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| **Radiocommunication Study Groups** |  |
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| **7 June 2022** |
| **English only**  **SPECTRUM ASPECTS &  WRC‑23 PREPARATIONS** |
| Saudi Arabia (Kingdom of) | |
| WORKING DOCUMENT ON SHARING AND COMPATIBILITY STUDIES OF IMT SYSTEMS IN THE FREQUENCY BAND 6 425-7 125 MHz  ATTACHMENT 4 | |
| Sharing and compatibility of FSS (Earth-to-space) operating in the frequency band 6 425-7 075 MHz and IMT operating  in the frequency band 6 425-7 125 MHz | |

At its February 2022 meeting, Working Party (WP) 5D developed further a working document for sharing and compatibility studies of IMT systems in the frequency band 6 425-7 125 MHz in response to WRC-23 agenda item 1.2 (Resolution **245 (WRC-19)**). The working document was attached to the WP 5D Chairman’s Report of the October 2021 meeting (Annex 4.16 to Document [5D/1078](https://www.itu.int/md/R19-WP5D-C-1078/en)).

This contribution provides further revision to the sharing and compatibility studies between IMT and incumbent Fixed Satellite Service (E-s) in the frequency band of 6 425-7 075 MHz. Changes are only being proposed in Attachment 4, Study C of the document.

Proposed changes to the existing document are shown in track changes, in yellow and green.

**Attachment:** 1

attachment

## 2.3 Study C (KSA & all (835))

[Editor’s note: The chapter structure of each study depends on the input contribution of the ITU members. The following chapter structure in each study can be used as a reference.]

This section contains an in-band, compatibility and sharing study, analysing interference from IMT stations (BS & UE) towards FSS (E-s) in the 6 425-7 075 MHz frequency range.

This study analyses aggregate interference from a large number of IMT stations to FSS space station receivers. The IMT deployment is based on macro-urban and macro-suburban cells and the FSS (E-s) characterises are based on GSO satellite, carrier 4.

Two scenarios were considered in these studies, one consider only IMT stations inside the 3 dB beamwidth (footprint area) of the FSS satellite and the second one consider IMT stations inside and beyond the 3 dB beamwidth, hereafter called Beyond 3 dB. The latter include IMT stations that are in a secondary or side-lobe of the satellite’s antenna that can still contribute to the interference.

This study intends to be responsive to *resolves* 2 of Resolution **245 (WRC‑19)** under   
WRC-23 agenda item 1.2.

### 2.3.1 Technical characteristics

[Editor’s note: This section provides the specific parameters used in the included study/studies, as provided by the contributing groups to WP 5D.]

This section describes the technical characteristics of IMT and FSS space station (S/S) analysed in this study. Provided a range of values available for the IMT and FSS parameters, the conservative values were chosen as a way to guarantee the protection of the incumbent service.

#### 2.3.1.1 Technical and operational characteristics of IMT systems operating in the frequency band 6 425-7 125 MHz

[Editor’s note: This section provides specific characteristics of IMT systems provided by WP 5D for sharing/interference analyses used in the study.]

The tables below provide technical and operational characteristics of IMT taken from Tables 7-1, 7‑2, and 10 of Annex 4.4 of WP 5D Chairman’s Report ([5D/716](https://www.itu.int/md/R19-WP5D-C-0716/en)) for the 6 425-7 125 MHz frequency range. Implementation of AAS is considered for IMT base stations in these frequency bands. Implementation of AAS is not considered in IMT user equipment.

The Ra and Rb values for the Beyond 3 dB Beamwidth are the highest values according to WP 5D and the comments from GSOA (see Document [5D/1135](https://www.itu.int/md/R19-WP5D-C-1135/en)).

Table 1

IMT BS parameters in the 6 425-7 125 MHz frequency range

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 3 dB Beamwidth | | Beyond 3 dB Beamwidth | |  |
| Parameter | Value – Macro urban | Value – Macro suburban | Macro Urban | Macro Suburban | Unit |
| Duplex method | TDD | TDD | TDD | TDD |  |
| Channel bandwidth | 100 | 100 | 100 | 100 | MHz |
| Deployment density | 10 | 2.4 | 10 | 2,4 | BSs/km2 |
| Ra | 45 | 10 | 45 | 20 | % |
| Rb (Area < 3 500 000 km2) | 5 | 5 | 3 | 3 | % |
| Antenna height | 18 | 20 | 18 | 20 | M |
| Number of sectors | 3 | 3 | 3 | 3 |  |
| Sector coverage | 120 | 120 | 120 | 120 | Degree |
| Network loading factor | 20 | 20 | 20 | 20 | % |
| BS TDD factor | 75 | 75 | 75 | 75 | % |
| Antenna type | AAS only | AAS only | AAS only | AAS only |  |
| Antenna pattern | ITU-R M.2101 | ITU-R M.2101 | ITU-R M.2101 | ITU-R M.2101 |  |
| Element gain | 5.5 | 6.4 | 5,5 | 6,4 | dBi |
| Horizontal 3 dB beamwidth | 90 | 90 | 90 | 90 | Deg |
| Vertical 3 dB beamwidth | 90 | 65 | 90 | 65 | Deg |
| Horizontal front-to-back ratio | 30 | 30 | 30 | 30 | dB |
| Vertical front-to-back ratio | 30 | 30 | 30 | 30 | dB |
| Horizontal element spacing | 0.5 | 0.5 | 0,5 | 0,5 | d/lambda |
| Vertical element spacing | 0.5 | 0.7 | 0,5 | 0,7 | d/lambda |
| Array number of rows | 16 | 16 | 16 | 16 |  |
| Array number of columns | 8 | 8 | 8 | 8 |  |
| Mechanical downtilt | 10 | 6 | 10 | 6 | Degree |
| Array ohmic losses | 2 | 2 | 2 | 2 | dB |
| Conducted power | 22 | 22 | 22 | 22 | dBm |

Table 2

IMT UE parameters in the 6 425‑7 125 MHz frequency range

|  | 3 dB Beamwidth | | Beyond 3 dB Beamwidth | |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Value – Macro urban | Value – Macro Suburban | Macro Urban | Macro Suburban | Unit |
| Duplex method | TDD | TDD | TDD | TDD |  |
| Channel bandwidth | 100 | 100 | 100 | 100 | MHz |
| Indoor terminal usage | 70 | 70 | 70 | 70 | % |
| UEs per sector | 3 | 3 | 3 | 3 |  |
| Antenna height | 1.5 | 1.5 | 1,5 | 1,5 | M |
| UE TDD factor | 25 | 25 | 25 | 25 | % |
| Power control | Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1 | Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1 | Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1 | Refer to Recommendation ITU-R M.2101 Annex 1, section 4.1 |  |
| Maximum output power | 23 | 23 | 23 | 23 | dBm |
| Antenna type | Omnidirectional | Omnidirectional | Omnidirectional | Omnidirectional |  |
| Antenna gain | -4 | -4 | -4 | -4 | dBi |
| Body loss | 4 | 4 | 4 | 4 | dB |
| Building entry loss | ITU-R P.2109 | ITU-R P.2109 | ITU-R P.2109 | ITU-R P.2109 |  |

#### 2.3.1.2 Technical and operational characteristics of FSS (Earth-to-space) operating in the frequency band 6 425-7 025 MHz

[Editor’s note: This section provides specific characteristics of [Service type z] provided by other expert group for sharing/interference analyses used in the study.]

The FSS S/S parameters shown in Table 1 below are FSS parameters to Carriers 4 provided by WP 4A to WP 5D (see Document [5D/734](https://www.itu.int/md/R19-WP5D-C-0734/en)).

Table 3

FSS S/S parameters (interfered) – Carrier 4

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Unit |
| Bandwidth | 1 | MHz |
| Noise temperature | 400 | K |
| Peak gain | 38 | dBi |
| Beamwidth | 0.8 | deg |
| Antenna pattern | ITU-R S.672 |  |
| Altitude | 35786 | km |
| Minimum elevation angle | 5 | deg |
| Short term I/N value 1 | -2.33 | dB |
| Short term time percentage value 1 | 0.001 | % |
| Short term I/N value 2 | -6 | dB |
| Short term time percentage value 2 | 0.03 | % |
| Long term I/N | -10.5 | dB |
| Long term time percentage | 20 | % |

In a single BS sector, UEs share equally the channel bandwidth, i.e., each UE is allocated 1/3 of the channel bandwidth (see Rec. ITU-R [M.2101](https://www.itu.int/rec/R-REC-M.2101/en), Section 3.4.1, item 1e-f.). For this study a bandwidth of 100 MHz for IMT is considered (i.e., bandwidth of 33.3 MHz per UE), overlapping with the FSS bandwidth of 1 MHz. To account for this overlap, results are presented in the form of interference power spectral density and the protection criteria above were converted to absolute interference values over 1 MHz FSS stations.

According to Article **5** of the ITU Radio Regulations, in this frequency range, Fixed and Mobile services are allocated on a primary basis. Considering the wide coverage of the FSS satellite systems, these two services will exist within the FSS coverage. Therefore, for this study the FSS protection criteria is apportioned by 3 dB among the two potential sources of interference, i.e., the FS and MS.

#### 2.3.1.3 Propagation models for sharing and compatibility studies for IMT operating in 6 425-7 125 MHz

[Editor’s note: This section provides specific propagation models and related parameters for sharing/interference analyses used in the study.]

Propagation models used to estimate the path loss between the interferer IMT stations and the interfered with satellite and earth stations are described in the Table 4 below.

Table 4

FSS propagation parameters

|  |  |  |
| --- | --- | --- |
| Ground to Space | | |
| Parameter | Value | Unit |
| Model | Rec. ITU R P.525 |  |
| Gaseous attenuations | Rec. ITU-R P.676 |  |
| Polarization | Vertical |  |
| Building entry loss (indoor stations only) | ITU-R P.2109 |  |
| Building type | Traditional |  |
| Building entry loss percentage | Random per link |  |
| Clutter loss | The slant path clutter loss model as described in Annex 6 to Working Party 3K Chairman’s Report, Document 3K/178 |  |

### 2.3.2 Methodology

[Editor’s note: This section provides the methodology used in this study.]

This study performs a Monte Carlo analysis, which allows for the estimation not only of interference levels but also the deployment percentage. Additionally, urban macro cell, micro cell and indoor IMT deployments were analysed separately. Rural deployment was not considered for this study as, according to [Annex 4.4 to Document 5D/716](https://www.itu.int/md/R19-WP5D-C-0716/en), contiguous coverage is not expected in this frequency range in rural areas.

2.3.2.1 Interference from IMT to FSS (Earth-to-space) in the band 6 425-7 075 MHz

Two scenarios were analyzed:

1. Senario 1: IMT stations are within the 3 dB footprint of the spece station having spot beam.
2. Senario 2: IMT stations are within and beyond the 3 dB footprint of the spece station having a spot beam.

##### **2.3.2.1.1** Footprint area modelling

In order to evaluate the interference from the IMT system into the FSS space station, the whole area covered by the satellite beam has been calculated assuming a curved earth model and follows the methodology described here.

The methodology can be divided in two stages:

• First, the model approximates the coverage area as an ellipse, in order to obtain coarse estimates on the coverage area size and location.

• Then, rejection sampling is used in a spherical patch that contains the coverage area to generate the position of uniformly distributed IMT stations inside the coverage area.

The 3 dB footprint of the FSS satellite at a given elevation cannot be assumed as an ellipse on the surface of the Earth, since that doesn’t produce a good area approximation for angles lower than 20º. However, the ellipse approximation provides estimates used to generate latitude and longitude coordinates of points inside the exact coverage region. To this end, a rejection sampling method was chosen to estimate not only area but also the elevation angle for every IMT station inside the footprint area, respecting a minimum elevation angle.

The following figure gives an overview of the ellipse approximation initially used in the method.

FIGURE 1

Illustration of the satellite coverage footprint and geometry related

Diagram, schematic

Description automatically generated

The major and minor axes of the ellipse are calculated first. The following figure introduces the geometry considered and the variables that will be used to calculate the major axis of the FSS satellite 3 dB contour approximation.

FIGURE 2

Illustration of the considered geometry and introduction of the variables

A computer screen capture

Description automatically generated with low confidence

To calculate the major axis of shown in the above figure based on the elevation , the following steps must be applied (note that all angles are expressed in degrees):

**Step 1:** Calculation of the corresponding off‑nadir pointing angles of the satellite (angle between the satellite pointing and the sub‑nadir point): , and .

Apply the sine law:

From the FSS satellite beamwidth , and can be calculated as follows:

**Step 2:** Calculation of the elevation boundaries of the 3 dB footprint area: and .

Apply the sine law:

Similarly,

**Step 3:** Calculation of the corresponding angles at the centre of the Earth: , and :

**Step 4:** Calculation of major axis :

When applying the above steps to the analysed carrier, for different minimum elevation angles, the major axis is calculated and presented in Table 5.

To calculate the minor axis of the ellipse corresponding to the close approximation of the FSS satellite 3 dB footprint for a given elevation, the slant path distance (i.e., distance between the satellite and the ground for a specific elevation) needs to be calculated.

The slant path distance can be calculated by again applying the sine law:

This formula doesn’t apply for the case where . In other cases, the cosine law is used instead:

Once the slant path is calculated, the minor axis can be approximated by:

When applying the above method, for different minimum elevation angles, b is calculated and presented in Table 5.

Table 5

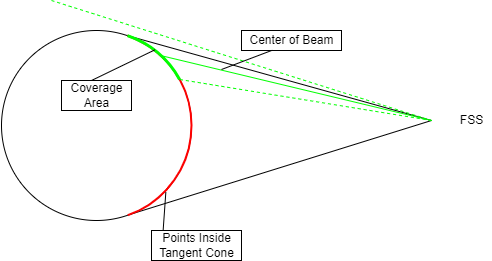
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Minimum Elevation Angles [degrees] | | | |
|  | 5 | 20 | 45 | 90 |
| a [km] | 1,964.7 | 1,781.7 | 741.04 | 499.87 |
| b [km] | 574.1 | 552.2 | 522.35 | 499.67 |

Using the elliptical approximation for the footprint of the FSS satellite described above, a more precise method is then used to estimate the footprint area and distribute the IMT stations inside this area.

The rejection sampling method used to generate uniform points inside a patch of the spherical surface only selects the points inside the tangent cone and inside the satellite beam. A tangent cone is a cone that defines the total visibility of the satellite station, i.e., it is a cone with its vertex at the satellite station and surface tangent to the spherical Earth. This method produces an exact distribution of users inside the desired region. By counting the points inside and outside the coverage area a Monte Carlo estimate of the coverage area can be computed. Figure 7 depicts the geometry considered.

FIGURE 7

Illustration of the considered geometry to compute elevation angle and slant path



A spherical patch with latitudes (in radians) and longitudes is defined. The elliptical approximation presented before is exact in terms of , but not in terms of , hence the slack factor of 1.5. Note that in the case part of the beam misses the earth, then is the angle at which the beam is tangent to the earth.

A point inside this patch is uniformly generated and the off-axis angle , at the satellite, towards this point is computed. The elevation at which a station in this point would see the FSS satellite station is also calculated. If , where BW is the satellite’s beamwidth, and , then the point is inside the beam cone and visible to the satellite. The following figure presents one of the random generated IMT station deployments inside the satellites’ 3 dB beamwidth. The random deployment of all the IMT stations is generated at each snapshot.

FIGURE 3

IMT deployment inside the satellite 3 dB beamwidth

Chart, scatter chart

Description automatically generated

This process is repeated until the desired amount points inside the coverage region is obtained. The total patch area is

This process is repeated until the desired amount points inside the coverage region is obtained. The total patch area is

Using the ratio of the number of points inside the coverage region to the total number of points generated inside the patch an approximation for the coverage area can be obtained.

This results in the following areas for different elevation angles are presented in table 6.

Table 6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Elevation Angles [degrees] | | | |
|  | 5 | 20 | 45 | 90 |
| Footprint Satellite Area [ km2] | 991,220 | 759,520 | 305,400 | 197,120 |

##### 2.3.2.1.2 Beyond 3 dB beamwidth modelling

In this scenario, the interference from the IMT system into the FSS space station is calculated considered the entire line of sight of surface on Earth. Hence, IMT stations that are in a secondary side-lobe of the satellite’s antenna are also considered in the interference calculation.

The modeling proposed distribute IMT stations uniformly on the surface of a spherical cap (or dome). The global beam area represents almost half size of the earth with approximate 216.490.348 square kilometers. The satellite sees the Earth in a cone of approximately 8.7 degrees. The Figure 4 presents examples of IMT stations distribution for different satellite elevation angles. Red and blue areas represent IMT stations deployments inside and outside the satellites’ 3 dB beamwidth, respectively.

FIGURE 4

**IMT deployment inside the satellite global beam**



The FSS satellite gain towards every IMT station in the spherical cap is calculated and it’s determined by the antenna radiation pattern given by ITU-R S.672. Figure 5 shows 2 different patterns with Ls=-20 and Ls=-30. The Ls=-30 was used for the spot beam coverage scenario.

Figure 6 shows the antenna gain heatmap over the earth surface for the satellite elevation angle of 50.

FIGURE 5

Antenna Radiation Pattern ITU-R S.672

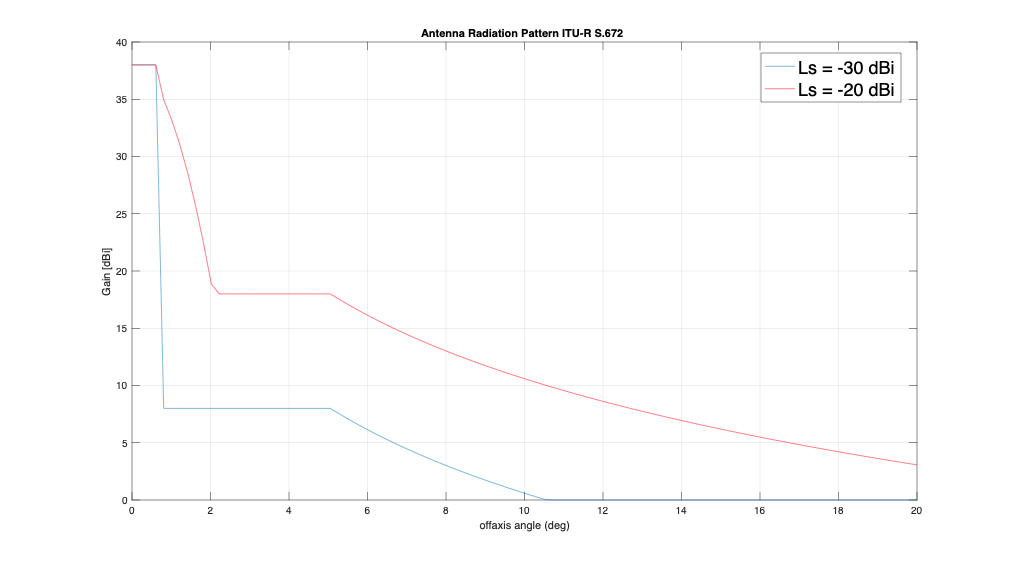


FIGURE 6

Satellite Antenna Gain

Chart, bubble chart

Description automatically generated

##### 2.3.2.1.3 Simulation Methodology

A coexistence static system-level simulator using the Monte Carlo method was developed in order to perform the studies. At each simulation snapshot, the IMT BS and IMT UE are randomly generated and located within a satellite footprint area and also over the entire line of sight surface on Earth using the method described above. All relevant losses are calculated between the IMT and FSS space station.

The main key performance indicator obtained from these simulations is the aggregate interference generated by the IMT base stations or user equipment into the satellite system. The aggregate interference-to-noise ratio *I/N* is calculated and compared with FSS space station protection criteria. Aggregate interference is a summation of interfering signals sourced from all active BSs and UEs for urban and suburban.

Once the study area is calculated, the interference into the GSO satellite receiver is estimated following these steps:

**Step 1:** Generating IMT station deployment seen by the satellite main beam and beyond 3 dB at the minimum elevation using the method described in Section 2.3.2.1.1 and considering the deployment density and ratio of coverage areas and built areas of region in study.

**Step 2:** Deactivate a proportion of IMT stations based on the TDD and loading factors. Deactivated stations are not considered in the interference calculation.

**Step 3:** Determining the aggregate interference form the IMT station deployment to the FSS satellite.

– The power spectral density (PSD) of an IMT station is assumed.

– The off‑axis gain for each of the IMT stations towards the FSS satellite is calculated following the methodology described in Section 2.1.2.1 of this study.

– The aggregate interferenceis calculated using the following formula:

where *Ii*isthe interference of interferer *i*

is the IMT station power spectral density (note: power control is applied for IMT UE simulation cases);

is the i‑th IMT station gain towards the FSS satellite;

is the FSS satellite main beam gain towards the IMT stations: scenario 1 as a 3 dB spotbeam coverage study area is considered and Recommendation ITU-R S.672 *recommends 1* does not define antenna gains for off-axis angles below the 3 dB beamwidth, peak gain is considered towards all IMT stations; scenario 2, antenna radiation pattern ITU-R S.672;

is propagation model loss based on Rec. ITU‑R P.525, with the gaseous attenuation based on Rec. ITU‑R P.676, and clutter loss (Document 3K/178), and body loss for IMT UE case. Building entry loss was considered for indoor user, modelled by Rec. ITU-R P.2109;

is the ohmic loss (2 dB). For interference from IMT UEs, 4 dB body loss was also considered;

*θ* is the off‑axis between the FSS satellite’s beam incidence angle and IMT BS.

– The result is stored.

**Step 4:** redo steps 1 to 3 sufficiently to obtain a stable cumulative distribution function curve and store it. In this study, 50 000 iterations were performed for scenario 1, and around 1000 iterations were performed for scenario 2.

Note: This methodology is based on the studies considered for Agenda Item 1.13 (WRC-19), see [Annex 13 to Document 5 1/478](https://www.itu.int/md/R15-TG5.1-C-0478/en).

### 2.3.3 Study results

[Editor’s note: This section provides the sharing and compatibility study results of this study.]

Scenario 1: Footprint area

Simulations with the space station at 5°, 20°, 45°, and 90° with center of beam elevation angles were performed and the following figure presents the aggregate IMT (BS and UE) interference CDF towards the FSS space station (FSS S/S) receiver for macro urban and suburban IMT deployments. As shown in the figure below, for elevation angles of 5° and 20° the FSS S/S short-term and long-term protection criteria are exceeded. In addition, the FSS long-term protection criteria (with apportionment) is exceeded for elevation angle of 45°.

Figure 7

Table

Description automatically generated with medium confidence

Table 7 below summarizes the achieved I/N values for the simulation cases shown above. The column labelled as “Exceedance” indicates the level of exceedance of the protection criteria with and without apportionment.

Table 7

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| FSS SS | Probability of time | *I/N* criteria [dB] | *I/N* criteria with apportionment [dB] | *IMT*  *I/N* result [dB] | Exceedance [dB] (without apportionment) | Exceedance [dB] (with apportionment) |
| 50 | 0.001% | -144.9 | -147.9 | -143.7 | 1,2 | 4,2 |
| 0.03% | -148.6 | -151.6 | -143.8 | 4,8 | 7,8 |
| 20% | -153.1 | -156 | -144.4 | 8.7 | 11.6 |
| 200 | 0.001% | -144.9 | -147.9 | -146.9 | -2 | 1 |
| 0.03% | -148.6 | -151.6 | -146.9 | 1,7 | 4,7 |
| 20% | -153.1 | -156 | -147.3 | 5.8 | 8.7 |
| 450 | 0.001% | -144.9 | -147.9 | -155.3 | -10.4 | -7.4 |
| 0.03% | -148.6 | -151.6 | -155.3 | -6.7 | -3.7 |
| 20% | -153.1 | -156 | -155.8 | -2.7 | 0.2 |
| 900 | 0.001% | -144.9 | -147.9 | -166.9 | -22 | -19 |
| 0.03% | -148.6 | -151.6 | -167 | -18.4 | -15.4 |
| 20% | -153.1 | -156 | -167.6 | -14.5 | -11.6 |

Scenario 2: Within and beyond the 3 dB beamwidth

In the same way as scenario 1, but now considering the global beam area that represents half the size of the earth, simulations with the space station at 5°, 20°, 45°, and 90° with center of beam elevation angles were performed and the following figure presents the aggregate IMT (BS and UE) interference CDF towards the FSS space station (FSS uplink direction) receiver for macro urban and suburban IMT deployments.

For all elevation angles the short and long term FSS uplink direction protection criteria are exceeded. When compared to scenario 1, the interference is increased since there are more IMT stations generating interference and the antenna radiation pattern gains are also considered outside the 3 dB beamwidth region.

The worst case is when the elevation is 90 degrees, in which case the interfering IMT stations have a gain of at least 13 dBi, leading to higher average interference than the other cases.

Figure 8

A picture containing graphical user interface

Description automatically generated

Table 9 below summarizes the achieved *I/N* values for the simulation cases shown above. The column labelled as “Exceedance” indicates the level of exceedance of the protection criteria with and without apportionment.

Table 8

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| FSS SS [degree] | Probability of time | *I/N criteria [dB]* | *I/N criteria with apportionment [dB]* | *IMT - I/N result [dB]* | Exceedance [dB] (without apportionment) | Exceedance [dB] (with apportionment) |
| 50 | 1% | -145 | -148 | -140 | 5 | 8 |
| 20% | -153 | -156 | -141 | 12 | 15 |
| 200 | 1% | -145 | -148 | -138 | 7 | 10 |
| 20% | -153 | -156 | -139 | 14 | 17 |
| 450 | 1% | -145 | -148 | -137,7 | 7,3 | 10,3 |
| 20% | -153 | -156 | -138,4 | 14,6 | 17,6 |
| 900 | 1% | -145 | -148 | -136,8 | 8,2 | 11,2 |
| 20% | -153 | -156 | -137,6 | 15,4 | 18,4 |

### 2.3.4 Summary and analysis of the results of Study C

[Editor’s note: This section provides the summary and analysis of the results of this study.]

For scenario 1 (footprint area), the power spectral density (PSD) results show that aggregate interference from IMT stations exceeds both the long-term and short-term criteria of FSS receivers at elevation angles of 20 and 5o the FSS S/S. The FSS long-term protection criteria (with apportionment) is exceeded for a 45o elevation.

For scenario 2 (Within and beyond the 3 dB beamwidth), the power spectral density (PSD) results show that aggregate interference from IMT stations exceeds both the long-term and short-term criteria of FSS receivers for all elevation angles of FSS in the uplink direction.

Annex 1

Proposed update on Study C in overview of the sharing   
and compatibility studies

Note: This annex provides and update to the overview of Study C in the comparison table of the sharing and compatibility studies. Proposed modifications have been indicated after all revisions in the previous working document were reflected.

|  | Parameters from expert  WPs and WP 5D | | Study C  Source: Doc. [5D/1124](https://www.itu.int/md/R19-WP5D-C-1124/en)  (KSA & al) – Within 3 dB | Study C  Source: Doc. [5D/1124](https://www.itu.int/md/R19-WP5D-C-1124/en)  (KSA & al) – Within and beyond 3 dB |
| --- | --- | --- | --- | --- |
| Number of IMT stations considered | Single-entry or Multiple-entry (aggregate) | | Multiple-entry (aggregate) | Multiple-entry (aggregate) |
| Type of interference evaluation method | Deterministic study or  Statistical study | | Statistical study | Statistical study |
| If statistical, based on Rec. [ITU‑R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf)? | | [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) | [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf" \t "_blank) |
| Deployment scenario | Urban/suburban macro, Small cell (outdoor)/Micro cell, Indoor (small cell), rural | | Urban and suburban macro | Urban and suburban macro |
| IMT stations | BS and UE | | BS and UE | BS and UE |
| Method to deploy multiple IMT stations for the aggregate interference analysis over a relatively large area (as applicable to scenarios for the studies) | Ra and Rb method:  Ra: Ra1, Ra 2  Rb: Rb1, Rb2, Rb3  Additional guidance (or further clarification) is found in section 3.3 of Annex 4.4 to Doc. 5D/716 | | Ra and Rb method | Ra and Rb method |
| Number of simultaneously transmitting IMT‑2020 stations deployed in the footprint | – | | Average active IMT stations in Suburban 2,028  Average active IMT stations in Urban 19,012 | Average active IMT stations in Suburban 467,610  Average active IMT stations in Urban 4,383,900 |
| Network loading factor for BS and UE (%) | 20 | | 20 | 20 |
| TDD activity factor (%) | BS: 75  UE: 25 | | BS: 75  UE: 25 | BS: 75  UE: 25 |
| UE power control factor (dB) | Refer to section 4.1 in Annex 1 to Rec. [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) and Items in Table 7-2 in Annex 4.4 to Doc. 5D/716 | | Refer to section 4.1 in Annex 1 to Rec. [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) and Items in Table 7-2 in Annex 4.4 to Doc. 5D/716 | Refer to section 4.1 in Annex 1 to Rec. [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf" \t "_blank) and Items in Table 7-2 in Annex 4.4 to Doc. 5D/716 |
| UE body loss (dB) | 4 | | 4 | 4 |
| IMT Antenna pattern | Rec [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) Annex 1, section 5 | | Rec [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) Annex 1, section 5 | Rec [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf" \t "_blank) Annex 1, section 5 |
| BS antenna pointing | Mechanical pointing in elevation angle (downtilt angle of 10 degrees urban and 6 degrees suburban) and random in azimuth - See Table 10 in Annex 4.4 to Doc. 5D/716 | | Mechanical pointing in elevation angle (downtilt angle of 10 degrees urban and 6 degrees suburban) and random in azimuth - See Table 10 in Annex 4.4 to Doc. 5D/716 | Mechanical pointing in elevation angle (downtilt angle of 10 degrees urban and 6 degrees suburban) and random in azimuth - See Table 10 in Annex 4.4 to Doc. 5D/716 |
| UE antenna pointing |  | |  |  |
| Carriers | #1; #7; #8; #11 | #2; #3; #4; #12 | Carrier 4 |  |
| Space station noise bandwidth (MHz) | 1; 0.024-72; 0.024-72; 1.8/ 4.2/ 13; | 1; 1; 1; 0.004-1; | 1 |  |
| Space station peak receive antenna gain (dBi) | 22; 22; 32; 30.8; | 28; 32; 38; 20 (global)/36;4 (spot) | 38 |  |
| Beamwidth, degree | 15 (global beam); 14; 4.5; -; | Hemi beam (ellipse, 6x7 deg); Zone beam (ellipse, 3x7 deg); Multispot beam (circular, 0.8 deg); 17.7º / 2.6º; | 0.8  for the footprint area (~~3dB~~3 dB beamwith coverage area) and global beam (secondary or side-lobe of the satellite’s antenna) |  |
| Space station system noise temperature (K) | 630; 500-900; 500-900; 900 | 400 | 400 |  |
| Normalization of FSS receiver antenna gain |  |  |  |  |
| FSS receiver antenna efficiency |  |  |  |  |
| FSS receiver feederloss |  |  |  |  |
| Earth station diameter (m) | 1.2; 1.2; 7; 11.3 | 1.8; 16; 32; 13.2 | N/A |  |
| Earth station peak transmit antenna gain (dBi) | N/A; 36; 51; 56.6 | N/A (for carriers #2, 3, 4); 57.2 (for carrier #12); | N/A |  |
| Earth station peak spectral density (dBW/Hz) | N/A; -33; -33; -33 (4 kHz BW)/-43(1 MHz BW); | N/A (for carriers #2, 3, 4); -32.5 (for carrier #12); | N/A |  |
| Earth station antenna gain pattern | Recommends 2 of Recommendation ITU-R S.524-9; Rec. ITU-R S.465-6; Rec. ITU-R S.580-6 ; Rec ITU-R S.672 | Recommends 2 of Recommendation ITU-R S.524-9 (for carriers #2, 3, 4); Rec. ITU-R S.465-6 (for carrier #12) | N/A |  |
| Earth station minimum elevation angle (degrees) | See Liaison Statement, Table 1, Note 2 | See Liaison Statement, Table 1, Note 2 | N/A |  |
| Earth station height (m) | Not provided | Not provided | N/A |  |
| Other remarks, if any | Carrier Bandwidth is 1-50 MHz | Feeder links for GSO MSS | N/A |  |
| Protection criterion *I/N* (dB)[[1]](#footnote-1) | -10.5 for 20%  -2.33 for 0.001%  -6 for 0.03% | -10.5 for 20%  -2.33 for 0.001%  -6 for 0.03% | -10.5 for 20%  -2.33 for 0.001%  -6 for 0.03% |  |
| Apportionment value (dB) | Case-by-case | Case-by-case | 3 dB |  |
| Baseline | See Document 5D/[722](https://www.itu.int/md/R19-WP5D-C-0722/en) | |  |  |
| Beam Spreading | See Document 5D/722 Rec. | |  |  |
| Atmospheric gases loss | See Document 5D/722 | | ITU-R P.676 | ITU-R P.676 |
| Clutter loss | See Document 5D/722 | | [ITU-R P.2108](http://www.itu.int/rec/R-REC-P.2108/en) | ITU-R P.2108 |
| Building entry loss | See Document 5D/722 | | ITUR-R P.2108 | ITUR-R P.2108 |
| Cross-polarization loss (dB) |  | | 3 dB | 3 dB |
| Level of interference |  | |  |  |
| Level of exceedance of the protection | – | |  |  |
| Results based on parameters from concerned/ involved groups  Level of interference |  | |  |  |
| Level of exceedance of the protection |  | |  |  |
| Sensitivity analysis |  | |  |  |
| Sensitivity analysis results |  | |  |  |
| Other studies |  | |  |  |
| Other studies result Level of interference |  | |  |  |
| Level of exceedance of the protection |  | |  |  |
| Additional notes |  | |  |  |

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1. See Document [5D/734](https://www.itu.int/md/R19-WP5D-C-0734/en). [↑](#footnote-ref-1)