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| **Radiocommunication Study Groups** |  |
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| U.S. Radiocommunications SectorFact Sheet |
| **Working Party:** ITU-R WP 5D | **Document No:** USWP5D50/23 |
| **Ref:** Resolution **256 (WRC-23)**, **Document 5D/TEMP/336** | **Date:** July 17, 2025 |
| **Document Title:  Sharing between the fixed satellite service (space-to-Earth) in the frequency band 7 250-7 750 MHz and IMT operating in the frequency band 7 125-8 400 MHz** |
| **Author(s)/Contributors(s):**Kathryn Martin, DoD CIOThu Luu, DAFDominic Nguyen, eSimplicity for DAFKellen Gibson, USARMYJennifer Seiler, RKF Engineering for DoD CIOTed Kaplan, RKF Engineering for DoD CIOTaylor King, ACES for DON CIOChristine DiLapi, HII for DoD CIO | kathryn.a.martin23.civ@mail.milthu.luu@us.af.mildominic.nguyen@esimplicity.comkellen.k.gibson.civ@army.miljseiler@rkf-eng.com tkaplan@rkf-eng.comtaylor.king@aces-inc.omchristine.dilapi@hii.com  |
| **Purpose/Objective:** This contribution proposes a new IMT and Fixed satellite service 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 Fixed Satellite Service (FSS) space-to-earth, focusing on the impact of new IMT deployments on existing FSS systems. However, the influence of existing FSS services on IMT deployments, commonly referred to as reverse studies, is not considered. Attachment 1 contains sharing studies between the fixed satellite service and IMT operating in the frequency band 7 125-8 400 MHz. This study is focused on IMT compatibility with fixed satellite s[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 |
| Sharing between the fixed satellite service (space-to-Earth) in the frequency band 7 250-7 750 MHz and IMT operating in the frequency band 7 125-8 400 MHz |
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# 1 Introduction

This document contains a sharing study between IMT in the frequency band 7 125-8 400 MHz and the fixed satellite service (space-to-Earth) to which the frequency band 7 250-7 750 MHz is allocated on a primary basis. 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 Attachment 4 of Annex 2 of Annex 4.11 to Document 5D/TEMP/336, “Sharing and compatibility studies between services to which the band is currently allocated and IMT systems in the frequency band  125-8 400 MHz under WRC-27 agenda item 1.7”.

**Attachment:** 1

attachment

Sharing between the fixed satellite service (space-to-Earth) and IMT operating in the frequency band 7 125-8 400 MHz

This Attachment contains a sharing study of the fixed satellite service (space-to-Earth) in 7 250-7 750 MHz and IMT operating in the frequency band 7 125-8 400 MHz. The technical characteristics of IMT are provided in Annex 4.15 to Document 5D/563. The fixed satellite service (space-to-Earth) characteristics are provided in Annex 40 of, Document 4A/343, draft reply liaison statement to WP 5D, Relevant technical information to support studies under WRC-27 agenda item 1.7.

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

## A1.1 IMT deployment

The IMT characteristics are found in Document 5D/TEMP/361. This document focuses solely on modeling macro-cell interference, 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 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 urban2.4 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% |

The initial simulations will assume a dense deployment of macro-cells. The IMT network will be modeled using hexagonal grid configuration featuring three base stations at each hexagonal site, each providing 120 degrees of azimuth coverage. The grid consists of 19 cell sites, corresponding to a 57-sector laydown of IMT base stations as shown in Figure A-1. Both urban and suburban geometries defined in Table A-1 will be simulated. The IMT grid inter-site distances (ISD) will be set to 600 m for urban areas resulting in a cell radius of 400 m and an ISD of 1 200 m for suburban areas resulting in a cell radius of 800 m. These cell radii are designed to meet the BS densities shown in Table A-1, which is taken from Table 13 of Doc. 5D/TEMP/361.

The simulations will be used to determine the separation distance between the IMT deployment and the FSS earth station to meet both long-term and short-term interference criteria.

Figure A-1

IMT interference scenario into an FSS receiver from a deployment of 19 IMT cell sites



## A1.2 BS model

The IMT BSs are assumed to use advanced antenna systems (AAS) capable of beamforming. The antenna characteristics from []Annex 4.xx of document 5D/792 for the AAS BS antenna is shown in Table A-2.

Table A-2

Beamforming antenna characteristics for IMT Macro-cell BS Antenna Characteristics Annex 4.xx,
Document 5D/792 (Table 19)

|  |  |
| --- | --- |
| Antenna pattern model  | Document 5D/563 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 antenna coverage



Network loading factors will be employed to determine the percentage of base station antennas that were active for a given snapshot. A typical loading factor of 20% will be assumed according to Annex 4.15 to Document 5D/563. As a sensitivity analysis, studies will also consider a 50% loading factor consistent with Document 5D/792 for highly loaded base stations. 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 considered. This yields a BS transmitter output power per sector of 78.3 dBm as per Table A-2. The IMT BS heights will be set to 18 m for urban and 20 m for suburban. 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 will be evenly split among the three UEs per snapshot.

## A1.3 Path and clutter loss considerations

Accurate modeling of environmental clutter is essential for demonstrating the coexistence of systems. Clutter models are key in validating spectrum sharing scenarios, as environmental features can provide the necessary isolation between systems.

For macro-cell base stations, which are typically designed to operate above the rooftops within their service area, the situation becomes more complex when considering areas beyond their immediate coverage. While the base station may be above local clutter within its service area, it may be below clutter when viewed from outside that area. This variability must be accounted for in clutter modeling to ensure realistic and reliable analysis of potential interference and isolation.

Therefore, an appropriate clutter model is essential for accurately assessing the potential for IMT systems to share the 7/8 GHz band with incumbent users. In 5D/160, Study Group 3 referenced Recommendation ITU-R P.2108 for clutter modeling but did not specify the conditions under which its use is appropriate. Within WP5D, two approaches have been commonly used when applying P.2108. It is either applied to all IMT base stations or only to base stations below rooftop.

Section 3.2 of P.2108 assumes a terminal located deep within clutter, resulting in a very low probability of clutter free paths. This can be seen in Figure A1.3.1.3.3 which shows the clutter loss CDF at 8 GHz from P.2108, section 3.2. The probability of a clutter free path is 1e-16 and the probability of a clutter path less than 20 dB is less than 1e-3. Therefore if P.2108 is applied to all base stations there won’t be any clutter free paths. On the other hand, if P.2108 isn’t applied to base stations above rooftop the probability of clutter free paths in urban areas is 35% and 85% in suburban areas.



Figure A1.3.1.3.3: Clutter Loss CDF at 8 GHz (P.2108, Section 3.2)

Seeing as how IMT macro-cell base stations are generally designed to operate above rooftop within the area that they cover and until we receive more guidance from SG3, this report has selected to apply P.2108 only to base stations below rooftop.

### A.1.3.1 Terrain heights

At the previous meeting of 5D, concerns were raised, and a request was made to ensure that all modeling assumptions are clearly justified. At the same time, the group advised that random terrain be incorporated into the modeling of interference paths. However, the random terrain needs to be selected appropriately given that we are modelling IMT deployments. This section justifies the terrain modelling approach used in this report.

The interference paths from IMT deployments all start either in urban or suburban areas. Thus, the interference paths should be selected starting in either urban or suburban centers. In this report, population is used to identify urban and suburban centers in the US. To do this population tiles [reference] were sorted from highest density to lowest density. Urban centers and suburban centers were thresholded using definitions in [reference]. Thus Urban centers are defined as those having population densities greater than 500 people per square Km [TBD], while suburban centers are defined as those have population densities greater than 250 people per square Km but less than 500 people per square Km [TBD].

In order to examine geometries indicative of border areas, population tiles within 100 Km on either side of the US/Canadian and US/Mexico borders are examined. Random paths are drawn from the population tiles classified as either urban or suburban, based on the specific IMT deployment being modeled. Each path is assigned a random azimuth within a range that is within 100 Km of a border crossing.

### A.1.3.2 Clutter loss

Accurate modeling of environmental clutter is essential for demonstrating the coexistence of systems. Clutter models are key in validating spectrum sharing scenarios, as environmental features can provide the necessary isolation between systems.

For macro-cell base stations, which are typically designed to operate above the rooftops within their service area, the situation becomes more complex when considering areas beyond their immediate coverage. While the base station may be above local clutter within its service area, it may be below clutter when viewed from outside that area. This variability must be accounted for in clutter modeling to ensure realistic and reliable analysis of potential interference and isolation.

WP 5D defines macro-cell base stations above rooftops and macro-cell base stations below rooftops. This study will assume no clutter is added when the BS is above the roof top. For below roof-top BS deployments, Recommendation ITU-R P.2108 will be applied for end-point correction.

# A2 Technical/operational characteristics and protection criteria of fixed satellite service (space-to-Earth) operating in the frequency band 7 250-7 750 MHz

Only satellite network earth station receiver parameters are included in this document. The satellite parameters are not included because this is an *I/N* study into FSS Earth stations. Also, studies from transmitting FSS earth stations into IMT BSs are not considered in this document.

## A2.1 GSO Earth Station Characteristics

This section provides technical characteristics of GSO receive earth stations for sharing and compatibility studies, which were received from WP 4A in Doc. 5D/610, reply liaison statement regarding 7/8 GHz FSS characteristics for AI 1.7 sharing studies. Table A-4 below, from Table 2 of 5D/610, shows the technical parameters used in the analysis.

Table A-4

GSO earth station receiver characteristics (Frequency Band 7 250 to 7 750 MHz)

| Characteristics of earth station | Units | Earth stationtype 5 | Earth stationtype 15 |
| --- | --- | --- | --- |
| Antenna type |  | Parabolic | Parabolic |
| Antenna height | (m) | 1 | 10 |
| Receive antenna diameter | (m) | 1 | 18.3 |
| Receive antenna peak gain (if different from transmit) | (dBi) | 35.6 | 61.3 |
| Receive antenna –3 dB beamwidth | (deg.) | 2.89 | 0.16 |
| Receive antenna pattern type |  | RR Appendix **8** Annex 3 | Appendix **8** or see ITU-R S.580, if necessary |
| Receive antenna full range of elevation angles towards the satellite[[1]](#footnote-1) | (deg.) | 3-90 | 3-90 |
| Receive antenna polarization |  | Circular | Circular |
| Receiver noise temperature[[2]](#footnote-2) | (K) | 160 | 178 |
| Receiver channel bandwidth | (MHz) | 0.0024-40 | 125 |

## A2.2 Non-GSO Earth Station Characteristics

Non-GSO earth stations are not studied in this report as more detail is need from WP4C on appropriate constellations to consider and the satellite selection criteria. It will be important to consider non-GSO earth stations in the future as they need clear line-of-sight to the sky down to very low elevation angles and therefore should not be considered immersed in clutter fields.

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# A.3 FSS Interference Criteria

Considering that receivers in the FSS operate with low margin and require protection from interference from other radiocommunication services, the protection criteria to be used for their protection in the sharing and compatibility studies with respect to IMT under WRC-27 agenda item 1.7 are summarized in Table A-6 below.

The FSS protection criteria in Table A-6 are from Annex 40, Doc. 4A/343.

[Note: This table is to be updated based on the outcome of the WP 4A LS.]

Table A-6

GSO FSS Protection Criteria (7 250-7 750 MHz (s-E)

|  |  |  |
| --- | --- | --- |
| Options | % exceedance time | *I/N* Criteria (dB)  |
| **Option 1 (GSO)** | 20%0.001%0.03% | −10.5−2.33−6 |
|  |  |  |

# A3 Simulation methodology

## A3.1 FSS earth station pointing directions

Figure A-3 illustrates the modeled scenario, depicting 19 hexagonal IMT cell sites interfering with the FSS earth station as a function of distance from the IMT deployment.

Figure A-3

Scenario 2: High density IMT deployment density geometry



Table A-7 shows FSS earth station pointing directions to be modelled in simulations. GSO systems will be modelled with fixed elevations from 10 degrees to 60 degrees. In each case, the pointing azimuth angle is pointed toward the center of the IMT deployment.

Table A-7

Earth station pointing directions

|  |  |
| --- | --- |
| Earth Station Type | Elevation Angle Pointing Direction (degrees) |
| GSO | 10, 20, 30, 60 |
|  |  |

The interference simulations are performed for the FSS earth station terminals defined in Table A-8. The subset of GSO terminal types is from Table A-4.

Table A-8

FSS earth station terminal types simulated

| Satellite | ES Type | ES Height (m) | ES Bandwidth (MHz) | Receiver Noise Temp (K) |
| --- | --- | --- | --- | --- |
| GSO | Type 5Type 15 | 110 | 40125 | 160178 |
|  |  |  |  |  |

Table A-9 describes the simulations that will be performed for this study:

Table A-9

Simulations to be performed for this study

|  |  |
| --- | --- |
| Scenario |  |
| Simulation 1 | □ M.2101 simulation, □ BS dynamic beamforming to 3 randomly selected UEs per iteration□ IMT loading factor equal to 20%□ Elevation angles defined in Table A-7□ FSS terminal types in Table A-8□ Clutter loss ○ IMT BS: P.2108, Sec. 3.2 for BSs below rooftops ○ GSO FSS ES: P.2108, Sec. 3.2 for ESs below 6 m |
| Simulation 2 | □ Same as Simulation 1, but with the IMT loading factor equal to 50% |

The simulations will use the IMT parameters outlined above. The distance between the base station and the FSS earth station is varied and I/N calculated at each distance to find where the long-term and short-term interference criterion are met. The calculation of interference at the FSS earth station is then calculated over all the 57 sectors and is given by Equation 2.

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

Where

 I = Interference at the FSS station (dB) calculated over all 57 sectors

 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 FSS station (dBi)

 $G\_{R\_{k}}$ = Gaing of the FSS Receiver Antenna in the direction of the kth BS

 PLk = Path loss calculated over the full distribution (0 to 100%) using P.2001 (dB) for the kth BS

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

 $L\_{C\\_ES}$ = Clutter loss applied at FSS earth stations (i.e., P.2108 or no clutter loss)

 LP = Polarization Loss = 3 dB

The simulations will be conducted using the IMT parameters outlined above. For each iteration of the Monte Carlo simulations, random variables—including path loss (calculated according to ITU-R P.2001-4), IMT base station beam activation (determined by network loading), and azimuth/elevation pointing directions of non-GSO earth stations—are varied to reflect realistic operational conditions. The separation distance between IMT base stations and the FSS Earth station is systematically adjusted, and the resulting I/N ratios are computed at each distance step. The simulations are repeated enough times to determine the short-term interference with statistical significance.

# A.4 Study results

[To be developed and provided at the next WP 5D meeting.]

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1. The exact elevation depends on the position of the satellite with respect to the Earth station. [↑](#footnote-ref-1)
2. Receiver Noise Temperature values are valid for elevation angles of 10-90 degrees. For elevation angles below 10°, the applicable noise temperature could be increased by 30% with respect to the values given in this table. [↑](#footnote-ref-2)