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| **U.S. Radiocommunications Sector****Fact Sheet** |
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| **Document Title:**  Sharing between MSS (Space-to-Earth) and IMT operating in the frequency band 7 125-8 400 MHz  |
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| **Purpose/Objective:** This contribution proposes a new IMT and MSS and MMSS (Space-to-Earth) compatibility study in the frequency band 7125-8400 MHz under WRC-27 agenda item 1.7.   |
| **Abstract:** This study examines the compatibility of IMT with Mobile Satellite Service (MSS), focusing on the impact of new IMT deployments on existing MSS downlinks to aircraft. Aircrafts have the widest field of view and therefore could be the most sensitive to an IMT deployment.   However, the influence of existing MSS services on IMT deployments, commonly referred to as reverse studies, is not considered. Attachment 1 contains sharing studies between the fixed service and IMT operating in the frequency band 7 125-8 400 MHz.  [DoD notes that these studies are technical in nature, consistent with ITU practices, and are being submitted solely for purposes of consideration in the U.S. preparatory process for the ITU-R WRC-27 WP5D meetings.  The results of these studies do not reflect policy positions of DoD and shall not be used for or have any bearing upon separate studies being performed by DoD or any other entity on the 7/8GHz band, including U.S./domestic studies that will be performed later this year.]  |

United States of America |
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| sharing between MSS (Space-to-EARTH) and IMT operating in the frequency band 7 125-8 400 MHz |
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# 1 Introduction

This document contains the sharing study between IMT in the frequency band 7 125-8 400 MHz and mobile satellite services (MSS) aircraft stations to which the frequency band is allocated on a primary basis. Future studies may also consider land and maritime terminals. The study is found in the attachment.

# 2 Proposal

The USA proposes that the study found in the attachment be added to other studies that will go in the update of Annex 4.11 to Document **5D/TEMP/338**, “Sharing and compatibility studies between services to which the band is currently allocated and IMT systems in the frequency band 7 125-8 400 MHz under WRC-27 agenda item 1.7”.

**Attachment:** 1

attachment

Sharing between the MSS and IMT operating in the
frequency band 7 125-8 400 MHz

This Attachment contains a sharing study of the mobile satellite service (MSS) and IMT operating in the frequency band 7 125-8 400 MHz. The technical characteristics of IMT are provided in Document **5D/TEMP/361**. The MSS characteristics are provided in Document [5D/596](https://www.itu.int/md/R23-WP5D-C-0596/en), reply liaison statement to Working Party (WP) 5D, Technical information to support studies under WRC‑27 agenda item 1.7.

# A1 Technical/operational characteristics of IMT systems modelled for the frequency band 7 125-8 400 MHz

## A1.1 IMT deployment model

The IMT characteristics are found in Document 5D/TEMP/361. This document focuses solely on modeling interference from macro-cell base stations (BS), as it is anticipated to be the primary contributor to overall interference. Future studies may include additional interference contributions from small cells and UEs.

Table A-1 shows the IMT deployment parameters from Table 13 in Doc. 5D/TEMP/361.

Table A-1

Deployment-related parameters

|  |  |
| --- | --- |
| Macro-cell deployment density | 600 m ISD Urban (400 m cell size) 1200 m ISD Suburban (800 m cell size) |
| Metropolitan area deployment density | 10 BSs/km2 urban 2.4 BSs/km2 suburban  |
| Antenna height | 18 m urban20 m suburban |
| Sectorization | 3 |
| Frequency reuse | 1 |
| Below rooftop base station antenna deployment  | Urban: 65%Suburban: 15%  |
| Typical channel bandwidth  | 100 MHz |
| Network loading factor | 20%, 50% |
| TDD / FDD | TDD |
| BS TDD activity factor | 75% |
| Power dynamic range  | 56 dB |
| Maximum output power | 23 dBm |
| Noise figure | 13 dB |
| Spectral mask | 3GPP TS 38.101-1 “NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone”, § 6.5.2.2 |
| Blocking response | 3GPP TS 38.101-1 v.18.6.0, § 7.6 and 7.7 Tables |

Simulations will be performed to assess the sensitivity of MSS aircraft earth stations to IMT network interference as a function of distance from the IMT deployment. The study will determine the probability of a representative IMT network exceeding interference thresholds for cross-border MSS systems.

In this study the aircraft has a wide field of view, of approximately 500 km for an aircraft altitude of 20 000 m, per Doc. 5D/596. Figure A-1 shows the scenario where the aircraft is at a distance D from the border where an IMT network is deployed. The aggregate interference to the aircraft is analyzed as a function of the distance from the border. The simulations will be used to examine the required separation distance between the IMT deployment and the aircraft station to meet both long-term and short-term interference criteria. The radius of the circle is 500 km.

Figure A-1

Aircraft flying in Country A at a distance D from the border from an IMT deployment in Country B



Within the visible area of the aircraft, the base station deployment density follows the Ra/Rb deployment recommendations in section 5 of [Annex 4.15](https://www.itu.int/dms_ties/itu-r/md/23/wp5d/c/R23-WP5D-C-0563%21H4-N4.15%21MSW-E.docx) to Document 5D/792, where:

 *Ra* (%) = ratio of coverage areas to areas of cities/built areas/districts;

 *Rb* (%) = ratio of built areas to total area of region in study.

Within this area the deployment is assumed to follow Option 1 from Table 22 of Annex 4.15 to Document 5D/563 where:

The Ra, Rb values are used to determine the total number of IMT BSs ($N\_{BS}$) within the deployment area A, as given by Equation (1).

 $N\_{BS}=N\_{BS\_{suburban}}+N\_{BS\_{urban}}=A×R\_{b}×(R\_{aSub}×D\_{BS\_{Sub}}+R\_{aUr}×D\_{BS\_{Ur}})$ (1)

where:

 $A$ : is the surface of the considered area in km2;

 $R\_{a}$ : is the ratio of coverage areas to areas of cities/built areas/districts;

 $R\_{b}$ : is the ratio of built areas to total area of region;

 $D\_{BS\_{Sub}}$ : is the BS density in suburban (2.4 / km2);

 $D\_{BS\_{Urb}}$ : is the BS densities in urban (10 / km2).

## A1.2 IMT BS model

The IMT BSs are assumed to use advanced antenna systems (AAS) capable of beamforming. The antenna characteristics from document 5D/TEMP/361 for the AAS BS antenna are shown in Table A-2.

Table A-2

Beamforming antenna characteristics for IMT Macro-cell BS antenna characteristics Document 5D/TEMP/361 (Table 19)

|  |  |
| --- | --- |
| Antenna pattern model  | Document 5D/TEMP/361 Table 17 (Extended AAS Model) |
| Element gain (dBi) (Note 2) | 6.4 |
| Horizontal/vertical 3 dB beam width of single element (degree)  | 90º for H65º for V |
| Horizontal/vertical front-to-back ratio (dB) | 30 for both H/V |
| Antenna polarization  | Linear ±45º polarized sub-array |
| Antenna array configuration (Row × Column) (Note 4) | 8 × 16 |
| Horizontal/Vertical radiating sub-array or element spacing (Note 5) | 0.5 of wavelength for H, 2.1 of wavelength for V |
| Number of element rows in sub-array | 3 |
| Vertical element separation in sub-array ($d\_{v,sub}$) | 0.7 of wavelength for V |
| Pre-set sub-array down-tilt (degrees) (Note 6) | 3 |
| Array Ohmic loss (dB) (Note 2) | 2 |
| Conducted power (before Ohmic loss) per sub-array or element (dBm) (Note 3) | 22 |
| Base station horizontal coverage range (degrees) | ±60 |
| Base station vertical coverage range (degrees) (Note 1) | 90-100 |
| Mechanical down-tilt (degrees) | 6 |
| Base station output power/sector (e.i.r.p.) (dBm) (Note 7) | 78.3 |

Simulations will follow Recommendation ITU-R M.2101 assuming AAS BS antennas point toward the UE as shown in Figure A-2. At each iteration of the simulation, 3 UEs are selected in each sector and the BS forms a beam in the UE direction.

Figure A-2

BS dynamic beamforming



Network loading factors will be employed to determine the percentage of base stations active for a given snapshot. A typical loading factor of 20% will be assumed according to Annex 4.15 to Document 5D/563. The TDD activity factor will be set to 75% for the BSs downlinks.

The BS transmit power of 46.1 dBm/100 MHz and the BS peak antenna gain of 32.2 dBi will be used. The BS output power per sector of 78.3 dBm is per Table A-2. As the simulations have three user equipment (UEs) being simultaneously served per base station, the power per sector is split among the three BS-UE links, resulting in lower output power per link. Following Recommendation ITU-R M.2101, the available resource blocks for the BS transmissions are evenly split among the three UEs per snapshot. The IMT BSs heights are set to 18 m for urban and 20 m for suburban for all BSs.

## A1.3 Propagation

For terrestrial to airborne systems, Recommendation ITU-R P.528-5, which is applicable in the 100 MHz to 30 GHz frequency range, will be applied. This calculation assumes smooth earth. This Recommendation also supports time percentage exceedance from 1-99%, which will be varied as a random variable in the Monte Carlo trials.

Clutter modeling is based on the updated version of ITU-R P.2108, Section 3.3, as outlined in document 5D/629. The model is applied using directional base station antennas, as specified in the attachment to document 5D/629. The Recommendation supports time percentage exceedance from 1-99%, which will be varied as a random variable in the Monte Carlo trials.

# A2 Technical/ operational characteristics and protection criteria of MSS earth stations within the frequency band 7 125-8 400 MHz

This contribution focuses on the interference from an IMT network into an MSS aircraft earth station connected to GSO satellites. Non-GSO systems are not considered as WP 4C hasn’t provided guidance on the satellite selection criteria to use. However, future studies may consider non-GSO constellations. Future studies may also consider MSS land and maritime systems.

The characteristics of representative aircraft station types are detailed in Table 3 of Doc. 5D/596, reply liaison statement to WP 5D regarding 7/8 GHz MSS characteristics for AI 1.7 sharing studies,, and the relevant information for the studies performed in this contribution is distilled in Table A-3, below. The earth station altitude in the table is 20 Km. However, note 1 indicates that there could be altitude variations. For sensitivity, an altitude of 12 Km will also be considered.

TABLE A-3

Characteristic earth station parameters for MSS GSO systems

|  |  |  |
| --- | --- | --- |
| Characteristics of earth station | ES 10 | ES 11 |
| Earth station description | Note 1 | Note 1 |
| Antenna type | Parabolic | Parabolic |
| Antenna platform | Airborne | Airborne |
| Antenna height above ground (m) | 20 000 | 20 000 |
| Beam positioning | All Visible azimuth | All Visible azimuth |
| Receiver tuning range (MHz) | 7 250-7 375 | 7 250-7 375 |
| Receive antenna diameter (m) | 0.84 | 1.14 |
| Receive antenna peak gain (dBi) | 33 | 36.3 |
| Receive antenna 3 dB beamwidth (deg) | 3.21 | 2.37 |
| Typical elevation angle (deg) | 10-30 | 10-30 |
| Full range elevation angle (deg) | 3-90 | 3-90 |
| Receiver antenna polarization  | Circular | Circular |
| Receiver noise temperature (K) | 190 | 102 |
| Receiver channel bandwidth (MHz) | 125 | 125 |

Note 1: For aircraft, there could be altitude variations.

## A2.1 MSS airborne earth station antenna pattern and fuselage blockage

The MSS airborne earth station antenna pattern is based on Rec. ITU-R F.699. Since the airborne antenna is pointed skyward the antenna is typically located near the top of the fuselage. This means there will be blockage in the direction of the earth from the aircraft fuselage. The airborne antenna is pointing at elevation angles given in Table A-3 for the GSO MSS system.

Fuselage blockage is estimated using Report ITU-R M.2221. A measurement campaign conducted by an aeronautical Internet Service Provider serves as the reference for fuselage loss. In this report, attenuation caused by the aircraft body was measured using an antenna mounted on top of a full cylinder with a radius of curvature similar to that of a Boeing 737 fuselage. Although measurements were conducted at 14.2 GHz, they are assumed to be applicable to the 7/8 GHz band. The fuselage loss mask used in this study is shown in Figure A-3, which is reproduced from Figure 3.6-14 of Report ITU-R M.2221.

Figure A-3

Attenuation due to the fuselage of the aircraft



**A2.2** **MSS interference criterion**

The MSS protection criteria for both the space-to-Earth and Earth-to-space are listed in Table 9 in Annex 2 of Doc. 5D/596 and are summarized in the table below.

TABLE A-4

MSS protection criteria (see Notes 1 and 2)

|  |  |  |
| --- | --- | --- |
| Frequency ranges | Percentage of time for which the *I/N* value could be exceeded (%) | *I/N* criteria (dB) |
| 7 250-7 375 MHz (space-to-earth) | 20%0.001% | −10.5−2.33 |
| NOTE 1 – The noise N in the *I/N* criteria as specified above is the system receiver noise (i.e. thermal noise) and is equal to the receiver antenna noise at the assumed elevation angle plus the receiver referred to the antenna. Hence studies conducted by WP 5D should only use the values presented above when evaluating the compliance with the protection criteria.NOTE 2 – The protection criteria specified are related to the required availability of MSS links in these bands, which is associated with time. It is appropriate to understand such percentages as percentages of time, for interference analysis where the degradation is a direct function of time (e.g. time-varying atmospheric degradation or antenna pointing).However, Monte Carlo sharing studies conducted between satellites and IMT systems under WRC‑27 agenda item 1.7 may involve other considerations and calculations, based on additional variables which are not varying in the time domain (e.g. geographical locations in the space or deployment domain associated with IMT positions).For such studies, it may be appropriate to understand percentages as being in other domains, such as time, location and probability, recognising that additional alternative measures might be needed in some cases, and that it is not possible to foresee all future modelling options. |

# A3 Simulation methodology

The parameters and assumptions outlined below form the basis of the simulations conducted for this report:

* IMT deployment according to Figure A-1 with BS densities as described in section A1.1
* BS dynamic beamforming to 3 randomly selected UEs per iteration
* IMT loading factor equal to 20%
* GSO earth station elevation angles: 10°, 20°, 30° and 60°
* MSS aircraft earth terminal characteristics as defined in Table A-3
* MSS aircraft earth terminal altitudes: 12 km and 20 km
* IMT BS clutter loss: P.2108, Sec. 3.3 as described in document 5D/629
* MSS earth station fuselage loss: Figure A-3

In each simulation iteration, an aircraft will be placed at a certain horizontal distance (0 to 800 km) away from the eastern border of the IMT deployment and aligned vertically with the IMT network center. The aggregate interference from each active IMT beam will be calculated as above.

For each iteration, random parameters will be exercised (Path loss variables, clutter distribution, BS deployment and beam-pointing directions). For MSS station pointing geometry, several elevation angles toward the GSO satellite will be considered (10°, 20°, 30° and 60°). For each elevation angle considered the azimuth angle is pointed at the IMT deployment center.

A Monte Carlo simulation is then used to randomise the location and azimuth pointing of the base stations in the area around the earth station for a total of 100,000 Monte Carlo steps. For each step, the aggregate interference from the IMT stations into the earth station is calculated using Equation 2.

 $I=\sum\_{k=1}^{57}\left[\sum\_{i=1}^{3}\left(P\_{Tki}+G\_{Tki}\right)+PL\_{k}+L\_{C\\_BS\_{k}}+G\_{R\_{k}}+L\_{F\\_AES}\right]+L\_{P}$ (2)

where:

 *I/N* = Aggregate interference to noise ratio at the MSS station (dB) calculated over all sectors in the simulation

 *PTki* = Transmit power of the Kth BS and the ith beam (dBm)

 $G\_{Tki}$ = Gain of the kth BS and the ith BS beam in the direction of the MSS station (dBi)

 $G\_{R\_{k}}$ = Gain of the FSS Receiver Antenna in the direction of the kth BS (dBi)

 *PLk* = Path loss calculated over the full distribution (1 to 9%) using P.528(dB) for the kth BS

 $L\_{C\\_BSk}$ = Clutter loss applied at base stations below rooftop (i.e., P.2108 section 3.3) for the kth BS

 *LP* = Polarization loss = 3 dB

The IMT channel bandwidth (BWBS) in this study is 100 MHz (see Table A-1).

## A.4 Study results (to be provided at next meeting)

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