2 · MHz)).

In Table 7 of section 8.2, the lowest pfd value for systems using omni-directional antenna is that of System 1, at -114.7 dB(W/(m^2. MHz)).

8.2.1.1 Isolation for BS output of 48 dBm/MHz and pfd[6]$_{agg}$ = -116.57 dB(W/(m^2. MHz))

Isolation = BS output e.i.r.p (dBW/MHz) – Ae - pfd_{agg} – Building Entry Loss dB

= 169.8 dB

where,

BS output = Maximum Non-AAS BS output power/sector (e.i.r.p.) = 64 dBm in 40 MHz

= 48 dBm/MHz

= 18 dBW/MHz, for Urban/suburban macro deployment

Ae = 10log$\left(\frac{\lambda^2}{4\pi}\right)$ =-35.26 dBm^2

From Section 8.1: assume a wavelength of 0.0612m (corresponding to a frequency of 4 900 MHz) which yield an effective aperture constant ($\left(\frac{\lambda^2}{4\pi}\right)$ of 0.000298

6 $pfd_{single} = pfd_{agg}$, with no aggregation factor

pfd_{agg} = –113.7 dB(W/(m^2. MHz))

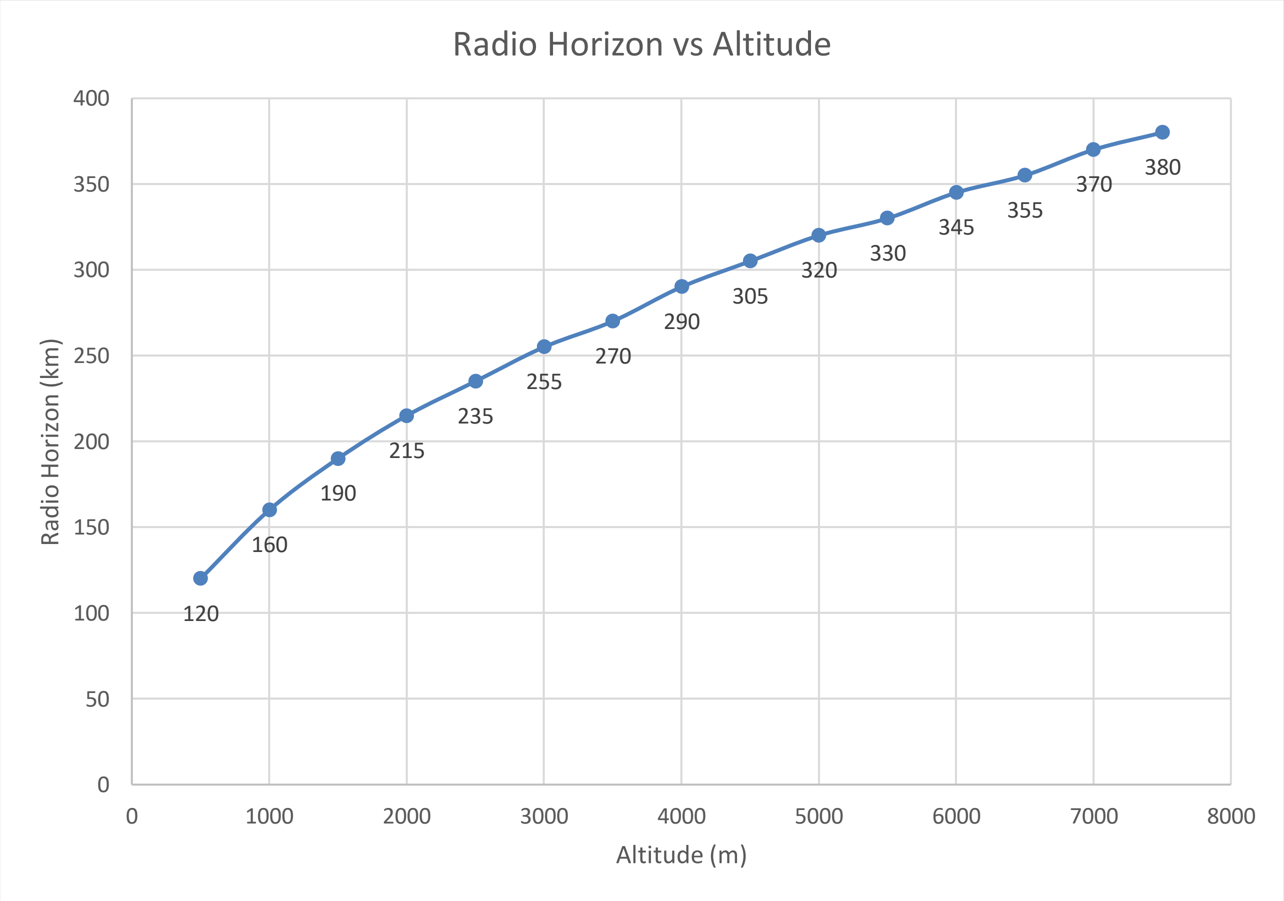
Building entry loss = 0 dB for outdoor deployment

8.2.1.2 Basic transmission loss to produce isolation of 169.8 dB

The basic transmission loss between an IMT base station and an airborne AMS station increases rapidly when the separation distance is such that the base station is in the region beyond the line of sight (radio) horizon of the AMS station.

Chart W below is a plot of radio horizon against altitude of an AMS station.

Chart W



If the separation distance is greater than the radio horizon then the basic transmission loss produced is higher compared to the free space loss from the line-of-sight distance. By setting the pfd criteria at a distance from the coast that is greater than the radio horizon due to the altitude above sea level of the criteria can result in basic transmission loss that can meet or exceed the required isolation.

Examples of minimum separation distances and altitudes that produces basic transmission losses that exceeds the isolation of 169.8 dB are shown in Table X below:

TABLE X

Separation distance (km)	Altitude above sea level (m/ft)	Basic transmission loss[7] (dB)	Margin above 169.8 dB (dB)
150	500 m / 1640 ft	176.6	6.8
200	1000 m / 3280 ft	180.6	10.8
200	1250 m / 4101 ft	176.3	6.5
300	3400 m / 11154 ft	180.5	10.7
370	3400 m / 11154 ft	195.5	25.7

8.3 Study of interference from IMT to AMS within the 4 800-4 990 MHz frequency band

8.3.1 Characteristics of IMT-2020 in the frequency band 4 800-4 990 MHz

Tables 1 and 2 provides deployment related and user equipment characteristics that were used in the simulation, taking into account that for the 3-6 GHz range, contiguous coverage is not expected in this frequency range in rural areas, the study analyses interference only from urban deployment.

TABLE 1

Deployment characteristics of IMT-2020 in the 4800-4990 MHz frequency band

	Urban macro
Cell radius / Deployment density (AAS)	Typical cell radius 0.4 km urban / 0.8 km suburban (10 BSs/km^2 urban / 2.4 BSs/km^2 suburban (Note 2))
Antenna height	20 m urban / 25 m suburban
Sectorization	3 sectors
Frequency reuse	1
Below rooftop base station antenna deployment	Urban: 50%
Typical channel bandwidth	40 or 80 or 100 MHz
Network loading factor (base station load probability X%) (see section 3.4 below and Rec. ITU-R M.2101 Annex 1, section 3.4.1 and 6)	20%,
TDD / FDD	TDD
BS TDD activity factor	75%

TABLE 2

UE parameters for bands between 3 and 6 GHz

	Urban macro
Indoor user terminal usage	70%
Indoor user terminal penetration loss	Rec. ITU-R P.2109

[7] Base station antenna height = 25 m, frequency = 4 800 MHz, vertical polarisation, time percentage = 5%

User equipment density for terminals that are transmitting simultaneously (Note 1)	3 UEs per sector
UE height (Note 2)	1.5 m
Average user terminal output power	Use transmit power control
Typical antenna gain for user terminals	−4 dBi
Body loss	4 dB
UE TDD activity factor	25%
Power control model	Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1
Maximum user terminal output power, PCMAX	23 dBm
Power (dBm) target value per RB, P0_PUSCH (Note 3)	−92.2
Path loss compensation factor, α (same as "balancing factor" mentioned in Rec. ITU-R M.2101)	0.8

Table 3 provides antenna beamforming characteristics; this study doesn't not consider non-AAS systems.

TABLE 3

Beamforming antenna characteristics for IMT in 4800-4 990 MHz

		Urban macro
1.1	Antenna pattern	Recommendation ITU-R P.2101
1.2	Element gain (dBi)	6.4
1.3	Horizontal/vertical 3 dB beam width of single element	90º for H 65º for V
1.4	Horizontal/vertical front-to-back ratio (dB)	30 for both H/V
1.5	Antenna polarization	Linear ±45º
1.6	Antenna array configuration (Row × Column)	4 × 8 elements
1.7	Horizontal/Vertical radiating element/sub-array spacing, d_h /d_v	0.5 of wavelength for H, 2.1 of wavelength for V
1.7a	Number of element rows in sub-array, M_{sub}	3
1.7b	Vertical radiating element spacing in sub-array, $d_{v,sub}$	0.7 of wavelength of V
1.7c	Pre-set sub-array down-tilt, $\theta_{subtilt}$ (degrees)	3
1.8	Array Ohmic loss (dB)	2
1.9	Conducted power (before Ohmic loss) per antenna element/sub-array (dBm)	28
1.10	Base station horizontal coverage range (degrees)	±60
1.11	Base station vertical coverage range (degrees)	90-100
1.12	Mechanical downtilt (degrees)	6
1.13	Maximum base station output power/sector (e.i.r.p.) (dBm)	72.28

When simulating beamforming, three spatially directive signals were transmitted pointing to each UE within the sector, the UEs were distributed randomly within the sector. Figures 1 and 2 show composite sub-array IMT antenna pattern in the 4 800-4 990 MHz frequency band that was used in the studies.

FIGURE 1

IMT AAS BS antenna pattern in the 4 800-4 990 MHz

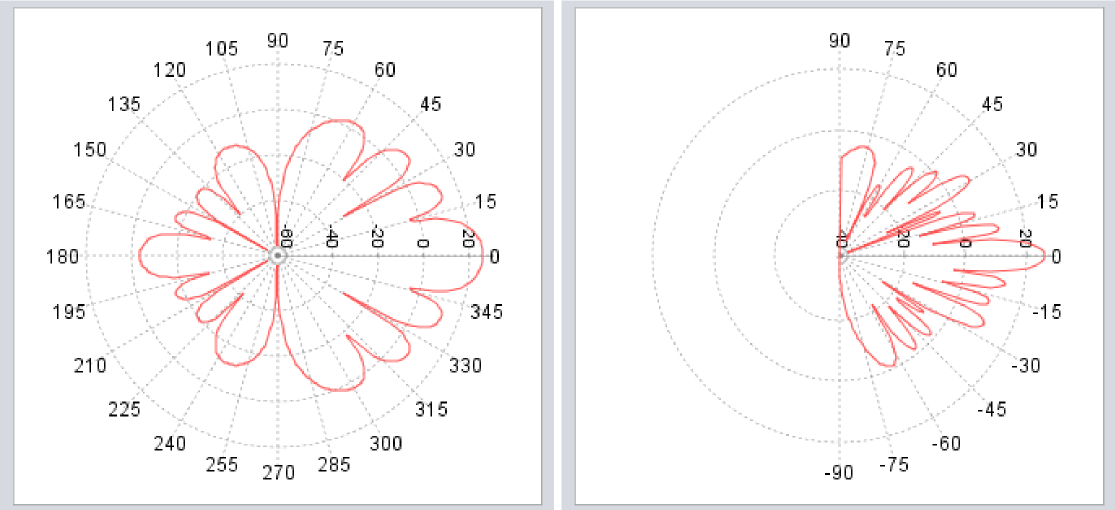
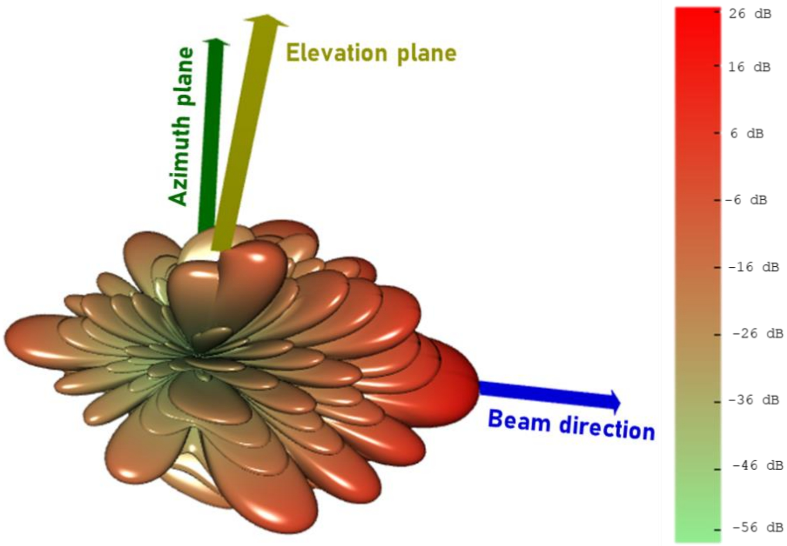


FIGURE 2

3D representation of the IMT AAS BS antenna pattern in the 4 800-4 990 MHz



8.3.2 Characteristics of AMS systems

Two types of AMS receivers were considered in the studies the one with omnidirectional antenna (System 1) and the one with a directional antenna (System 7). Table 4 presents characteristics of the AMS that were used in simulations.

TABLE 4

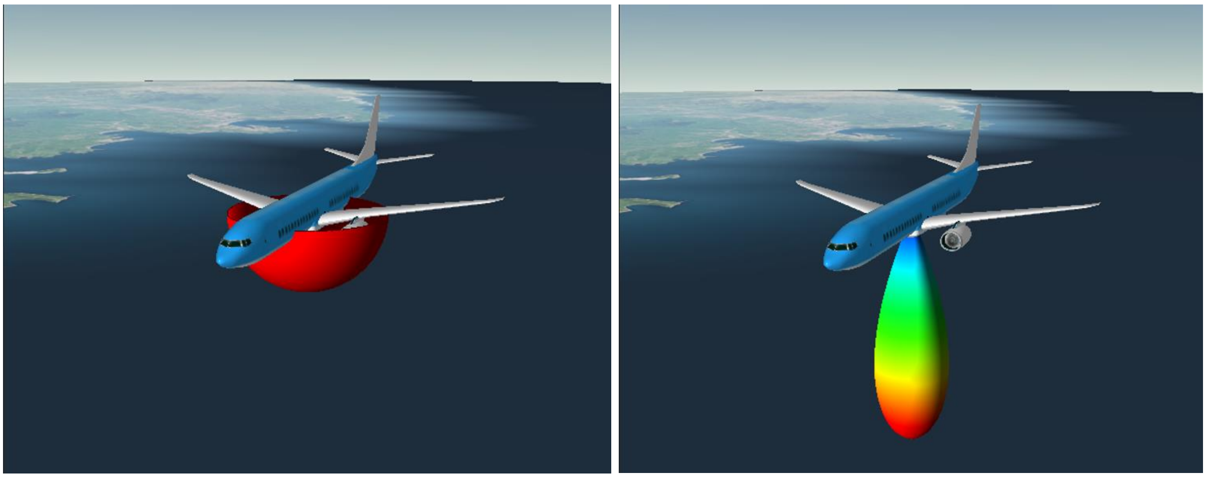
Characteristics of the aeronautical mobile service used in simulation

Parameter	**Units**	**System 1 Airborne**	**System 7 Airborne 1**	**System 7 Airborne 2**
Transmitter				
Tuning range	MHz	4 400-4 990(1)	4 400-4 990	4 400-4 990
Power output	dBm	45	30-43	30-43
Bandwidth (3 dB)	MHz	1	5 / 0.008	5 / 0.008
Tuning range	MHz	4 400-4 990(1)	4 400-4 990	4 400-4 990
Selectivity (3 dB)	MHz	1	5 / 0.008	5 / 0.008
Noise figure	dB	3.5	6	6
Thermal noise level	dBm	−110.5	-103 / −131	-103/ −131
Antenna type		Omnidirectional	Directional	Directional
Antenna gain	dBi	3	14	14
1st sidelobe	dBi	N/A	-1	-1
Polarization		Vertical	Vertical	Vertical
Antenna pattern		N/A(2)	Uniform distribution (Refer to Rec. ITU-R M.1851)	Uniform distribution (Refer to Rec. ITU-R M.1851)

Figure 3 provides graphical representation of the AMS receiver depending on the antenna type.

FIGURE 3

Omnidirectional and directional antennas of AMS



8.3.3 Simulation methodology

To study the interference level from IMT to AMS it is important to consider proper deployment of IMT, unrealistic deployment may lead to the incorrect results which would never occur in practice.

In this study, to simulate close to the real case of interference from IMT towards the international airspace or zones beyond jurisdiction of any country, the particular region has been chosen for the research. It should be noted that in practice the AMS would fly much farer from the maritime border, in this study however to analyse worst case scenario, the aircraft moves along the state maritime border.

Figure 4 shows the scenario which was considered in the study, the AMS aircraft is moving across the border of territorial seas and receives interference from IMT deployed in the cities that are in the vicinity of the aircraft. Taking into account that 4 800-4 990 MHz band will be used predominately for urban deployments, only the cities were considered.

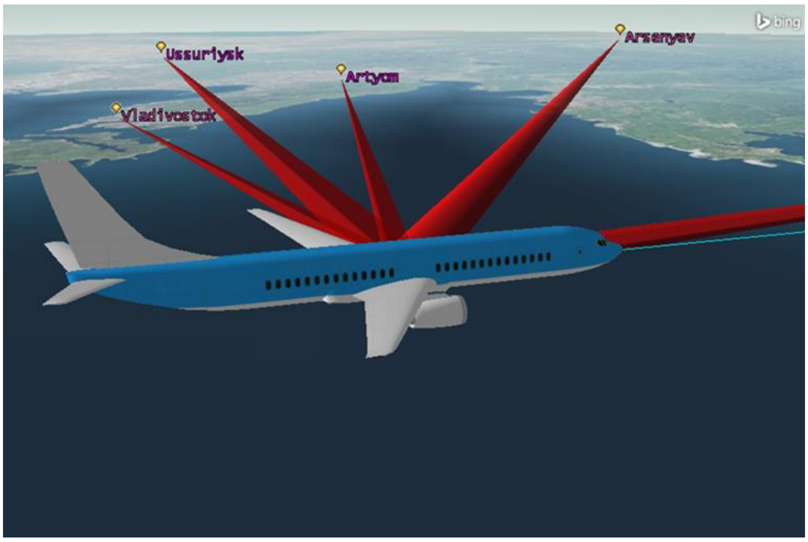
FIGURE 4

Scenario of the AMS flying along the territorial seas border

Figure 5 displays 3D modelling of IMT interference IMT networks deployed in 5 cities to the aircraft that moves across the neutral waters border.

FIGURE 5

Interference from urban IMT to the AMS receiver

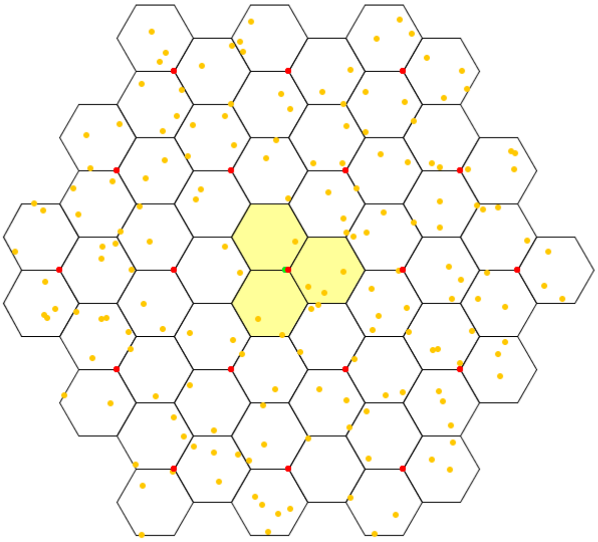


To estimate interference from IMT to the AMS receiver, Monte-Carlo analysis simulation was conducted using protection criterion interference-to-noise (*I/N*). The number of simulation events was 5 000. During the simulations the aircraft was placed across the border line of the territorial sea. In each city IMT network was simulated and according to Recommendation ITU-R M.2101 was consisted of 19 tri-sector BS with 3 UEs at ach sector, thus the interference was calculated from 285 sectors overall.

Typical deployment topology of the 57 sectors networks provided in Figure 6. It should be noted that many cities have much more IMT BS however they will not operate at the same frequency as AMS receiver simultaneously, therefore, 57 sectors per city is sufficient to estimate the interference level.

FIGURE 6

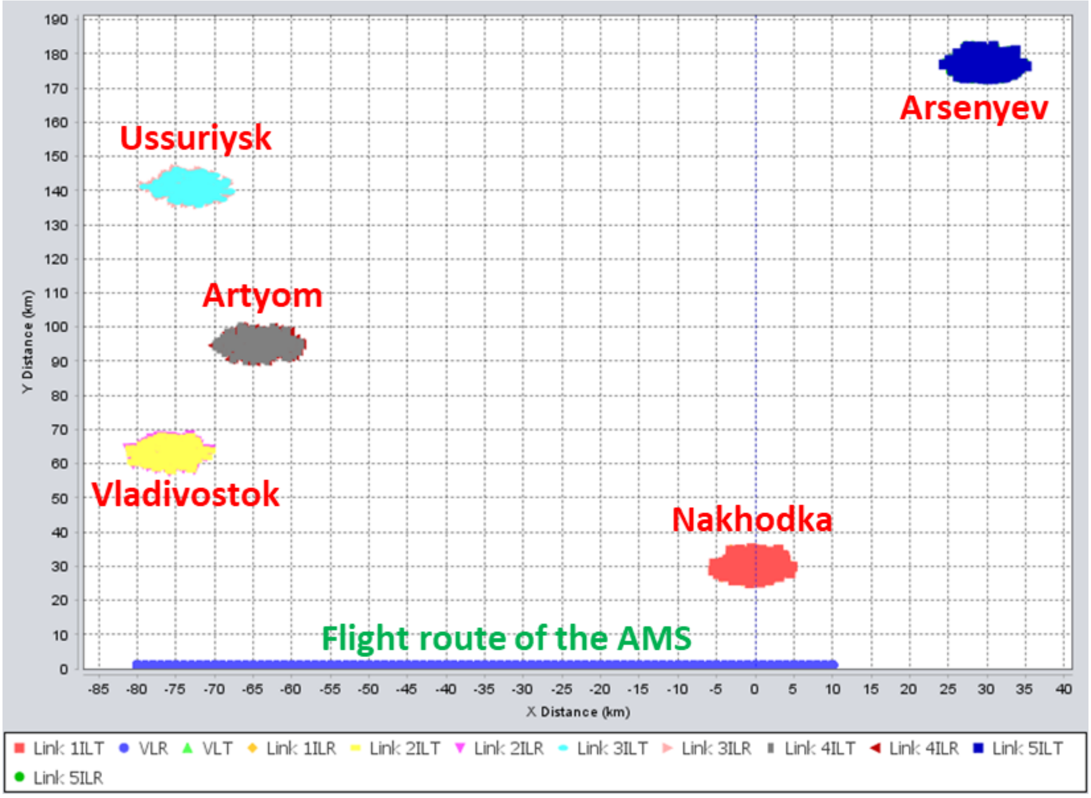
Typical IMT urban deployment topology



The simulations consider aggregate interference from the cities located inside the IMT urban deployment area. Figure 7 provides simulations of interference from IMT networks deployed in 5 cities to the victim AMS station.

FIGURE 7

Simulation of interreference from 5 cities where IMT is deployed to the AMS/MMS station



The interference from the i^{th} active IMT-2020 BS or the j^{th} active UE to the FS receiver can be calculated by the following equation:

$$I_{IMT} = P_{TX} + G_{IMT} + G_{AMS} - L_p - L_{xpr}$$

where:

- P_{TX}: the transmitted power of the IMT BS or UE, in dBm;
- G_{IMT}: the transmit antenna gain of the IMT BS or UE towards the victim receiver, in dBi;
- G_{AMS}: the receive antenna gain of the AMS towards the interfering station, in dBi;
- L_p: the propagation loss from the IMT transmitter to the AMS receiver, in dB;
- L_{xpr}: the polarization loss, in dB.

After calculation interference from each IMT active station, total *I/N* taking into account aggregate interference from IMT-2020 BS and UE can be calculated using the following equation:

$$\frac{I}{N}[\text{dB}] = 10\, log_{10}\left(\text{Pr}_{\text{IMT}} \sum_i 10^{\frac{I_{IMT}(i)}{10}}\right) - (D + 10\, log(B))$$

where:

- IIMT (i): the interference from ith active IMT BS or jth active UE to the FS receiver, respectively, in dBm;
- D: AMS receiver noise power density, in dBm/Hz;

B: AMS receiver channel bandwidth, in Hz.

8.3.4 Protection criteria

An increase in receiver effective noise of 1 dB would result in significant degradation in communication range. Such an increase in effective receiver noise level corresponds to an $(I + N)/N$ ratio of 1.26, or an I/N ratio of about −6 dB.

8.3.5 Propagation models

Two propagation models were used in the study:

- Recommendation ITU-R P.528 “A propagation prediction method for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands” with 5% percentage of time;
- Recommendation ITU-R P.2108 “Prediction of clutter loss” with random percentage of locations, the clutter was applied to all IMT BS.

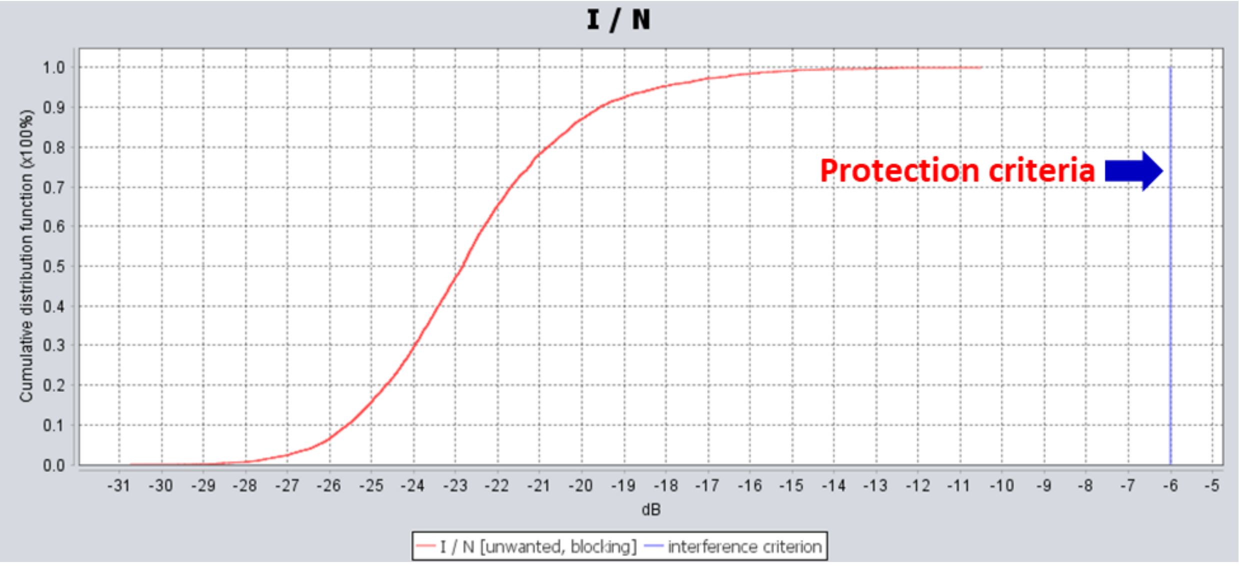
8.3.6 Results

8.3.6.1 Results for System 1

Interference analysis for system 1 showed that I/N margin is more than 5 dB. Figure 6 shows cumulative distribution function of I/N when interfering from IMT to the System 1 AMS receiver.

FIGURE 6

Cumulative distribution function of *I/N*



It should be noted that the highest I/N which is - 11 dB has very lower probability to occur, Figures 7 and 8 show I/N at each simulation step and probability distribution of I/N.

FIGURE 7

***I/N* at each simulation step**

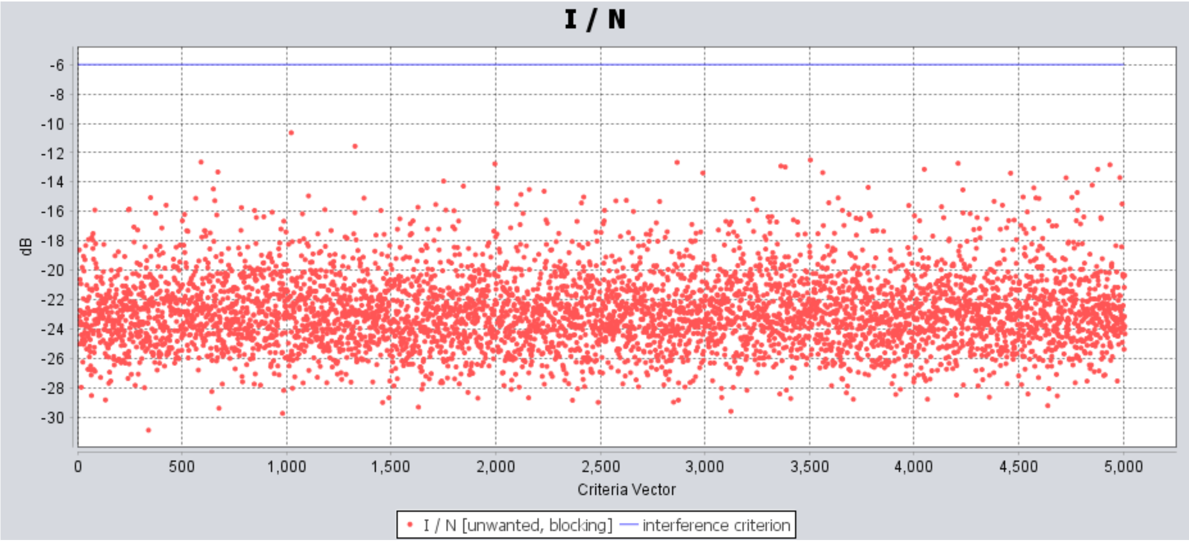
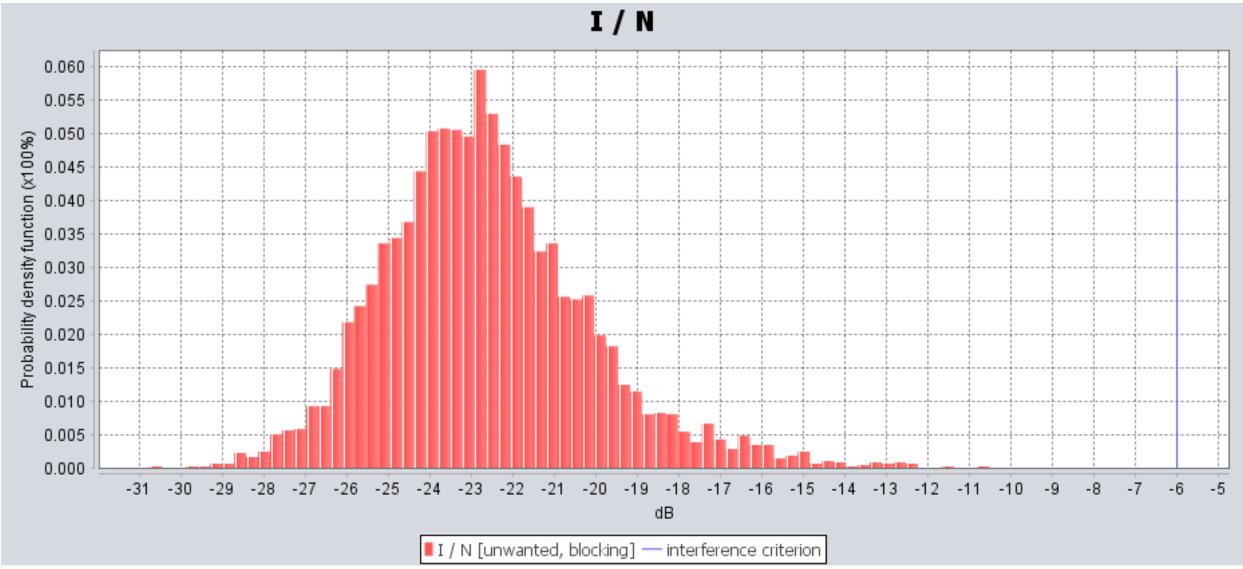


FIGURE 8

Probability density function of *I/N*

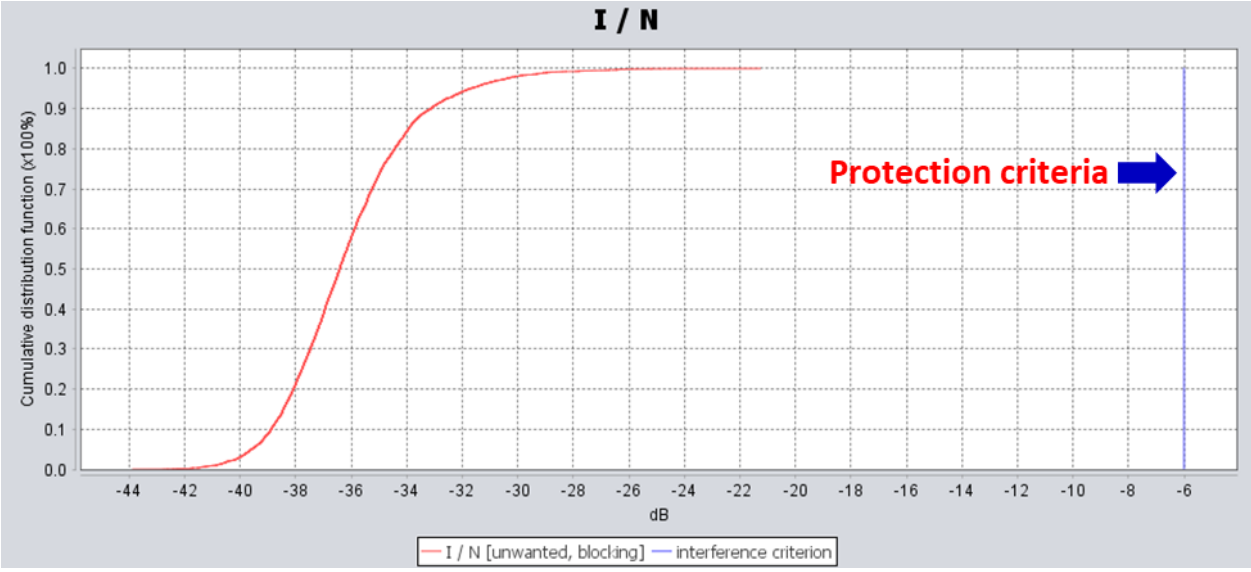


8.3.6.2 Results for System 7

Interference analysis for system 7 showed that *I/N* margin is more than 15 dB. Figure 9 shows cumulative distribution function of *I/N* when interfering from IMT to the System 7 AMS receiver.

FIGURE 9

Cumulative distribution function of *I/N*



It should be noted that the highest *I/N* which is 21 dB has very lower probability to occur, Figures 10 and 11 show *I/N* at each simulation step and probability distribution of *I/N*.

FIGURE 10

***I/N* at each simulation step**

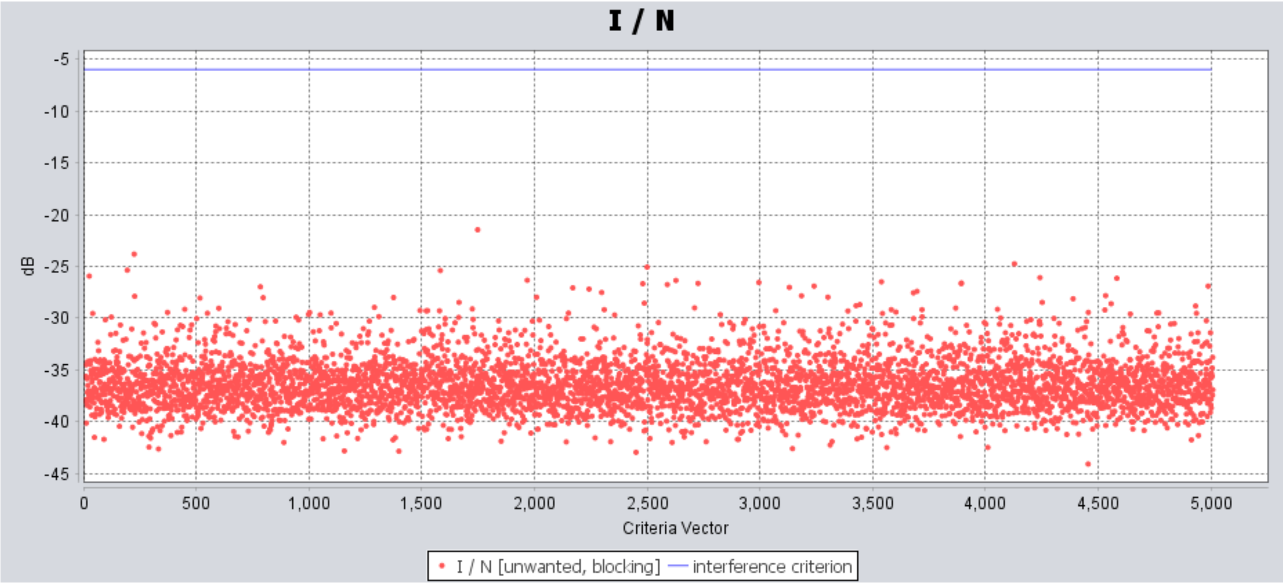
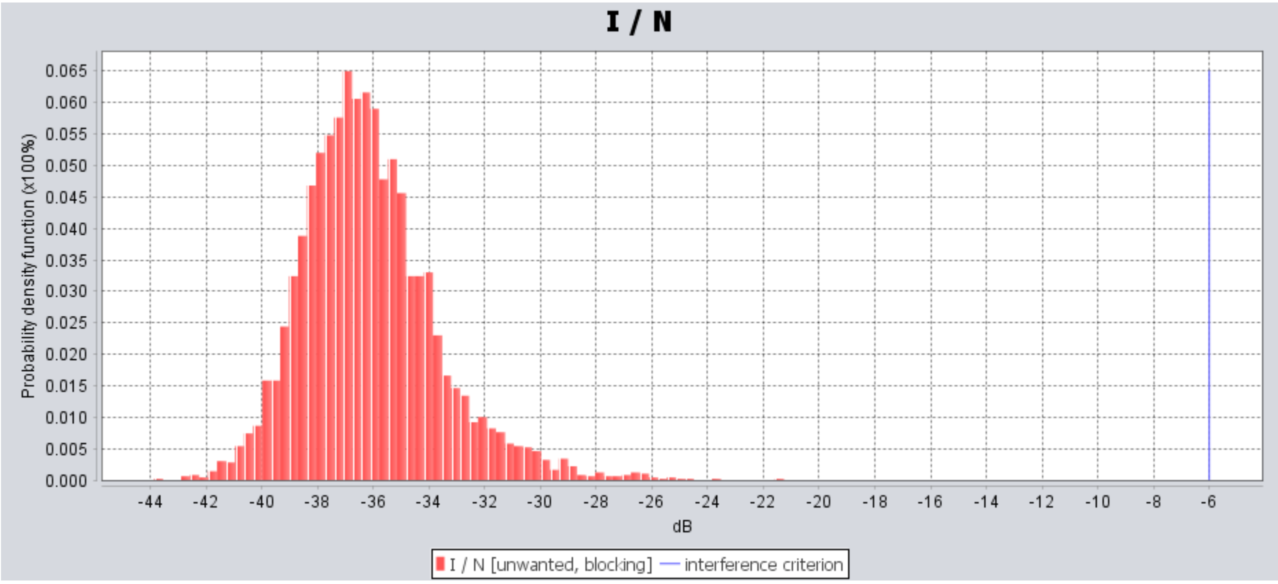


FIGURE 11

Probability density function of *I/N*



8.3.7 Conclusions

Based on the obtained results, it can be summarized that *I/N* threshold of AMS receivers will not be exceeded when interfered by IMT stations deployed in urban areas. The margins are from 5 to 25 dB for the case of the omnidirectional AMS receiver and from 11 dB to 35 dB for the directional AMS receiver.

Taking into account high margins of *I/N* it can be concluded that protection of AMS receivers operating close to the borders of territorial seas would be excessive and unnecessary since no interference problems would occur in practice.

8.4 Conclusions

TBD

From section 8.2 - Study on basic transmission loss between air borne station of the aeronautical mobile service and terrestrial base station – the technical condition for sharing the bands 4 800 – 4 825 MHz and 4 835 – 4 940 MHz between terrestrial IMT and AMS is feasible if the separation distance between IMT and AMS station is greater than the radio horizon of the airborne AMS station.

9 Regulatory Studies

9.1 Provisions of the Radio Regulations for the band 4 800-4 990 MHz

Provisions RR No. **5.441B** stipulates:

Quote

"**5.441B** In Angola, Armenia, Azerbaijan, Benin, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, China, Côte d'Ivoire, Djibouti, Eswatini, Russian Federation, Gambia, Guinea, Iran (Islamic Republic of), Kazakhstan, Kenya, Lao P.D.R., Lesotho, Liberia, Malawi, Mauritius, Mongolia, Mozambique, Nigeria, Uganda, Uzbekistan, the Dem. Rep. of the Congo, Kyrgyzstan, the Dem. People's Rep. of Korea, Sudan, South Africa, Tanzania, Togo, Viet Nam, Zambia and Zimbabwe, the frequency band 4 800-4 990 MHz, or portions thereof, is identified for use by administrations wishing to implement International Mobile Telecommunications (IMT). This identification does not preclude the use of this frequency band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. The use of IMT stations is subject to agreement obtained under No. **9.21** with concerned administrations, and IMT stations shall not claim protection from stations of other applications of the mobile service. In addition, before an administration brings into use an IMT station in the mobile service, it shall ensure that the power flux-density (pfd) produced by this station does not exceed −155 dB(W/(m^2 · 1 MHz)) produced up to 19 km above sea level at 20 km from the coast, defined as the low-water mark, as officially recognized by the coastal State. This pfd criterion is subject to review at WRC-23. Resolution **223 (Rev.WRC-19)** applies. This identification shall be effective after WRC-19. (WRC-19)"

Unquote

Editor's note: *The results of the study could have impact on this footnote. This may need to be reviewed and revised, as appropriate, under AI 1.1.*

Resolution **223 (Rev.WRC-19)** establishes additional conditions for the band 4 800-4 990 MHz. In particular, Resolution **223 (Rev.WRC-19)** *decides*:

3 that in the frequency bands 4 800-4 825 MHz and 4 835-4 950 MHz, in order to identify potentially affected administrations when applying the procedure for seeking agreement under No. ***9.21*** *by IMT stations in relation to aircraft stations, a coordination distance from an IMT station to the border of another country equal to 300 km (for land path)/450 km (for sea path) applies;*

4 that in the frequency band 4 800-4 990 MHz, in order to identify potentially affected administrations when applying the procedure for seeking agreement under No. ***9.21*** *by IMT stations in relation to fixed-service stations or other ground-based* *stations of the mobile service, a coordination distance from an IMT station to the border of another country equal to 70 km applies;*

5 that the power flux-density (pfd) limits in No. ***5.441B****, which is subject to review at WRC-23, shall not apply to the following countries: Armenia, Brazil, Cambodia, China, Russian Federation, Kazakhstan, Lao P.D.R., Uzbekistan, South Africa, Viet Nam and Zimbabwe.*

9.2 The analysis of the regulatory conditions for the protections of stations of the aeronautical mobile service

9.2.1 Analysis of Mobile service allocations and their use for AMS applications in the 4 800-4 990 MHz band

The frequency range 4 400-4 990 MHz is allocated on a primary basis in all three ITU regions to the mobile service. Under the mobile service allocation, systems and networks operating in the aeronautical mobile service comprise stations for broadband, airborne data-links to support remote sensing and stations of aeronautical mobile telemetry. RR No. **5.442** states:

In the frequency bands 4 825-4 835 MHz and 4 950-4 990 MHz, the allocation to the mobile service is restricted to the mobile, except aeronautical mobile, service. In Region 2 (except Brazil, Cuba, Guatemala, Mexico, Paraguay, Uruguay and Venezuela), and in Australia, the frequency band 4 825-4 835 MHz is also allocated to the aeronautical mobile service, limited to aeronautical mobile telemetry for flight testing by aircraft stations. Such use shall be in accordance with Resolution ***416 (WRC-07)*** *and shall not cause harmful interference to the fixed service.* *(WRC-15)*

Table XX below provides a summary of the regulatory status of aeronautical mobile service in the various portions of the band as an easy reference and for better understanding of the situation.

TABLE XX

Status of Aeronautical Mobile Service in 4 800-4 990 MHz

	Region 1	**Region 2**	**Region 3**
4 800-4 825	Mobile primary	Mobile primary and, in addition, AMT may be used for aeronautical mobile telemetry for flight testing by aircraft stations (except Brazil, Cuba, French overseas departments and communities, Guatemala, Paraguay, Uruguay and Venezuela). Reference: RR No. **5.440A**	Mobile primary and, in addition, AMT may be used in Australia for aeronautical mobile telemetry for flight testing by aircraft stations Reference: RR No. **5.440A**

	Region 1	Region 2	Region 3
4 825-4 835	Mobile primary, allocation restricted to the mobile, except aeronautical mobile, service. Reference: RR No. **5.442**	Mobile primary, allocation restricted to the mobile, except aeronautical mobile, service. And, in addition, Aeronautical mobile service is allocated in Region 2 except in Brazil, Cuba, Guatemala, Mexico, Paraguay, Uruguay, and Venezuela, but limited to aeronautical mobile telemetry for flight testing by aircraft stations. Reference: RR No. **5.442**	Mobile primary allocation restricted to the mobile, except aeronautical mobile, service. Ad, in addition, Aeronautical mobile service is allocated in Australia but limited to aeronautical mobile telemetry for flight testing by aircraft stations. Reference: RR No. **5.442**
4 835-4 940	Mobile primary	Mobile primary and, in addition, AMT may be used for aeronautical mobile telemetry for flight testing by aircraft stations (except Brazil, Cuba, French overseas departments and communities, Guatemala, Paraguay, Uruguay and Venezuela) Reference: RR No. **5.440A**	Mobile primary and, in addition, AMT may be used in Australia for aeronautical mobile telemetry for flight testing by aircraft stations Reference: RR No. **5.440A**
4 940-4 950	Mobile primary	Mobile primary	Mobile primary
4 950-4 990	Mobile primary, allocation restricted to the mobile, except aeronautical mobile, service. Reference: RR No. **5.442**	Mobile primary, allocation restricted to the mobile, except aeronautical mobile, service. Reference: RR No. **5.442**	Mobile primary, allocation restricted to the mobile, except aeronautical mobile, service. Reference: RR No. **5.442**

9.2.2 Analysis of Recommendation ITU-R M.2116 on the use of Airborne data links (ADL)

Recommendation ITU-R **Error! Hyperlink reference not valid.**, which is currently being revised, provides technical characteristics and protection criteria for aeronautical mobile service systems operating in the 4 400-4 990 MHz frequency range.

As stated in *considering a)* of Recommendation ITU-R M.2116, "systems and networks operating in the aeronautical mobile service are used for broadband, airborne data-links to support remote sensing, e.g. earth sciences, land management, energy distribution, etc., applications".

In addition, Recommendation ITU-R M.2116 states that "...aeronautical mobile data links are operated between aeronautical stations and aircraft stations, or between aircraft stations equipped with AMS data links (ADL) and can be deployed anywhere within a country whose administration has authorized their use in accordance with regulations".

The working document towards a preliminary draft revision to Recommendation ITU-R M.2116-0, contained in WP 5B Chairman's Report #26, indicates that some countries are operating AMS systems in support to disaster relief and search and rescue activities within international airspace.

However, it should be understood that the AMS systems in the Recommendation ITU-R M.2116 in frequency bands 4 800-4 990 MHz do not operate in support of safety of life aeronautical applications.

9.2.3 Analysis of the use of the bands for aeronautical mobile telemetry (AMT)

The use of the frequency band 4 800-4 990 MHz for AMT in Region 2 (except some countries) and in Australia is subject to RR No. **5.440A**[8], No. **5.442**, and Resolution **416 (WRC-07)**, which resolved that in the portions of the frequency band 4 400-4 940 MHz AMT emissions are limited to transmission from aircraft stations only (see RR No. **1.83**).

Here the use of AMT stations is only related to country use (except as noted in Figure 1 of Report ITU-R M. 2119 in the case of one administration). In accordance with Resolution **416 (WRC-07)** transmissions limited to designated flight test areas, where flight test areas are airspace designated by administrations for flight testing.

In accordance with Resolution **416 (WRC-07)** in the band 4 400-4 940 MHz, also AMT in the aeronautical mobile service is not considered an application of a safety service as per RR No. **1.59**.

In any case where the receiver is ground based, protection of the AMS stations is covered by the provision that the use of IMT by an administration is subject to an agreement under RR No. **9.21**, pursuant to RR No. **5.441B**. Therefore, a pfd limit at the 19 km above sea level is not required for the protection of the aeronautical telemetry in this case.

In accordance with RR No. **5.440A** any use of AMT does not preclude the use of this band by other mobile service applications or by other services to which this band is allocated on a co-primary basis and does not establish priority in the Radio Regulations. According to Resolution **416 (WRC-07)** in the frequency band 4 400-4 940 MHz it is necessary to carry out bilateral coordination of transmitting AMT aircraft stations in relation to the fixed and mobile receiving stations when an AMT aircraft station is located within a distance of 450 km from the receiving fixed or mobile stations.

However, it should be noted that in the case above the application of RR No. **9.21** to the mobile stations in the frequency band 4 800-4 990 MHz in accordance with RR. No. **5.441B** with respect to AMT stations is not in conflict with Resolution **416 (WRC-07)** because RR No. **9.21** is relevant to the protection of the AMT receiver and Resolution **416 (WRC-07)** applies to the protection of fixed and mobile service.

In accordance with Resolution **416 (WRC-07)** administrations authorizing AMT per RR Nos. **5.440A**, **5.442** in the bands 4 400-4 940 MHz shall implement technical and/or operational measures on AMT where appropriate to facilitate sharing with other services and applications in these bands. Based on the fact that there is no priority established in the Radio Regulations both provisions are applicable. Reading RR No. **5.440A** in harmony with RR No. **5.441B** leads to the observation that, while other applications of the mobile service, such as IMT, are not precluded by AMT (RR No. **5.440A**), IMT is still subject to the conditions for operation in the band 4 800-4 990 MHz.

Other cases of implementation of AMT stations not relevant to RR Nos **5.440A** and **5.442** cases or cases of operation of AMT in international airspace/waters in the band 4 800-4 990 MHz were not considered in the Radio Regulations and ITU-R Recommendation and Reports (except as noted in

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[8] ***5.440A*** In Region 2 (except Brazil, Cuba, French overseas departments and communities, Guatemala, Paraguay, Uruguay and Venezuela), and in Australia, the band 4 400-4 940 MHz may be used for aeronautical mobile telemetry for flight testing by aircraft stations (see No. **1.83**). Such use shall be in accordance with Resolution **416 (WRC-07)** and shall not cause harmful interference to, nor claim protection from, the fixed-satellite and fixed services. Any such use does not preclude the use of this band by other mobile service applications or by other services to which this band is allocated on a co-primary basis and does not establish priority in the Radio Regulations. (WRC-07)

Figure 1 of Report ITU-R M.2119). In accordance with Resolution **416 (WRC-07)** and Report ITU-R M.2119 the studies have been conducted within ITU-R concerning only the sharing and compatibility of AMT for flight testing with other services in the band 4 400-4 940 MHz. In the case of no use of AMT in international airspace, study of conditions of its protection is not required and therefore, a pfd limit in the band 4 800-4 990 MHz is not relevant for AMT.

9.2.4 Analysis of existing practice to protect stations in AMS in the international airspace

There is common understanding that no country has jurisdiction over the use of spectrum in international airspace/waters.

According to the provision in RR No. **8.1**, "The international rights and obligations of administrations in respect of their own and other administrations' frequency assignments shall be derived from the recording of those assignments in the Master International Frequency Register (the Master Register) or from their conformity, where appropriate, with a plan. Such rights shall be conditioned by the provisions of these Regulations and those of any relevant frequency allotment or assignment plan."

However, there is no specific notification and registration procedure in international airspace and waters for frequency assignments of AMS and MMS stations in this band pursuant to RR No.**11.14**. Such situation does not provide possibility to obtain international rights recognition in respect to frequency assignments of AMS stations in international airspace and waters and to claim protection against subsequent assignments from another country taking into account RR No. **8.1**, taking also into account that there is no frequency allotment or assignment Plan in the 4 800-4 990 MHz frequency band for the AMS nor MMS services. Therefore, protection of AMS/MMS stations in international airspace/waters on the basis of registration of frequency assignments is not feasible. At the same time, it should be noted that AMS/MMS frequency assignments for coast and aeronautical stations can cover a service area which overlaps with international airspace/waters. For this case (such as in Figure 1 of Report ITU-R M.2119), application of No. **9.21** would enable the protection of AMS/MMS stations in the international airspace covered by the service area.

The inability to address protection of AMS/MMS stations in international airspace/waters via the registration procedure in accordance with RR Article **11.14** does not exclude the possibility of applying other mechanisms, through current and future provisions in the Radio Regulations.

Within international airspace the operation of AMS shall comply with the Radio Regulations. Analysis of Radio Regulations indicates that certain measures can be applied to mitigate harmful interference to aeronautical mobile stations outside national territories. Mechanisms for enabling the protection of AMS in international airspace include the following:

- Pfd limit, at a certain height and distance from the coast as in RR No. **5.441B**. It should, however, be noted that RR No. **5.441B** is under review and is set to be reconsidered at WRC-23, under agenda item 1.1.
- Measures based on frequency planning

It can be noted that:

- the Radio regulation specifically provides for the international protection of frequencies relating to distress and safety and flight safety and control use in RR (e.g. Article **31** and Appendix **27**) which operated in AMS or MMS. However, it should be noted that 4 800-4 990 MHz frequency band is neither a GMDSS frequency band nor an AM(R)S frequency band.
- RR No. **9.21** may enable the protection of some zones in international airspace /waters that are in the service area of AMS land stations. This solution is therefore valid only

for very specific area/cases and not for the general case of operations in international airspace/water. Therefore the use of RR No. **9.21** may be applicable in some areas/cases without additional measures.

Based on the review of current RR, it is observed that:

- There are examples of RR footnotes providing protection for services in international airspaces and waters, such as **5.502** and **5.509D** and,
- There are cases where no specific measures are provided to protect mobile service systems operated in international airspace or waters (e.g. all the bands identified for IMT except the band 4 800-4 990 MHz which is currently being studied under AI 1.1).
- There are cases wherein mobile service systems operated in international airspace or waters protect authorized stations operating within national territories. (e.g. ESV, IMT onboard vessels and aircrafts).

In several bands with IMT identification and aeronautical mobile service allocation in the Radio regulations, some administrations operates AMS services systems in accordance with the relevant Recommendations (ITU-R M.2114, ITU-R M.2115, etc.) and it is not clear whether the situations with the use of such bands may differ from one another.

This variety of situations is likely to reflect the differences of circumstances under which WRC have decided a new allocation or identification based on the principle that incumbent services and applications have to be protected.

In keeping with this principle, WRC-15 adopted RR No. **5.441B** and identified the frequency band 4 800-4 990 MHz, or portions thereof, for use by administrations wishing to implement International Mobile Telecommunications (IMT). RR No. **5.441B** establishes, among other conditions, a pfd limit applied to IMT in that frequency band as an additional measure to provide protection to AMS stations operating outside territorial waters of coastal states. Due to diverging views with respect to the relevance of the pfd criterion for the protection of AMS, its value, conditions of use and the frequency band within which the pfd limit would apply, WRC-15 invited ITU-R to conduct studies for technical and regulatory conditions for the use of this band for IMT, in order to protect AMS and review the pfd criterion in RR No. **5.441B** at WRC-19".

It should, be noted that RR No. **5.509D** addresses the case of restriction on FSS earth stations in order to protect stations in international airspace. As for mobile service systems which can also operate in the 14.5-14.8 GHz band (e.g. see Recommendation M.2068 "Characteristics of and protection criteria for systems operating in the mobile service in the frequency range 14.5-15.35 GHz") there are no limitations placed on their operation on the national territories.

It should also be noted that the provision of RR No.**5.502** protects stations both in national and international waters

It should also be noted that for some countries of Region 2, in a similar situation *within* the band 4 800-4 990 MHz, RR No **5.441A** does not define additional measures like a pfd limit for the protection of the AMS or MMS stations in the band 4 800-4 900 MHz against possible interference from IMT stations.

9.3 The analysis of the regulatory conditions for the protection of stations of the maritime mobile service

The frequency range 4 800-4 990 MHz is allocated, on a primary basis in all three ITU regions, to the mobile service. As the mobile allocation is generic, the band or portions of it, can be used by stations of maritime mobile service in accordance with the Radio Regulations. With specific reference to the status of the maritime mobile service in this band, there are no band-specific restrictions in the RR and therefore station of that service can use any part of the band.

Section 9.2.4 addresses the specifics of notification and registration procedure in international airspace and waters for frequency assignments of AMS and MMS stations and the regulatory consequences.

RR No. **5.441B** provides a pfd limit, which is subject to review by WRC-23, applicable in the band 4 800-4 990 MHz based on assumptions relevant to AMS. In practice, the existing provisions of RR No. **5.441B** protects MMS operations in international waters. However, it should be confirmed, based on the studies under WRC-23 agenda item 1.1, whether specific measures are required for the protection of MMS in international waters, if any, also taking into account allocations in the various portions of the band.

The use of the band 4 800-4 990 MHz for the maritime mobile service (MMS) has not been considered until WRC-19. No studies with regard to compatibility between IMT and MMS had been conducted and MMS characteristics were not available. Some administrations informed they had MMS systems in operations but focused on studies for the protection of AMS, more sensitive to interference than MMS due to largest line of sight distances.

Development of technical and regulatory measures for the protection of the MMS in international waters, if necessary, required appropriate studies including those based on the ongoing revision of Recommendation ITU-R M.2116,, which provides technical characteristics and protection criteria for the systems operating in the maritime mobile service within the 4 400-4 990 MHz frequency range

The working document towards a preliminary draft revision to Recommendation ITU-R M.2116-0, contained in WP 5B Chairman's Report #28, contains some technical and operational characteristics as well as applications in relation to MMS systems in the band 4 800-4 990 MHz.

Section 9.2.4 already provides information on existing regulation related to protection of AMS/MMS stations and other applications in international waters.

10 [/Provisional Summary] on the technical and regulatory studies

This section contains summary of the results of the studies of technical and regulatory conditions for the protection of AMS and MMS stations located in international airspace or in international waters (i.e. outside national territories) and operating in the frequency band 4 800-4 990 MHz.

10.1 Technical studies

Editor's note: the inclusion of the highlighted text below in square brackets referring to EEZ requires further consideration

[The curve on the water surface which should be used as reference for deriving the technical conditions for protection of AMS/MMS applications (at the heights typical for their operations respectively) should correspond to the external boundary of the costal state's "exclusive economic zone" having a maximum breadth. Such a reference curve would be located 370.4 km away from the costal baseline but could be closer in certain geographical situations. In such situations, the technical conditions defined at the reference curve corresponding to the maximum breadth of the costal state's EEZ (i.e. at 370.4 km away from the costal baseline) would be scaled to correspond to the actual length of the EEZ in question.

If the actual breadth of the costal state's EEZ is larger than the maximum distance from the costal baseline at which technical studies show that AMS and MMS systems would be protected without any restrictions on IMT systems of the costal state, then no conditions on the operation of the mentioned IMT systems with respect to the protection of the AMS and MMS applications in international airspace and waters respectively would be required.]

Editor's note: it can be considered to specify in this sub-section which results correspond to which studies

Studies have estimated the single-entry pfd required to protect AMS and MMS systems for omnidirectional antennas and directive antennas. Results are included in Tables XX and YY.

TABLE XX

Calculated pfd required to protect AMS systems for maximum receiving antenna gain direction

Parameter (unit)	AMS receiver antenna gain (dBi)		Power flux density (dB(W/(m² · MHz)))	
System 1 Airborne	3		−114.07	
System 2 Airborne	3		−114.07	
System 3 Airborne	3.5 (omni)	16 (directional)	−115.57 (omni)	−128.07 (directional)
System 3 Shipborne	3 (omni)	30 (directional)	−111.57 (omni)	−138.57 (directional)
System 4 Airborne	4.5 (omni)	16 (directional)	−116.57 (omni)	−128.07 (directional)
System 5 Airborne	3 (omni)	19 (directional)	−114.07 (omni)	−130.07 (directional)
System 5 Shipborne	3 (omni)	31 (directional)	−111.57 (omni)	−139.57 (directional)
System 6 Airborne 1	4.7		−113.27	
System 6 Airborne 2	4.7		−113.27	
System 6 Shipborne	6 (omni)	11.8 (directional)	−114.57 (omni)	−120.37 (directional)
System 7 Airborne 1	14		−122.57	
System 7 Airborne 2	14		−122.57	
System 8 Airborne	0		−105.57	
System 8 Shipborne	15		−124.57	

TABLE YY

Calculated pfd required to protect MMS systems for maximum receiving antenna gain direction

Parameter (Unit)	MMS receiver antenna gain (dBi)	Power flux density (dB(W/(m² · MHz)))
System 1 Shipborne	6	−114.57
System 2 Shipborne	15	−124.57

Some other studies have assessed the aggregation factor to be applied to derive a pfd limit per station in the case of omnidirectional antenna. The aggregation factor derived for AMS is 13.5 dB and for MMS 10 dB.

In a study on basic transmission loss between air borne station of the aeronautical mobile service and terrestrial base station it is observed that at specific separation distances between an airborne station and a terrestrial station, and at up to specific altitudes of the airborne station, the basic transmission loss can be high enough to meet the isolation needed to mitigate interference to the airborne station.

Another study presented a simulation of interference from IMT with AAS to AMS within the 4 800-4 990 MHz frequency band and estimated whether the required protection criteria of I/N= –6 dB is met when AMS operated close to the territorial sea of a costal state. Based on the obtained results, it can be summarized that I/N threshold of AMS receivers will not be exceeded when interfered by IMT stations deployed in urban areas with 57 BS in each city (285 BS total) in accordance with simulation methodology of Recommendation ITU-R M.2101. The margins are from 5 to 25 dB for the case of the omnidirectional AMS receiver and from 11 dB to 35 dB for the directional AMS receiver.

Taking into account high margins of *I/N* this study concluded that no interference problems to AMS receivers are expected even for a worst-case scenario assumed in the study. The study noted that in practice, the AMS receiver would not operate at the border of the territorial seas and thus real margins would be significantly higher.

10.2 Studies on regulatory aspects

This sub-section contains a summary of the results of the studies of regulatory conditions for the protection of AMS and MMS stations located in international airspace or in international waters (i.e. outside national territories) and operating in the frequency band 4 800-4 990 MHz.

The studies revealed the variety of the regulatory situations which could be considered relevant to the discussion under this agenda item and which are addressed by the various regulatory provisions of the RR and other relevant regulation. Based on the above mentioned studies, the following aspects should be taken into account when making decision on agenda item 1.1.

a) The term operation of vessels and aircrafts in international waters and international airspace, respectively, referred to in WRC-23 agenda item 1.1, is understood to mean that such operation would take place in an area which is outside the territory under jurisdiction of any administration.

There is a common understanding that no country has jurisdiction over the use of spectrum in international airspace/waters.

b) Based on the AMS allocations in the Radio Regulations the question of potential protection of aeronautical stations in international airspace may only be discussed for the frequency bands 4 800-4 825 MHz and 4 835-4 950 MHz and not for the whole band 4 800-4 990 MHz (except in Region 2 (other than Brazil, Cuba, Guatemala, Mexico, Paraguay, Uruguay and Venezuela), and in Australia, where the frequency band 4 825-4 835 MHz is also allocated to the aeronautical mobile service, limited to aeronautical mobile telemetry for flight testing by aircraft stations.).

c) According to the provision in RR No. **8.1**, "The international rights and obligations of administrations in respect of their own and other administrations' frequency assignments shall be derived from the recording of those assignments in the Master International Frequency Register (the Master Register) or from their conformity, where appropriate, with a plan. Such rights shall be conditioned by the provisions of these Regulations and those of any relevant frequency allotment or assignment plan."

However, there is no specific notification and registration procedure in international airspace and waters for frequency assignments of AMS and MMS stations in this band pursuant to RR No. **11.14**. Such situation does not provide possibility to obtain international rights recognition in respect to frequency assignments of AMS and MMS stations in international airspace and waters and to claim protection against subsequent assignments from another country taking into account RR No. **8.1**, taking also into account that there is no frequency allotment or assignment Plan in the 4 800-4 990 MHz frequency band for the AMS nor for the MMS service.

Therefore, protection of AMS/MMS stations in international airspace/waters on the basis of registration of frequency assignments is not feasible. At the same time, it should be noted that AMS/MMS frequency assignments for coast and aeronautical stations can cover a service area which overlaps with international airspace/waters. For this case (such as in Figure 1 of Report

M.2119), application of RR No. **9.21** would enable the protection of AMS/MMS stations in the international airspace covered by the service area.

The inability to address protection of AMS/MMS stations in international airspace/waters via the registration procedure in accordance with RR Article **11.14** does not exclude the possibility of applying other mechanisms, through current and future provisions in the Radio Regulations.

d) It is observed that:

- There are examples of RR footnotes providing protection for services in international airspaces and waters, such as No. **5.502** and No. **5.509D** and;
- There are cases where no specific measures are provided to protect mobile service systems operated in international airspace or waters (e.g. all the bands identified for IMT except the band 4 800-4 990 MHz which is currently being studied under AI 1.1);
- There are cases wherein mobile service systems operated in international airspace or waters protect authorized stations operating within national territories. (e.g. ESV, IMT onboard vessels and aircrafts).

In several bands with IMT identification and aeronautical mobile service allocation in the Radio regulations, some administrations operates AMS services systems in accordance with the relevant Recommendations (ITU-R M.2114, ITU-R M.2115, etc.) and it is not clear whether the situations with the use of such bands may differ from one another.

This variety of situations is likely to reflect the differences of circumstances under which WRC have decided a new allocation or identification, based on the principle that incumbent services and applications have to be protected.

In keeping with this principle, WRC-15 adopted RR No. **5.441B** and identified the frequency band 4 800-4 990 MHz, or portions thereof, for use by administrations wishing to implement International Mobile Telecommunications (IMT). RR No. **5.441B** establishes, among other conditions, a pfd limit applied to IMT in that frequency band as an additional measure to provide protection to AMS stations operating outside territorial waters of coastal states. Due to diverging views with respect to the relevance of the pfd criterion for the protection of AMS, its value, conditions of use and the frequency band within which the pfd limit would apply, WRC-15 invited ITU-R to conduct studies for technical and regulatory conditions for the use of this band for IMT, in order to protect AMS and review the pfd criterion in RR No. **5.441B** at WRC-19".

e) RR No. **5.441B** provides a pfd limit, which is subject to review by WRC-23, applicable in the band 4 800-4 990 MHz based on assumptions relevant to AMS. In practice, the existing provisions of RR No. **5.441B** protects MMS operations in international waters. However, it should be confirmed, based on the studies under WRC-23 agenda item 1.1, whether specific measures are required for the protection of MMS in international waters, if any, also taking into account allocations in the various portions of the band.

The use of the band 4 800-4 990 MHz for the maritime mobile service (MMS) has not been considered until WRC-19. No studies with regard to compatibility between IMT and MMS had been conducted and MMS characteristics were not available. Some administrations informed they had MMS systems in operations but focused on studies for the protection of AMS, more sensitive to interference than MMS due to largest line of sight distances.

Development of technical and regulatory measures for the protection of the MMS in international waters, if necessary, required appropriate studies including those based on the ongoing revision of Recommendation ITU-R M.2116, which provides technical characteristics and protection criteria for the systems operating in the maritime mobile service within the 4 400-4 990 MHz frequency range.

Editor's note: the inclusion of the highlighted text below in square brackets referring to EEZ requires further consideration

[f) According to the UN Convention on the Law of the Sea (the UNCLOS), national territories include a so called "exclusive economic zone" (EEZ) defined as an area beyond and adjacent to the territorial sea (EEZ can extend up to 200 nautical miles (or 370 km) from the baselines from which the breadth of the territorial see is measured). The UNCLOS establishes that a costal state has jurisdiction and sovereign rights for the various activities related to the economic exploitation and exploration in such a zone. Accordingly, international airspace and international waters, which are considered under agenda item 1.1 of WRC-23, can be considered as zones outside the respective exclusive economic zones in which coastal states have priority for the various types of activities defined in the UNCLOS. Therefore, the question of the possible protection of operations of vessels and aircraft in international waters and international airspace respectively should be constrained by the area beyond the boundary of the costal state's EEZ. It is important to note that the size of the EEZ varies from country to country, and therefore the application of a uniform technical criterion for the protection of AMS/MMS applications beyond such a zone may not be appropriate.]