ECC Recommendation
(22)01

Guidelines to support the introduction of MFCN in 40.5-43.5 GHz while ensuring, in a proportionate way, the use of FSS receiving earth stations in the frequency band 40.5-42.5 GHz and the use of FSS transmitting earth stations in the frequency band 42.5-43.5 GHz and the possibility for future deployment of these earth stations

approved 18 November 2022

INTRODUCTION

To ensure coexistence between MFCN systems operating in 40.5-43.5 GHz with transmitting FSS earth stations in the frequency band 42.5-43.5 GHz and receiving FSS earth stations in the frequency band 40.5-42.5 GHz, for GSO and non-GSO satellite systems, coordination zones and coordination contours may be required around FSS earth stations. The exact coordination zone and contour will have to be calculated on a case-by-case site specific basis, depending on the diffraction (due to terrain profile), clutter, site shielding and polarisation losses around the specific earth station and the characteristics of the specific FSS earth station and MFCN base stations.

This Recommendation provides guidance to administrations on the calculation of such coordination zones and coordination contours around receiving FSS earth stations in the frequency band 40.5-42.5 GHz and transmitting FSS earth stations in the frequency band 42.5-43.5 GHz. The calculation of coordination contours could help administrations to implement coordination zones around FSS earth stations (with respect to MFCN base stations).

Moreover, guidelines will be helpful for the deployment of MFCN in the 40.5-43.5 GHz frequency band allowing for continued development of FSS earth stations, while minimising the risk of interference between MFCN and FSS earth stations.

The calculated zone highlights the area where the operation of MFCN base station(s) would need to be taken into further consideration.

This Recommendation aims to support the introduction of MFCN while facilitating continued use of receiving FSS earth stations in the frequency band 40.5-42.5 GHz and transmitting FSS earth stations in the frequency band 42.5-43.5 GHz, and the possibility for future deployment of these earth stations while ensuring that the number and locations of new earth stations are determined so as not to impose disproportionate constraints on MFCN, subject to market demands.

This Recommendation complements Appendix 7 of the Radio Regulations [1], and does not intend to replace it.

ECC RECOMMENDATION 22(01) OF 18 NOVEMBER 2022 ON GUIDELINES TO SUPPORT THE INTRODUCTION OF MFCN IN 40.5-43.5 GHZ WHILE ENSURING, IN A PROPORTIONATE WAY, THE USE OF FSS RECEIVING EARTH STATIONS IN THE FREQUENCY BAND 40.5-42.5 GHZ AND THE USE OF FSS TRANSMITTING EARTH STATIONS IN THE FREQUENCY BAND 42.5-43.5 GHZ, AND THE POSSIBILITY FOR FUTURE DEPLOYMENT OF THESE EARTH STATIONS

"The European Conference of Postal and Telecommunications Administrations,

considering

a) that ECC Decision (22)06 [2] provides harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the frequency band 40.5-43.5 GHz;

b) that the frequency band 40.5-42.5 GHz is allocated to the fixed-satellite service (FSS) (space-to-Earth), where the interest in this band in Europe is primarily for receiving gateway FSS earth stations (ES) for which a relatively limited number of stations are needed, noting that it is feasible for stations of this nature to operate on a shared basis with terrestrial services;

c) that ECC Decision (02)04 [3] addresses the use of the frequency band 40.5-42.5 GHz by terrestrial and satellite services;

d) that ECC Recommendation (22)02 [4] addresses receiving FSS earth stations, which (as well as MSS earth stations) are designated for use in the frequency band 39.5-40.5 GHz, for GSO and non-GSO satellite systems, through ERC Decision (00)02 [5];

e) that the technical studies in the frequency band 40.5-42.5 GHz conducted using certain propagation models and assuming certain technical characteristics of MFCN base stations (BS) and receiving FSS ES operating at various relative locations and positions, showed that coexistence can be achieved through the calculation of a geographical separation distance and the determination of coordination zones that can be applied around receiving FSS earth stations, where further consideration may be needed if MFCN base stations were inside these zones;

f) that technical parameters for both the FSS and MFCN stations (base stations and user terminals) are required as a basis to calculate the required separation distances and determine the coordination zones;

g) that a methodology as described in Annex 1 to evaluate the geographical separation distances and to determine coordination zones around receiving FSS earth stations operating in 40.5-42.5 GHz will help administrations calculate these separation distances/coordination zones and ensure coexistence between MFCN and receiving FSS earth stations;

h) that the frequency band 42.5-43.5 GHz is allocated to the FSS (Earth-to-space), where the interest in this band in Europe is primarily for transmitting gateway FSS earth stations, noting that it is feasible for stations of this nature to operate on a shared basis with terrestrial services;

i) that the technical studies in the frequency band 42.5-43.5 GHz conducted using certain propagation models and assuming certain technical characteristics of MFCN BS and transmitting FSS ES operating at various relative locations and positions, showed that coexistence can be achieved through the calculation of a geographical separation distance, and the determination of coordination zones that can be applied around transmitting FSS earth stations, where further consideration may be needed if MFCN base stations were inside these zones;

j) that a methodology as described in Annex 2 to evaluate the geographical separation distances and coordination zones around transmitting FSS earth stations operating in 42.5-43.5 GHz will help administrations calculate their contours and ensure coexistence between MFCN and transmitting FSS earth stations;

k) that when the location of MFCN base stations is unknown, Annex 3 describes approaches for the application of the methodologies of Annex 1 and Annex 2 for calculation of coordination zones around FSS Earth stations and includes guidelines and examples of national approaches to identify possible locations for the deployment of FSS earth stations;

l) that the coordination zones will vary on a case by case basis as a function of earth station antenna diameter, station characteristics, elevation angle, surrounding terrain, diffraction loss, clutter loss, site shielding, polarisation loss and MFCN network characteristics and system design;

m) that the determination of separation distances, coordination zones and/or coordination contours around FSS earth stations should where possible utilise an appropriate propagation model such as Recommendation ITU-R P.452 [6] or Recommendation ITU-R P.2001 [7] together with suitable terrain data for the area surrounding the earth station. The methods to calculate coordination zones in this Recommendation will tend to over-estimate separation distances that are required;

n) that any co-existence analysis and implementation of sharing conditions based on determination of a separation distance, coordination zone and/or coordination contour implies the need for information on relative location of/or distance between interferer and victim, or on the location of one of these when planning the location of the other station, and thus in the case of an authorisation regime where the location of base stations are not known in advance of installation, additional considerations may be required to achieve co-existence;

o) that MFCN hotspot BSs use single sector active antenna systems (AAS) and hence the interference potential is dependent on the choice made for the location of the MFCN BS to cover its service area and the resulting pointing direction, which may contribute to reduce interference issues;

p) that ECC Decision (22)06 [2] considers that appropriate provisions are needed in the authorisation for MFCN to define precisely how to safeguard in a proportionate way the use of existing FSS earth stations, and the possibility for future earth station deployments in the 40.5-42.5 GHz (space-to-Earth) and the 42.5-43.5 GHz (Earth-to-space) frequency bands;

q) that the sharing between FSS earth stations and MFCN systems could be improved if coexistence measures of Annex 1 and Annex 2 are taken. If not feasible, FSS gateway earth stations and MFCN base stations could be deployed in different areas, recognising that MFCN base stations are expected to be deployed in densely populated areas;

r) that there are additional techniques that may help to further reduce the interference at the FSS earth station receiver such as the one described in Report ITU-R S.2150 [8], which may be used where applicable.

recommends

1. that the methodology and examples of calculations of coordination zones provided in Annex 1 (where further consideration may be needed if MFCN base stations were inside these zones) around FSS earth stations as per considering b), which are receiving from GSO or NGSO satellites in the frequency band 40.5-42.5 GHz, can be used by administrations as a guideline to implement coordination zones and support the coexistence between MFCN BS and receiving FSS earth stations;

2. that the methodology and examples of calculations of coordination zones provided in Annex 2 (where further consideration may be needed if MFCN base stations were inside these zones) around FSS earth stations as per considering h), which are transmitting to GSO or NGSO satellites in the frequency band 42.5-43.5 GHz, can be used by administrations as a guideline to implement coordination zones and support the coexistence between MFCN BS and transmitting FSS earth stations;

3. that guidance provided in Annex 3 can be used to help administrations in the practical application of the methodologies described in Annex 1 and Annex 2, including for cases where the locations of base stations are not known in advance of installation;

4. that administrations should consider coexistence measures between future FSS gateway earth stations and MFCN base stations where these would be close to each other, recognising that MFCN base stations are expected to be deployed in densely populated area."

Note:

Please check the Office documentation database https://www.docdb.cept.org *for the up to date position on the implementation of this and other ECC Recommendations.*

ANNEX 1: METHODOLOGY FOR CALCULATION OF COORDINATION ZONES AROUND FSS EARTH STATIONS RECEIVING IN THE FREQUENCY BAND 40.5-42.5 GHZ

A1.1 INTRODUCTION

There is potential for interference between MFCN and FSS earth stations receiving in the 40.5-42.5 GHz frequency range. This may require the establishment of coordination zones and a coordination contour around these FSS earth stations to minimise the risk of interference from MFCN. 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 that worst-case analysis is used. Hence, such zones should be considered as coordination zones within which MFCN could still be deployed, after more detailed analysis beyond this methodology is conducted or an agreement can be reached between the FSS earth station and MFCN operators.

A1.2 GENERAL METHODOLOGY

The general methodology for calculating a coordination zone is set out in the following steps:

1. Determine the parameters for both the FSS earth station (ES) and the MFCN base stations (BS). 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 a 20 x 20 metre to 50 x 50 metre pixel size (i.e. I determined for each pixel in the grid)[1]. 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 MFCN base station and a receiving FSS earth station will be calculated by evaluating the transmit power and antenna gain of an MFCN Base Station (BS) towards the receiving FSS earth station 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 FSS earth stations as shown in section A1.5.

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

5. Consider a range of mitigations when an MFCN base station is 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: MFCN BS antenna gain towards the FSS earth station, and fixed parameters: propagation and clutter losses, site shielding, FSS earth station antenna gain towards the MFCN BS, polarisation loss and MFCN antenna ohmic losses.

Note: Terrain, clutter data and site shielding should be taken into account.

A1.3.1 Satellite earth station antenna gain towards the MFCN BS

Information on the FSS earth station antenna pattern is required to be able to make the interference calculations. The resulting gain towards the MFCN 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 MFCN BS will

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[1] 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 the distance from the FSS earth station location is calculated for each azimuth around the FSS earth station,

need to be calculated for each point on a grid based on a 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 relevant information is in Recommendation ITU-R S.465 [9].

A1.3.2 Calculation of propagation losses between the FSS earth station and the MFCN BS

The signal propagating from the MFCN BS to the FSS earth station is subject to the following propagation losses/attenuations:

- Free space pathloss;
- Diffraction (i.e. from terrain);
- Clutter loss (e.g. buildings and/or foliage);
- Site shielding (where applicable).

For each pixel on a grid based on a 20 x 20 metre to 50 x 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 [6] or Recommendation ITU-R P.2001 [7], considering the terrain elevation in the area of the grid for the calculation of the coordination zone. For example, the terrain profile can be sampled with an azimuth step of 1 degree around the earth station of interest and a distance step of 25 m and the losses can then be computed around the station with an azimuth step of 1 degree and a distance step of 100 m.

Where there is a digital surface model (DSM) which includes objects above the terrain (e.g. buildings, trees, etc.), the clutter loss may be accounted for within Recommendation ITU-R P.452-16 in section 4.5 which describes the calculation of clutter loss. Higher resolution surface data may be used to reflect built up areas more accurately. Where a DSM is not available (or cannot be derived), the method in section 3.2 of Recommendation ITU-R P.2108 [10] should be used to calculate the statistical distribution of the clutter loss for urban and suburban environments.

A1.3.3 Polarisation losses

Polarisation loss will be specific to the FSS earth station and its polarisation and 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 earth stations may have 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 likely locations of MFCN base stations in populated areas. 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 MFCN BS antenna gain distribution towards FSS earth station

The MFCN BS antenna gain is described in Recommendation ITU-R M. 2101, section 5 "Implementation of MFCN Base Station (BS) and User Equipment (UE) Beamforming Antenna Pattern" [11].

The base station antenna panel is assumed pointing towards the FSS earth station in azimuth. The distribution of antenna gain towards the horizon is determined from the distribution of electric azimuth angles φ_{escan} and electrical tilt angles θ_{etilt}, as well as the mechanical tilt θ_{mtilt}. Those distributions themselves are given by the distributions of azimuths and distances of the user equipment as seen from the MFCN base station, using the BS and UE antenna heights.

In this ECC Recommendation, the mechanical tilt makes reference to the horizontal plane. As the antenna panel is always oriented towards the ground this value is negative. The electrical tilt is defined with reference to the angle perpendicular to the antenna panel where a negative value refers to an electrical down-tilt.

From distributions of (BS antenna) electric azimuth angles φ_{escan} and electrical tilt angles θ_{etilt}, it is possible to determine the antenna gain distribution towards the victim FSS earth station, using the antenna pattern from Recommendation ITU-R M.2101 [11].

A1.4 INTERFERENCE CALCULATION

The interference is calculated by applying formula (1) below. The level of interference (I) must be calculated for each pixel on a grid based on 20 x 20 metre to 50 x 50 metre pixel size. The interference should be calculated using the following formula:

$$I = e.i.r.p._{MFCN} (\theta_{MFCN}) - Losses + G_{FSS}(\theta_{FSS}) - PL \qquad (1)$$

Where:
- Interference in dBW/Hz;
- e.i.r.p.$_{MFCN}$(θ_{MFCN}): MFCN off-axis e.i.r.p. density in the direction of the FSS earth station in dBW/Hz;
- Losses: Propagation loss in dB (including losses due to terrain, clutter and site shielding);
- $G_{FSS}(\theta_{FSS})$: FSS earth station receive antenna gain in direction of the MFCN in dBi;
- PL: Polarisation Losses in dB, MFCN BS beam orientation related to the FSS earth station antenna (e.g. circular to linear or vertical to horizontal).

A1.5 FSS EARTH STATION PROTECTION CRITERIA

A protection criteria for FSS downlink in 40.5-42.5 GHz was provided by ITU-R WP 4A to ITU-R TG5/1 [12] for the protection of FSS in the context of the coexistence studies undertaken under WRC-19 agenda item 1.13.

Table 1: Protection criteria for FSS downlink in 40.5-42.5 GHz [12]

Percentage of time, probability or location for which the I/N value could be exceeded (%)	I/N Criteria (dB)
0.02	+8
1.0	-6
20 or I/N average	-10.5

The values provided assume the use of an I/N methodology, where 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 plus the receiver noise.

The following notes regarding the values in the above table were provided by ITU-R WP 4A in its Liaison statement to TG5/1:

> _**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 plus the receiver noise referred to the antenna as contained in the technical parameters liaised to Task Group (TG) 5/1 by WP 4A. Hence studies conducted by TG 5/1 should only use the values presented above when evaluating the compliance with the protection criteria.

> _**Note 2:**_ For interference analysis where the degradation is due to atmospheric attenuation, which varies as a function of time, it is appropriate to specify protection criteria based on a percentage of time. However, sharing studies conducted between satellites and IMT systems under WRC-19 agenda

item 1.13 may involve far more complex considerations and calculations, based on additional variables which are not a function of time. These studies may include geographical locations in the space domain associated to the IMT position. As such, the definition of the protection criteria cannot be expressed simply in terms of values against a percentage of time. Therefore, as depicted in Table 1, the percentage is expressed as a percentage of time, location or probability (for example, for Monte Carlo simulations, the percentage can be expressed in terms of a number of snapshots).

**Note 3**: It was concluded that apportionment of the _I/N_ protection criteria between services should be done on a case-by-case basis. The protection criteria values given in this document correspond to the total _I/N_ contributions present at the satellite or earth station receiver.

**Note 4**: Studies using these short-term protection criteria should be assessed on the basis that these values are put forward by WP 4A to facilitate and complete the work for WRC-19 agenda item 1.13 and these values may evolve in the future based on inputs to the ITU-R. Whilst WP 4A has not completed its work in developing short-term protection criteria, TG 5/1 should take due account of these short-term protection criteria but should not assume that all FSS/BSS systems will suffer harmful interference if these protection criteria are exceeded.

Studies should use the protection criteria for 20% or _I/N_ average for the long term, as well as the 0.6% or 1%, as applicable, for the short term to determine whether there is compatibility between the concerned service and the fixed-satellite service. Studies should also be assessed for the criterion associated with 0.02% in the table above; however, for studies in which results are not available for percentages down to 0.02%, short term _I/N_ values should not exceed the _I/N_ value associated with this percentage. The above information on protection criteria should not affect the status of the ongoing studies."

For the purposes of calculating the coordination contour, and in line with the principles of the methodology described here, the long-term protection criteria should be used (20% or I/N average), i.e. I/N = -10.5 dB. By using this value, the resulting coordination contour, as described in the next section, will be such that for MFCN BS deployed anywhere outside the contour, there will be no problem for co-existence between the FSS ES and the MFCN BS in question.

Bearing in mind the notes above, contours generated using the medium- or short-term criteria could be useful.

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 FSS earth station site.

The calculation of interference for each pixel on a grid based on a 20 x 20 metre to 50 x 50 metre pixel size is compared to the FSS earth station protection criteria (40.5-42.5 GHz) 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 FSS earth station, each of the distances from the FSS earth station location is calculated. Figure 1 shows an example of coordination contour around an FSS earth station.
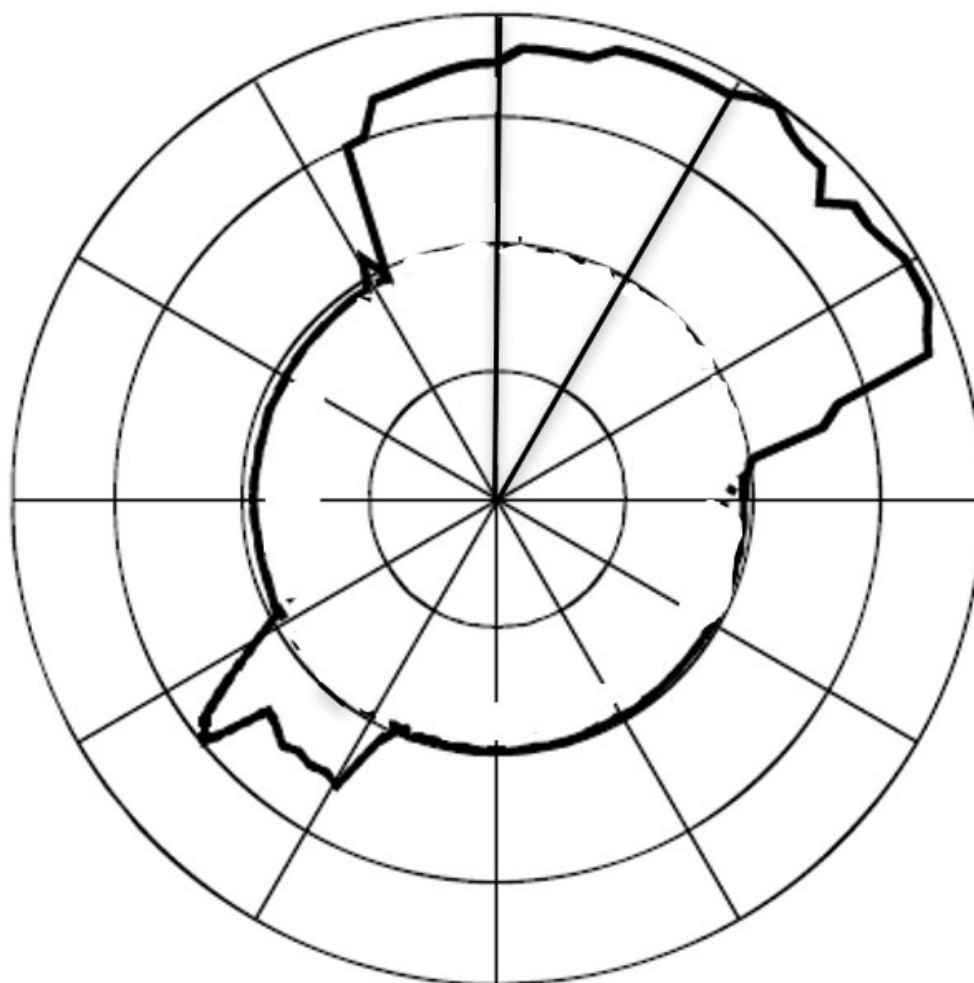
Figure 1: Example of coordination contour around an FSS earth station

A1.7 MITIGATION MEASURES FOR THE CASE THAT MFCN BS OPERATE IN THE COORDINATION ZONE

The coordination zone will generally be based on worst case assumptions. If MFCN BS operate within the coordination zone, there are a number of mitigations that could be available to both the FSS earth station and MFCN operator to minimise the risk of interference. Administrations could choose 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 MFCN operators undertake coordination and discussions.

Some of the technical mitigations that could be considered include:

1. The presence of additional site shielding at the FSS earth station site;

2. Further consideration of the likely azimuth and elevations of the MFCN 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 where the MFCN base station is pointed directly at the FSS earth station with its maximum gain to determine the coordination contour and the resulting coordination zone; For example, if an MFCN BS points towards the FSS ES within a limited arc (e.g. +/- 65°, and for other pointing directions), this would reduce the interference and allow MFCN BS to be sited closer to the FSS ES.

Other technical mitigations may be available beyond what is mentioned here.

ANNEX 2: METHODOLOGY FOR CALCULATING THE COORDINATION ZONES AROUND FSS EARTH STATIONS TRANSMITTING IN THE FREQUENCY BAND 42.5-43.5 GHZ

A2.1 INTRODUCTION

FSS earth stations transmitting in the 42.5 GHz to 43.5 GHz frequency range have the potential to cause interference to MFCN. This may require the establishment of coordination zones and a coordination contour around these FSS earth stations to minimise the risk of interference to MFCN. Calculation of these coordination zones needs to be site specific and on a case-by-case basis.

In the 42.5 GHz to 43.5 GHz frequency range, the interest in Europe is primarily for transmitting gateway FSS earth stations, which means that these earth stations are relatively limited in number and sparsely distributed.

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 MFCN base stations could still be deployed, after more detailed analysis beyond this methodology is conducted or an agreement can be reached between the FSS earth station and MFCN operators.

Given that in an MFCN system, the user equipment will operate indoor or in heavy clutter, the methodology focuses on the MFCN base station, only considering a single MFCN base station.

A2.2 GENERAL METHODOLOGY

The general methodology for calculating a coordination zone is set out in the following steps:

1. Determine the parameters for both the FSS earth station (ES) and the MFCN base station (BS). 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 A2.3.

2. Using the parameters calculate the Interference (I) for each pixel on a grid based on a 20 x 20 metre to 50 x 50 metre pixel size (i.e. I 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 MFCN base station will be calculated by evaluating the transmit power and antenna gain of a transmitting FSS earth station towards an MFCN Base Station (BS) as shown in section A2.4.

3. Compare the calculated interference for each pixel (on a grid based on a 20 x 20 metre to 50 x 50 metre pixel size) with the interference protection criteria for MFCN as shown in section A2.5.

4. Determine and draw the coordination zone and coordination contour based on the comparison of interference to the MFCN protection criteria for each pixel as shown in section A2.6.

5. Consider a range of mitigations should an MFCN base station be located in the coordination zone as shown in section A2.7.

A2.3 DETERMINATION OF THE PARAMETERS

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

Note: Terrain, clutter data and site shielding should be taken into account.

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[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

A2.3.1 Satellite earth station antenna gain towards the MFCN BS

Information on the FSS earth station antenna pattern is required to be able to make the interference calculations. The resulting gain towards the MFCN 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 MFCN BS will need to be calculated for each point on a grid based on a 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 relevant recommendations are:

▪ Recommendation ITU-R S.465 [9];
▪ Recommendation ITU-R S.1855 [13].

A2.3.2 Calculation of propagation losses between the FSS earth station and the MFCN BS

The signal propagating from the FSS earth station to the MFCN BS is subject to the following propagation losses/attenuations:

▪ Free space pathloss;
▪ Diffraction (i.e. from terrain);
▪ Clutter loss (e.g. buildings and/or foliage);
▪ Site shielding (where applicable).

For each pixel on a grid based on 20 x 20 metre to 50 x 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 [6] or Recommendation ITU-R P.2001 [7], considering the terrain elevation in the area of the grid for the calculation of the coordination zone. For example, the terrain profile can be sampled with an azimuth step of 1 degree around the earth station of interest and a distance step of 25 m, and the losses can then be computed around the station with an azimuth step of 1 degree and a distance step of 100 m.

Where there is a digital surface model (DSM) which includes objects above the terrain (e.g. buildings, trees, etc.), the clutter loss may be accounted for within Recommendation ITU-R P.452-16 in section 4.5 which describes the calculation of clutter loss. Higher resolution surface data may be used to reflect built up areas more accurately. Where a DSM is not available (or cannot be derived), the method in section 3.2 of Recommendation ITU-R P.2108 [10] should be used to calculate the statistical distribution of the clutter loss for urban and suburban environments.

A2.3.3 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.

A2.3.4 Site shielding

Some FSS earth stations may have 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 likely locations of MFCN base stations in populated areas. This will need to be considered on a case-by-case basis and an appropriate loss/attenuation figure will need to be determined.

A2.3.5 MFCN BS antenna gain distribution towards FSS earth station

The MFCN BS antenna gain is described in Recommendation ITU-R M. 2101, section 5 "Implementation of MFCN Base Station (BS) and User Equipment (UE) Beamforming Antenna Pattern" [11].

A2.4 INTERFERENCE CALCULATION

The interference is calculated by applying formula (2) below. The level of interference (I) must be calculated for each pixel on a grid based on a 20 x 20 metre to 50 x 50 metre pixel size. The interference should be calculated using the following formula:

$$I = \text{e.i.r.p.}_{FSS}\,(\theta_{FSS}) - \text{Losses} + G_{MFCN}(\theta_{MFCN}) - PL \qquad (2)$$

Where:

- Interference in dBW/Hz;
- e.i.r.p.$_{FSS}$(θ_{FSS}): Transmitting FSS earth station signal off-axis e.i.r.p. density in the direction of the MFCN receive BS in dBW/Hz;
- Losses: Propagation loss in dB (including losses due to terrain, clutter and site shielding);
- $G_{MFCN}(\theta_{MFCN})$: MFCN base station receive antenna gain in direction of the transmitting FSS earth station in dBi;
- PL: Polarisation Losses in dB, MFCN BS beam orientation related to the FSS earth station antenna (e.g. circular to linear or vertical to horizontal).

A2.5 MFCN PROTECTION CRITERIA

Administrations could apply the following criteria at national level:

A2.5.1 Option 1:

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

MFCN 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 MFCN BS is -200 dB(W/Hz).

A2.5.2 Option 2:

Apply a different measure for the protection of MFCN on a case-by-case basis (e.g. degradation of receive signal strength, percentage of throughput loss, etc.).

The interference calculation in A2.4 can be statistical. Therefore, the protection criteria of MFCN needs to be defined statistically on a case-by-case basis (e.g. degradation of receive signal strength threshold, percentage of throughput loss, etc.).

A2.6 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 FSS earth station site.

The calculation of interference for each pixel on a grid based on a 20 x 20 metre to 50 x 50 metre pixel size is compared to the MFCN 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 FSS earth station, each of the distances from the FSS earth station location is calculated. Figure 2 shows an example of coordination contour around an FSS earth station.
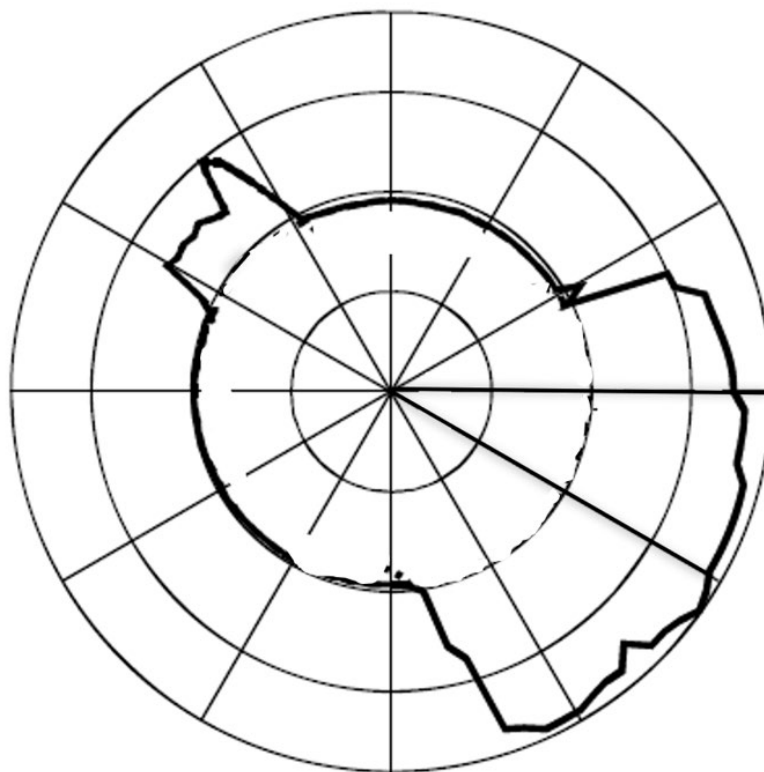
Figure 2: Example of coordination contour around an FSS earth station

A2.7 MITIGATION MEASURES FOR THE CASE THAT MFCN OPERATES IN THE COORDINATION ZONE

The coordination zone will generally be based on worst case assumptions. If MFCN base stations operate within the coordination zone there are a number of mitigations that could be available to both the FSS earth station and MFCN operator to minimise the risk of interference. Administrations could choose 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 MFCN operators undertake coordination and discussions.

Some of the technical mitigations that could be considered include:

1. The presence of additional site shielding at the FSS earth station site;

2. Further consideration of the likely azimuth and elevations of the MFCN BS main beam (e.g. sector pointing). It is noted that the general methodology as described in section A2.2 leads to a worst case where the MFCN base station is pointed directly at the FSS earth station with its maximum gain to determine the coordination contour and the resulting coordination zone. For example, if an MFCN BS points towards the FSS ES within a limited arc (e.g. +/- 65°, and for other pointing directions), this would reduce the interference and allow MFCN BS to be sited closer to the FSS ES;

3. The MFCN operator's tolerance to interference (via negotiation): Depending on where the MFCN base station is in the coordination zone, interference may only result in a reduction of coverage and capacity for particular azimuths and elevations.

Other technical mitigations may be available beyond what is mentioned here.

ANNEX 3: CONSIDERATIONS FOR THE APPLICATION OF THE METHODOLOGIES OF ANNEXES 1 AND 2 FOR CALCULATION OF COORDINATION ZONES AROUND FSS EARTH STATIONS WHEN THE LOCATION OF MFCN BASE STATIONS IS UNKNOWN

When the location of the MFCN base stations (BS) is unknown, further methods and mechanisms may be required in addition to the methodologies described in this recommendation (see ANNEX 1 and ANNEX 2).

This annex describes and details such methods, which are based on databases, geo-location, and/or cognitive solutions. Relevant details for implementation have not been provided during the development of this recommendation. However, this recommendation explains the main approach.

This Recommendation provides guidance to administrations to facilitate coexistence of FSS earth stations (ES) in a band designated within CEPT for MFCN deployment. For this the following constitutes the relevant background for the case where the location of the MFCN BS may not be known:

a) The technical studies conducted using certain propagation models and assuming certain technical characteristics of MFCN BS and FSS ES operating at various relative locations and positions, showed that coexistence can be achieved through the calculation of a geographical separation distance, and the determination of coordination zones that can be applied around FSS earth stations, where further consideration may be needed if MFCN base stations were inside these zones;

b) The studies have been made under the assumption of having information on relative location of/or distance between interferer and victim, or on the location of one of these when planning the location of the other station;

c) Coordination contours can however be calculated for FSS ESs without the knowledge of the location of the MFCN BSs;

d) It has been acknowledged that within some national authorisation regimes the location of the MFCN BS is not known (i.e., the licensee is not required to declare where a BS is located.);

e) In such a regime the MFCN operator is required by the license to respect the available coordination contours around FSS ESs (as well as other sensitive installations, e.g. RAS sites);

f) Where an MFCN BS is planned to be deployed inside the relevant coordination contour, the feasibility of the proposed deployment must be checked via a site-specific coordination calculation and in that situation the exact position and pointing of the MFCN BS is required to be known;

g) MFCN hotspot BSs use single sector active antenna systems (AAS) and hence, the interference potential is dependent on the choice made for the location of the MFCN BS to cover its service area and the resulting pointing direction, which may contribute to reduce interference issues;

h) If the administration requires to know where some or all of the BSs are located this can be requested from the operator.

To ensure that the separation distance is respected, there is a need for information on relative location of/or distance between interferer and victim, or on the location of one of these when planning the location of the other station.

This annex considers cases where the exact location of the MFCN BS is not known and provides guidance to administrations in applying possible methodologies to address the issue of assuring co-existence between FSS and MFCN in such cases.

A3.1 CASE 1 – TRANSMITTING FSS EARTH STATIONS IN THE BAND 42.5-43.5 GHZ

Assuming a configuration in a country whereby a number of FSS earth stations, all of which are individually coordinated and hence at physical locations known to the administration are successfully co-existing with an existing deployment of MFCN BS.

These MFCN BS, whose location may not be known by the administration, are either outside the coordination zones of all of the existing FSS earth stations, or if inside the coordination zones, are subject to particular circumstances, for example: protection due to pointing direction, clutter or shielding etc., such that co-existence is in any case still assured. This approach hereafter can also include the situation where either or both IMT and FSS have not yet begun deployment in the band in the national territory or a given region within it.

The objective for this Case 1 is thus to propose a means/methodology by which additional MFCN BS and/or additional FSS earth stations may be deployed in the band.

Given that the locations of MFCN BS are not specifically known by the administration, in order to be able to determine deployment sites where additional MFCN BS would be protected, the administration could provide a database with the location of the coordinated FSS earth stations in the territory (FSS data base).

This dataset could also include the coordination contours of the FSS earth stations, which could be generated as per the methods provided in ANNEX 2.

In the event of additional FSS earth stations being deployed, as per the cases described below, this database would need to be updated accordingly.

A3.1.1 Case 1a. Placing additional MFCN BS in the band 42.5-43.5 GHz

The MFCN operator can, with the data available as to the geographical location of the existing FSS earth station and then using the methodology as described in ANNEX 2, determine if the siting of a given MFCN BS has the potential to be interfered by a satellite FSS earth station.

If the site of the MFCN BS is outside any of the coordination zones as generated by ANNEX 2, then the MFCN BS may be simply deployed without any further consideration.

If on the other hand, the MFCN BS would be inside of any of these coordination zones, then the MFCN operator would need to determine if any mitigation is present, or could be applied, to allow for the successful co-existence of the two services. Some of these possible mitigation circumstances/measures are described in ANNEX 2.

The administration authorising the FSS earth stations has the option to implement certain considerations in its authorisation regime for FSS earth stations which minimise the probability that a new MFCN BS would be likely to fall within the coordination zones generated as per ANNEX 2.

A3.1.2 Case 1b. Placing additional transmitting FSS earth stations in the band 42.5-43.5 GHz

Deploying additional FSS earth stations such that the co-existence with MFCN BS at unknown locations is more complex than the case of deploying additional MFCN BS where the location of the FSS earth stations is known.

The only deterministic way in which this might be achieved is for the administration to pre-define zones in which FSS earth stations would be allowed (for example: further public consultation to assess FSS market demand), from which a combined coordination zone around this predefined zone could be generated. This combined zone could be constructed using the methodology of ANNEX 2 to calculate, and then merge, the coordination zones for FSS earth stations on the perimeter of the pre-defined zone in which the FSS earth stations are allowed.

Within such a scenario, the MFCN operators could be requested to provide details in the area(s) of interest for a new FSS ES deployment to determine if the location is feasible and if any mitigation would allow for an interference free deployment. After deployment the coordination contours for the new FSS ES should be included in the dataset.

In such a scenario, any additional MFCN BS to be sited by MFCN operators within this combined coordination zone would be on a non-protected basis from interference from the FSS earth stations.

Deployment of additional FSS earth stations outside the pre-defined zones in which FSS earth stations would be allowed, could still be accomplished in several ways:
1. Additional predefined zone to be added in the database in the case where location/region is not yet covered by any MFCN BS.

2. Case by case FSS site installation beyond such predefined zones: There is a need to demonstrate that there is no interference to a current or future deployment of any BS of MFCN operators around the vicinity of the FSS earth station.
3. In the case of a region where MFCN BS(s) are already in operation, there is no more possibility to add such pre-defined zones, however an individual site-specific coordination may still prove it is feasible to deploy a new FSS ES.
4. Limited number of earth stations to be accommodated under certain conditions and market demand.

To initiate/address the above cases, a site investigation could be done prior to installing new earth stations (visual, monitoring) and adding additional pre-defined zones in the data base.

A3.2 CASE 2 – RECEIVING FSS EARTH STATIONS IN THE BAND 40.5-42.5 GHZ.

Similar to case 1 for transmitting FSS earth stations, the methodology described in ANNEX 1 can be used to determine the coordination zone for which, provided there are no MFCN BS operating within the zone, there would be no coexistence issues.

Assuming a configuration in a country whereby a number of FSS earth stations, all of which are individually coordinated and hence at physical locations known to the administration, are successfully co-existing with an existing deployment of MFCN BS.

As for Case 1, the following paragraphs generally apply:

These MFCN BS, whose location may not be known by the administration, are either outside the coordination zones of all of the existing FSS earth stations, or if inside the coordination zones, are subject to particular circumstances, for example additional site shielding, pointing direction, clutter etc., such that co-existence is in any case still assured

Of course, this starting configuration can also include the situation where either or both MFCN and FSS earth stations have not yet begun deployment in the band in the national territory or a given region within it.

The objective for Case 2 is thus to propose a means/methodology by which additional MFCN BS and/or additional FSS earth stations may be deployed in the band.

Given that the location of the MFCN BS is not specifically determined, in order to be able to protect FSS earth stations against additional MFCN BS deployment, the administration should establish a database/make available the location of the coordinated FSS earth stations in the territory.

For future FSS ESs the only deterministic way in which this might be achieved is for the administration to pre-define zones in which FSS earth stations would be allowed (for example: further public consultation to assess FSS market demand), from which a combined coordination contour around this predefined zone could be generated. This dataset could also include the coordination contours of these FSS earth stations, which could be generated as per the methods provided in ANNEX 1.

In the event of additional FSS earth station(s) being deployed, as per the cases described below, this database would need to be updated accordingly.

A3.2.1 Case 2a. Placing additional MFCN BS in the band 40.5-42.5 GHz

To deploy an MFCN BS at an additional site, the MFCN operator would have to consult the database or use other means of determining the location of the FSS earth station, where the combined coordination contours around the earth stations would constitute no-deployment zones/coordination contours for new MFCN BS. These contours would be calculated using the methods described in ANNEX 1, similarly as described for the Case 1 above.

A3.2.2 Case 2b. Placing additional receiving FSS earth stations in the band 40.5-42.5 GHz

When the locations of the MFCN BSs are not known, it is not generally possible for a new FSS earth station to be deployed while assuring co-existence with MFCN, as no separation distance can be determined if the location of the MFCN BS is not known.

Alternatively, for such a scenario, the MFCN operators could be requested to provide details in the area(s) of interest for a new FSS ES deployment to determine if the location is feasible and if any mitigation would allow for an interference free deployment. After deployment the coordination contours for the new station should be included in the data set.

Deployment of additional FSS earth stations outside the pre-defined zones in which FSS earth stations would be allowed, could still be accomplished in several ways:

1. Additional predefined zones could be added in the case of a location/region that is not yet covered by any MFCN BS or in consultation with the MFCN operators.

2. Case by case FSS site installation beyond predefined zones: There is a need for the FSS operator to assess the risk of interference from MFCN BS. This could be aided by a request to the MFCN operators to provide the location of any BSs in the vicinity of a new proposed FSS ES deployment. A mechanism to further add new FSS earth station locations to the FSS database should also be studied/developed.

3. Limited number of earth stations to be protected under certain conditions and market demand.

ANNEX 4: LIST OF REFERENCES

[1] ITU Radio Regulations, Edition of 2020

[2] ECC Decision (22)06: "Harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the band 40.5-43.5 GHz", approved November 2022

[3] ECC Decision (02)04: "The use of the band 40.5 – 42.5 GHz by terrestrial (fixed service/ broadcasting service) systems and uncoordinated Earth stations in the fixed satellite service and broadcasting-satellite service (space to Earth)", approved March 2002

[4] ECC Recommendation (22)02: "Guidelines on measures to facilitate compatibility between MFCN operating in 40.5-43.5 GHz and FSS earth stations receiving in 39.5-40.5 GHz and to prevent and/or resolve interference issues", approved November 2022

[5] ERC Decision (00)02: "Use of the band 37.5-39.5 GHz by the fixed service and by earth stations of the fixed-satellite service (space-to-Earth) and use of the band 39.5-40.5 GHz by earth stations of the fixed-satellite service and the mobile-satellite service (space-to-Earth)", approved March 2000, amended March 2022

[6] Recommendation ITU-R P.452-16: "Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz", (07/2015)

[7] Recommendation ITU-R P.2001: "A general purpose wide-range terrestrial propagation model in the frequency range 30 MHz to 50 GHz"

[8] Report ITU-R S.2150: "An interference reduction technique by adaptive-array earth station antennas for sharing between the fixed-satellite service and fixed/mobile services", (09/2009)

[9] Recommendation ITU-R S.465: "Reference radiation pattern of earth station antennas in the fixed-satellite service for use in coordination and interference assessment in the frequency range from 2 to 31 GHz"

[10] Recommendation ITU-R P.2108-0: "Prediction of Clutter Loss"

[11] Recommendation ITU-R M. 2101-0: "Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies"

[12] ITU-R Document 5-1/411-E, "Working Party 4A Reply Liaison Statement to Task Group 5/1", 23 July 2018

[13] Recommendation ITU-R S.1855: "Alternative reference radiation pattern for earth station antennas used with satellites in the geostationary-satellite orbit for use in coordination and/or interference assessment in the frequency range from 2 to 31 GHz"