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Annex 4.3 to
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IAFI[1]

FURTHER UPDATES PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M. [FSS_ES_IMT_26GHz]

Guidelines to assist administrations to mitigate interference from FSS earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz

1. Introduction:

During the last meeting of WP5D, the working document towards a preliminary draft new recommendation ITU-R M. [FSS_ES_IMT_26GHZ] was upgraded to a PDNR with a view to its finalization at the 43rd Meeting of WP5D. This recommendation would assist administrations to mitigate interference from FSS Earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz. This recommendation also emphasizes on the importance of coordination zones and a coordination contour around the IMT base station to minimize the risk of interference to IMT systems.

2. Discussion:

Resolution-242 (WRC-19) regarding the future development of International Mobile Telecommunications (IMT) in the frequency band 24.25-27.50 GHz, *invited ITU-R* to develop recommendation(s) to assist administrations to mitigate interference from FSS earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz.

3. Proposal:

As the proposed recommendation is to be finalized at the 43rd meeting of WP5D, some minor editorial corrections have been made in the document in track change mode. With these changes, it is proposed that WP5D approve this draft new recommendation and submit it to SG5

Attachment: Updated PDNR

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

ANNEX 4.3 TO WORKING PARTY 5D CHAIRMAN'S REPORT

PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.
[FSS_ES_IMT_26GHZ]

Guidelines to assist administrations to mitigate interference from FSS earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz

[Editor's Note: The WP 5D meeting in October 2022 discussed the possibility of combining this Recommendation with the similar effort for the 42/47 GHz bands. Further contributions are welcome in this regard.]

Scope

The purpose of this document is to describe guidelines and examples of regulatory frameworks that may provide guidance and operational considerations to assist administrations to mitigate interference from FSS earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz. The frequency bands 24.65-25.25 GHz in ITU Regions 1 and 3, 24.75-25.25 GHz in ITU Region 2, and 27-27.5 GHz in ITU Regions 2 and 3 are allocated to the Fixed-Satellite Service (FSS) (Earth-to-space) on a primary basis.

Keywords

ITU, IMT, 5G, FSS, 26 GHz, Earth Stations, mm wave Bands, interference,

The following two elements (Abbreviations/Glossary and Related ITU Recommendations, Reports) may be placed below as shown or at the end of Recommendation.

Abbreviations/Glossary

IMT International Mobile Telecommunications

FSS Fixed-satellite service

EESS Earth Exploration Satellite Service

SRS Space Research Service

PFD Power Flux Density

Related ITU Resolutions, Recommendations, Reports

NOTE – In every case the latest edition of the Recommendation/Reports in force should be used.

Resolution-242 (WRC-19),

Resolution 750 (Rev.WRC-19),

Recommendation ITU-R M.2083,

Recommendation ITU-R M.2101,

Recommendation ITU-R S.465,

Recommendation ITU-R S.1855,

Recommendation ITU-R P.452

Recommendation ITU-R P.2001

Recommendation ITU-R P.2108.

considering

a) that the frequency bands 24.65-25.25 GHz in ITU Regions 1 and 3, 24.75-25.25 GHz in ITU Region 2, and 27-27.5 GHz in ITU Regions 2 and 3 are allocated to the Fixed-Satellite Service (FSS) (Earth-to-space) on a primary basis;

b) that the frequency band 24.65- 27-27.5 GHz is allocated to the Mobile Service (MS) on a primary basis in all three ITU Regions;

c) that the frequency band 24.25-27.5 GHz is identified for use by administrations wishing to implement the terrestrial component of International Mobile Telecommunications (IMT) and that 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 (RR 5.532AB) ;

d) that technical studies conducted in the frequency band 24.65-25.25 GHz between IMT systems and FSS earth stations assuming a known location for the FSS earth station and certain technical characteristics and propagation models, show that the co-existence can be achieved through the calculation of separation distances and the determination of coordination zones around IMT base stations;

e) that administrations would benefit from guidelines to calculate such zones, in order to assess and ensure co-existence between FSS and IMT;

f) that the coordination zones in *considering* c) may vary on a case-by-case basis, depending upon several factors, including earth station antenna diameter and it's gain in the direction of the interference path, receiver characteristics, elevation angle, surrounding terrain, mechanisms of radio-wave propagation, clutter loss, site shielding, polarisation loss and IMT system characteristics and system design;

g) that some administrations have developed a national framework for sharing of the frequency band between IMT stations and FSS earth stations at known locations in their national territory,

recognizing

a) that the bands 24.65-25.25 GHz in ITU Region 1, and 24.65-24.75 GHz in ITU Region 3 are limited to a minimum antenna diameter of 4.5 m for the Fixed-Satellite Service (Earth to Space) (see RR No. **5.532B**);

b) that WRC-19 identified the frequency band 24.25-27.5 GHz for use by administrations wishing to implement the terrestrial component of International Mobile Telecommunications (IMT);

c) that Resolution **242 (WRC-19)** invited the ITU-R to develop Recommendation(s) to assist administrations to mitigate interference from FSS earth stations into IMT stations operating in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz and encourages administrations to ensure that provisions for the implementation of IMT allow for the continued use of EESS, SRS and FSS earth stations and their future development,

noting

a) that the impact of satellite earth stations on the deployment of IMT systems could be minimised if co-existence measures can be taken, or FSS gateways are deployed away from areas where the demand for IMT in the 26 GHz frequency band could be expected;

b) that the guidance provided in this Recommendation is not applicable in the case of a ubiquitous deployment of FSS earth-stations, where the locations of the earth-stations are not at known fixed locations,

recommends

1 that the methodologies and/or frameworks as described in Annexes should be considered as guidance by administrations to determine geographic zones for the co-existence between IMT base stations and FSS transmitting earth stations in the frequency bands 24.65/24.75-25.25 GHz and 27-27.5 GHz;

2 that administrations should consider the proximity between FSS satellite gateways earth stations and IMT base stations in these bands where IMT base stations are expected to be deployed.

Annex 1

Example methodology for enabling the use of existing and planned FSS earth stations in the frequency bands 24.65 (Regions 1 and 3) /24.75 (Region 2) - 25.25 GHz and 27.0-27.5 GHz (Regions 2 and 3) while mitigating their interference into IMT base stations

A1.1 Introduction

FSS earth stations transmitting in the 24.65 (Regions 1 and 3) / 24.75 (Region 2) GHz to 25.25 GHz and 27 GHz to 27.5 GHz (Regions 2 and 3) frequency ranges have the potential to cause interference to IMT systems. This may require the establishment of coordination zones and a coordination contour around IMT base stations to minimise the risk of interference to IMT systems. Calculation of these coordination zones needs to be site specific and, on a, case-by-case basis.

The coordination zone which is determined through this methodology can be relatively large given worst case analysis is used. Hence, such zones should be considered as coordination zones within which FSS earth stations could still be deployed, after more detailed analysis beyond this methodology is conducted or an agreement can be reached between the IMT and the FSS earth station operators.

A1.2 General methodology

The general methodology for calculating a co-ordination zone is set out in the following steps:

1 Determine the parameters for both the IMT base station and the FSS earth station. This is on a site-specific case by case basis where the specific details of the FSS earth station should be used as shown in Section A1.3.

2 Using the parameters calculate the Interference (I) for each pixel on a grid based on 20 x 20 metre to 50 x 50 metre pixel size (i.e., Interference to be determined for each pixel in the grid)[2]. The area of the grid for the calculation should be set large enough to cover the entire coordination zone. The interference (I) between a transmitting FSS earth station and a receiving IMT base station will be calculated by evaluating the transmit power and antenna gain of an FSS transmit earth station towards an IMT base station (BS) as shown in Section A1.4.

3 Compare the calculated interference for each pixel (on a grid based on 20 x 20 metre to 50 x 50 metre pixel size) with the interference protection criteria for IMT as shown in Section A1.5.

4 Determine and draw the coordination zone and coordination contour based on the comparison of interference to the IMT protection criteria for each pixel as shown in Section A1.6.

5 Consider a range of mitigations should an IMT base station be located in the coordination zone as shown in section A1.7.

A1.3 Determination of the parameters

The interference is a combination of variable parameters: IMT base station antenna gain towards the FSS earth station, and fixed parameters: propagation and clutter losses, site shielding, FSS earth station antenna gain towards the IMT base station, polarisation loss and IMT antenna ohmic losses.

[2] This is based on simulation software that uses a raster / grid / pixel basis in its calculation method. Alternatively, in some simulation software, the coordination zone may be calculated on radials. This is where for each azimuth around the FSS earth station, the corresponding distance from the FSS earth station location is calculated.

A1.3.1 Satellite earth station antenna gain towards the IMT base station

Information on the FSS earth station antenna pattern is required to be able to make the interference calculations. The resulting gain towards the IMT base station will be a combination of the antenna pattern, elevation and azimuth (i.e., compound angle). The FSS earth station antenna gain towards the IMT base station will need to be calculated for each point on a grid based on 20 x 20 metre to 50 x 50 metre grid size (each pixel in the grid) in determining the coordination zone. The antenna pattern alone, unless pointed at nadir will result in a non-circular coordination zone.

In some cases, accurate information on the FSS earth station antenna pattern may be available from the manufacturer/operator. Otherwise, the two most relevant recommendations are:

- Recommendation ITU-R S.465.
- Recommendation ITU-R S.1855.

A1.3.2 Calculation of propagation losses between the FSS earth station and the IMT base station

The signal propagating from the FSS GSO earth station to the IMT base station is subject to the following propagation losses/attenuations:

- Free space pathloss;
- Diffraction (i.e., from terrain);
- Clutter loss;
- Site shielding (where applicable).

The method prescribes Recommendation ITU-R P.452-16 for calculation of the propagation losses (including clutter losses).

For each pixel on a grid based on 20 × 20 metre to 50 × 50 metre pixel size (or each azimuth around the FSS earth station and each distance from the FSS earth station, depending on the simulation software) the propagation loss should be determined using an appropriate propagation model such as the one contained in Recommendation ITU-R P.452-16, considering the terrain elevation in the area of the grid for the calculation the coordination zone.

The terrain elevation model can be the 1-arcsec resolution terrain profile data of the Shuttle Radar Topography Mission (SRTM), however more detailed terrain models, including built area models, may be used. The terrain profiles can be sampled with an azimuth step of 1 degree around the earth station of interest and a distance step of 25 m. The losses can then be computed around the station with an azimuth step of 1 degree and a distance step of 100 m.

Higher resolution terrain data, or a surface database plus a built area model, and/or higher resolution sampling, may be used to more accurately reflect built up areas.

Note: The propagation losses consist of several contributions. Recommendation ITU-R P.452 is the appropriate propagation model to use for terrestrial paths and terrain information should be considered where existing models such as SRTM are available. Recommendation ITU-R P.2001 could also be considered as it predicts the basic transmission loss due to both signal enhancements and fading effectively over the range from 0% to 100% of an average year. Sites where there is a specific shielding obstacle close to either terminal and the height and distance to the obstacle are known, section 4.5 of Recommendation ITU R P.452 can be used to account for the clutter loss. Where specific information on the statistical distribution of clutter loss is needed, the method in section 3.2 of Recommendation ITU-R P.2108 should be used to calculate additional loss due to clutter for urban and suburban environments. It should be noted that the model is not applicable to terminals in open areas.

A1.3.3 Polarisation losses

Polarisation loss will be specific to the FSS earth station and its polarisation, this will need to be looked at on a case-by-case basis. Where specific information is not available, the losses that could be considered are:

- 3 dB for circular to linear polarisation (or vice-versa);
- 1.5 dB for same polarisation;
- 0 dB for worst case analysis.

A1.3.4 Site shielding

Some FSS gateway earth stations may have natural or man-made site shielding where the FSS earth station is located behind a building or there is a structure (e.g., a wall) that shields the antennas from locations of IMT systems. This will need to be considered on a case-by-case basis and an appropriate loss/attenuation figure will need to be determined.

A1.3.5 IMT base station antenna gain distribution towards FSS earth station

The IMT base station antenna gain is described in Recommendation ITU-R M.2101, Section 5 Implementation of IMT Base Station (BS) and User Equipment (UE) Beamforming Antenna Pattern. Antenna height information is required as well, including the mechanical pointing of the antenna in elevation and azimuth.

A1.4 Interference calculation

To determine if an existing or planned FSS earth station could interfere with an IMT base station, a methodology is proposed to be used to calculate if the interference criteria of the IMT base station is exceeded. A separation distance or coordination zone should be calculated around the IMT base station, and if the FSS earth station would fall within such a separation distance or coordination zone, potential further mitigations need to be assessed. This is therefore an approach in two steps.

As a first step the interference level from FSS needs to be calculated, using the following formula:

$$I = EIRP_{FSS}(\theta_{FSS}) - Losses + G_{IMT}(\theta_{IMT}) - PL \quad \text{(dB)} \qquad (1)$$

where:

I : Interference level at IMT base station;

$EIRP_{FSS}(\theta_{FSS})$: FSS transmit earth station off-axis e.i.r.p. density in the direction of the receive IMT base station in dBW/Hz;

Losses: Propagation loss in dB (including losses due to terrain, clutter and site shielding);

$G_{IMT}(\theta_{IMT})$: IMT base station receive antenna gain in direction of the FSS transmit earth station in dBi;

PL: Polarisation losses in dB (related to IMT beam orientation related to the FSS earth station antenna (e.g., circular to linear or vertical to horizontal).

A1.5 IMT protection criteria

The protection criteria of the IMT base station will need to be considered against the interference level calculated from the FSS transmitting earth station. Administrations could apply the following criteria at national level:

Based on a protection criterion of *I/N* =-6 dB, the maximum interference level has been evaluated as follows:

IMT receiver noise floor – 6 dB = thermal noise + noise figure – 6 dB= -204 dB(W/Hz) + 10 dB -6 dB= -200 dB(W/Hz).

The maximum interference level acceptable for an IMT BS is -200 dB(W/Hz).

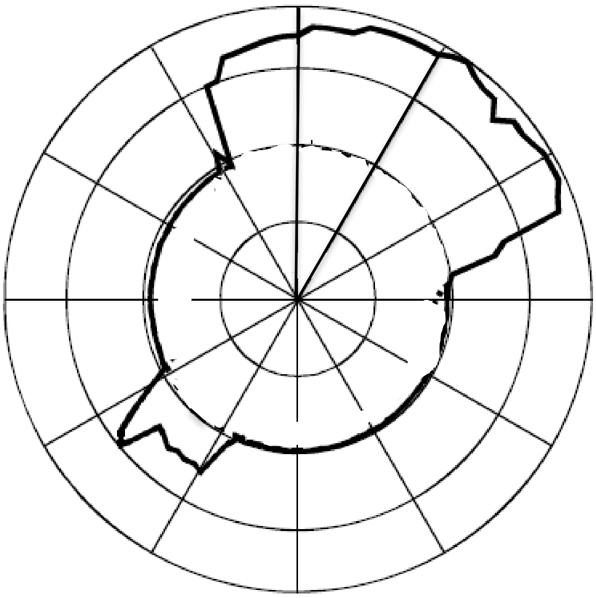
A1.6 Determination of the coordination contour

The calculation of all coordination contours should be on a case-by-case basis and site specific as the size and shape of the coordination contour can vary significantly depending on the IMT base station site.

The calculation of interference for each pixel on a grid based on 20 × 20 metre to 50 × 50 metre pixel size is compared to the IMT interference protection criteria to determine the risk of interference in each pixel. This is then used to determine the size and shape of the coordination zone. Alternatively, depending on the simulation software being used, the coordination zone could be calculated on radials. This is where for each azimuth around the IMT base station, each of the distances from the IMT base station location is calculated. Figure 1 shows an example of coordination contour around an IMT base station.

FIGURE 1

Example of coordination contour around an IMT base station



A1.7 Mitigation measures for the case that FSS earth station operates in the coordination zone

If both the FSS earth station and IMT base station location are known, then the calculation of I/N will determine if additional mitigation techniques for such a specific case could be applied. If one of the two locations is not known in advance, a coordination zone can be calculated by using the above formula (and generating grid points), that can show the area within which the I/N protection criteria would be exceeded.

The calculation of the coordination zone will generally be based on the worst case assumptions. If an FSS earth station operates within the coordination zone, then there are a number of mitigation measures that could be available to both the FSS earth station and IMT system operator to minimise the risk of interference.

Administrations may consider to:

1 Undertake further detailed technical analysis to determine the level of interference risk; and/or;

2 Ask/request that the FSS earth station and IMT operators undertake coordination and discussions.

Some of the technical mitigations that could be considered include:

a make use of more detailed terrain data, or information on build areas that can provide additional blocking. Actual measured antenna patterns could also be used to consider feasibility in more detail;

b The presence of additional site shielding at the FSS gateway earth station site;

c Further considerations of the likely azimuth and elevations of the IMT BS main beam (e.g., sector pointing). It is noted that the general methodology as described in Section A1.2 leads to a worst-case scenario wherein the IMT base station is pointed directly at the FSS earth station with its maximum gain to determine the coordination contour and the resulting coordination zone;

Other technical mitigations may be available.

Example A

A calculation is made of an example contour around an IMT base station in order to show the impact that using terrain data as a mitigation technique can assist administrations in ensuring compatibility between a transmit FSS earth station and a receive IMT base station.

The parameters used for this calculation for the FSS earth station and the IMT base station are provided in Tables 1 and 2. The FSS earth station was assumed to have an antenna size of 5.6 m, with an elevation angle of 15 degrees and an azimuth angle of −70 degrees (0 degrees is north). For the IMT base station, one antenna sector was assumed, with azimuth of 90 degrees and a 10 degrees mechanical down tilt angle. Electronic steering was assumed towards a user terminal, and contours are generated for three different positions of the user terminal (in order to simulate different electronic steering scenarios). The azimuth for the electronic steering was simulated to be 48 degrees, 90 degrees, and 132 degrees. The elevation of the electronic steering was between -1.7 and -2.3 degrees. The choice for the position of the user terminals was arbitrarily.

TABLE 1

IMT BS parameters

Parameter	Unit	BS
Antenna array configuration $N_H \times N_V$	N/A	8 × 8
Maximum element gain	dBi	5
Maximum composite antenna gain	dBi	23
H/V radiating element spacing	N/A	λ/2
Antenna height (above ground level)	m	6 (suburban hotspot)
H/V 3 dB beamwidth	°	65 for both
Azimuth angle	°	−90 degrees
Mechanical downtilt	°	10 (suburban hotspot)
Thermal noise	dBW/Hz	−204
Noise figure	dB	10

TABLE 2

FSS earth station parameters

Parameter	Value
Transmit frequency	25.0 GHz
Earth station	
Antenna diameter	5.6 m
Peak transmit antenna gain	61.8 dBi
Peak transmit power spectral density (clear sky)	−59 dB(W/Hz)
Antenna gain pattern	Rec. ITU-R S.465-6
Antenna height (above ground level)	6 m
Elevation angle	15 degrees
Azimuth angle	−70 degrees

The software tool “Visualyse” was used to generate the *I/N* contours. This was done by creating a grid of 20 m by 20 m around the IMT base station and placing the FSS earth station in each of those points and calculate the *I/N* for the IMT base station. Based on this grid calculation, contours can be generated for any specific *I/N* value.

Recommendation ITU-R P.452 was used to calculate the propagation losses. In particular, the time percentage was set to 10%, the average radio refractive index lapse rate through the lowest 1 Km (N units per km) was set to 53, and the sea-level surface refractivity (N units) was set to 328. No polarization loss was assumed.

For clutter loss, the parameters as per Section 4.5 of Recommendation ITU-R P.452 was used. In particular, the values were taken from Table 4 for the suburban scenario. Clutter was assumed only at the IMT base station side.

The location for the FSS earth station and base station was random, together with the applied terrain data (SRTM).

Figure 1 shows in one overview[3] the difference between performing the analysis without terrain data (red contours), and with terrain data (bleu contours). This plot was created by exporting the generated contours from Visualyse in kml format into another (proprietary) tool in order to be able to clearly show the impact of applying terrain. The conclusion that could be drawn from this example is that the application of terrain data improves the potential for coexistence between the FSS earth station and the IMT base station, as there would be more areas where the FSS earth station could be deployed without exceeding the *I/N* threshold (the area covered by the bleu contours is much smaller).

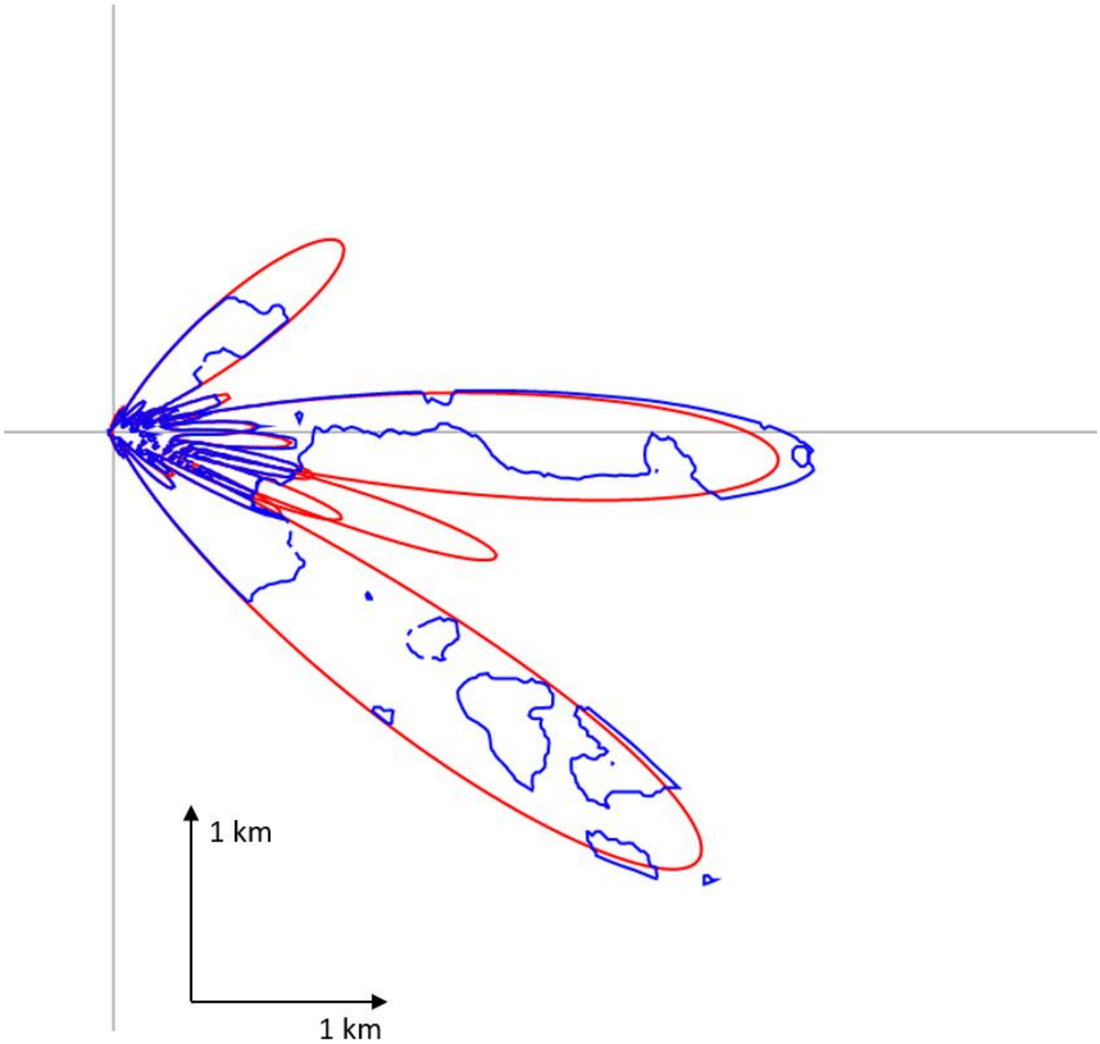
Clearly, any analysis to be done by an administration would have to take into account the parameters that apply locally, and results will differ on a case-by-case basis.

[3] The contours for each of the different positions of the user terminals were generated individually. The contours in Figure 1 are a composite of the different simulation cases that were run.

However, this example shows that making use of terrain data can help in mitigating the interference from an FSS earth station. If more localized data is available concerning clutter (both at the FSS earth station side and at the IMT base station side, the analysis can be further refined.

FIGURE 1

Example red contours are without terrain data and blue contour are, with terrain data



ANNEX 2

Example of regulatory framework and operational considerations for enabling the use of FSS earth stations in the frequency bands 24.65/24.75-25.25 GHz and 27.0-27.5 GHz while mitigating their interference into IMT base stations

Following the decision of WRC-19 to identify the 24.25-27.5 GHz band for IMT, administrations may consider new regulatory frameworks to implement the frequency band, or portions thereof, for IMT systems. As noted in Resolution **242 (WRC-19)**, administrations are encouraged to ensure that provisions for the implementation of IMT allow for the continued use of FSS earth stations and their future development. This annex provides relevant information that administrations can use to facilitate sharing between individually licensed, transmitting FSS earth stations and deployment of IMT systems.

Geographic licensing for IMT operations. Geographic area licensing provides licensees with the flexibility to provide a variety of services, expedite deployment, and is consistent with the existing licensing schemes in IMT identified bands. Geographic licensing based on “Economic Areas” (EAs) can strike a balance between large and small IMT providers and simplifying frequency coordination while incentivizing investment in, and rapid deployment of, new technologies. By the use of EAs, operators can combine or partition their service into a license area of their choice, taking advantage of smaller areas that more efficiently accommodate mmW propagation characteristics.

Licensing of FSS earth stations. Transmitting earth stations in the 24.65/24.75-25.25 GHz and 27-27.5 GHz bands may cause interference to IMT stations if there is no sufficient separation, thus licensing should be limited to individually or area licensed earth stations. Several regulatory tools to implement coordination are available to ensure the compatible co-frequency operation of FSS with IMT base stations. Examples are aggregate population limits within the specified earth station PFD contour, or established maximum number of FSS earth stations that could operate in the same IMT license area. Further, population coverage requirements can balance the service requirements for IMT operators while providing geographic areas for FSS operations.

As an example, an applicant for the license of a transmitting earth station in the band would be required to demonstrate the area in which the earth station generates a pfd, at 10 meters above ground level, of greater than or equal to −77.6 dBm/m^2/MHz[4], together with the area generated by of any other earth stations authorized in the same EA does not cover, in the aggregate, more than the amount of an established population limitation of the EA within which the earth station is located.

Administrations have the flexibility to decide what licensing regime best accommodates the shared use of FSS earth station with the deployment of IMT stations.

[4] This pfd, provided as an example, was calculated using assumptions to protection IMT networks from existing transmit FSS earth stations: https://docs.fcc.gov/public/attachments/FCC-16-89A1.pdf

TABLE 1

(Example Population Coverage Limitations[5])

Population within IMT license area	Maximum permitted aggregate population within −77.6 dBm/m^2/MHz pfd contour of earth stations
Greater than 450,000	0.1 percent of population in IMT license area.
Between 6,000 and 450,000	450 people.
Fewer than 6,000	7.5 percent of population in IMT license area.

Based on the expected deployment for wireless services, some regulatory frameworks may require satellite applicants to show that the permitted zone does not infringe upon any major event venue, arterial street, interstate or highway, urban mass transit route, passenger railroad, or cruise ship port.

Finally, before a satellite earth station applicant is licensed, they must successfully complete frequency coordination with the IMT licensees within the area in which the earth station generates a pfd contour, at 10 meters above ground level and equal to −77.6 dBm/m^2/MHz with respect to existing facilities constructed and in operation by the IMT licensee.

In order to facilitate the compliance process for an FSS earth station applicant, additional technical guidance is to be provided on computing the PFD contours and protection zones: the use of applicable propagation models, measured gain patterns, the effect of terrain, clutter and shielding and other conditions. Regulators could provide this information publicly[6] to minimize the impact on IMT operations and provide a predictable regulatory environment to accommodate multiple earth station zones within a license area.

[5] This example could vary administration to administration based on its geographic size, population metrics and existing/new licensing structure.

[6] For example: https://www.fcc.gov/document/international-bureau-issues-guidance-compliance-section-25136.