CEPT ECC
Electronic Communications Committee

ECC Report 375

Study and assessment of coexistence and compatibility between MFCN in the frequency band 6425-7125 MHz and incumbent spectrum users

approved 6 March 2026

0 EXECUTIVE SUMMARY

The European Commission has tasked CEPT "to study feasibility of and develop least restrictive harmonised technical conditions for the potential shared use of the 6425-7125 MHz (‘upper 6 GHz’) frequency band for the provision of wireless broadband (WBB) electronic communications services (ECS) and by wireless access systems including radio local area networks (WAS/RLANs)".

This Report supports the CEPT response to this Mandate from the European Commission (Task 1: “Study and assessment of coexistence and compatibility of (i) terrestrial systems capable of providing WBB ECS with incumbent spectrum users and (ii) WAS/RLANs with incumbent spectrum users”). It presents a series of studies assessing the compatibility and coexistence between Mobile/Fixed Communication Networks (MFCNs) and existing uses of the upper 6 GHz band and their potential evolution. The studies in this Report cover the following identified services and applications in the band: the fixed-satellite service (FSS) downlink, fixed service (FS), radio astronomy service (RAS), and Ultra-Wideband (UWB). Earth exploration-satellite service (EESS - passive) and FSS uplink are not addressed in this Report. FSS Uplink is covered by Resolution 220 (WRC-23), in particular with regard to the MFCN base station expected *e.i.r.p.* mask set out in Resolves 2 of the Resolution.

The Report also considers relevant existing uses in adjacent bands (such as FSS, FS, and WAS/RLANs below 6425 MHz) and their potential evolution over time. Only studies on adjacent WAS/RLANs were undertaken in this Report.

Studies were conducted in accordance with MFCN deployment parameters and scenarios as defined in section 3. This includes full power and reduced power base stations, operating with a maximum channel bandwidth of 100 MHz. In addition to that, when considering the UE contribution to the interference, only UE power class 3 with a maximum 23 dBm *e.i.r.p.* was considered.

Section 7 provides detailed conclusions from the results of the studies (which are based on Minimum Coupling Loss (MCL) and Monte Carlo analyses). These can be summarised as follows:

- MFCN and FS sharing studies. Depending on the assumptions and methodologies used, the results of the studies indicated geographic separation distances for the protection of the FS ranging from 42 km to 321 km in the main beam of the FS receivers, and from 2 km to 56 km outside of the main beam of the FS receivers. One study also considered the associated impacted areas;
- MFCN and RAS sharing and compatibility studies. Depending on the assumptions and methodologies used, the results of the studies indicated geographic separation distances for the protection of the RAS ranging from 60 km to 380 km;
- MFCN and WAS/RLAN adjacent channel coexistence studies. Depending on the assumptions and methodologies used, with or without frequency separation, the study results indicated a range of different probabilities of interference from MFCN into WAS/RLAN in the adjacent band;
- MFCN and non-GSO FSS downlink sharing studies. Depending on the assumptions and methodologies used, results of the studies indicated geographic separation distances for the protection of the non-GSO FSS Downlink ranging from 12 km to 30 km;
- MFCN and UWB (channel 5) sharing studies. The results of a study indicate that, using an interference threshold of −78 dBm/500 MHz, 75% of simulated events exceeded the threshold. An analysis of some technical documentations and measurements suggest that this threshold may be relaxed depending on the UWB use case.

Some of the studies also considered site-specific mitigation techniques to improve coexistence with FS receivers and RAS receivers, including but not limited to:

- Limiting the MFCN BS beam steering to reduce the interference towards the relevant receiver, including limiting the beam directions so that they point at 3 degrees or more below the horizon;
- Adjusting the MFCN antennas' mechanical downtilt and azimuth to avoid coupling with the FS main lobe;
- Downlink subcarrier blanking in the MFCN signals to avoid the use of specific parts of the band during downlink transmissions;
- Operating MFCN base stations at a lower *e.i.r.p.* level;
- Applying frequency separation;
- Ensuring that clutter is present between MFCN BS and receiving stations.

Studies indicate when applying one or more mitigation techniques may lead to reduced geographic separation distances (see section 6).

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
5G	5th generation of mobile networks
5G NR	5G New Radio
6G	6th generation of mobile networks
AAS	Active Antenna System
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
AGL	Above Ground Level
AMSL	Above Mean Sea Level
AP	Access Point
ATPC	Automatic Transmit Power Control
BEL	Building Entry Loss
BS	Base Station
CCDF	Complementary Cumulative Distribution Function
CDF	Cumulative Distribution Function
CEPT	European Conference of Postal and Telecommunications Administrations
CRAF	Committee on Radio Astronomy Frequencies
CW	Continuous Wave
DFT-S-OFDM	Discrete Fourier Transform-Spread-Orthogonal Frequency Division Multiplexing
DL	Down Link
ECA	European Common Allocation
EC	European Commission
ECC	Electronic Communications Committee
ECS	Electronic Communications Services
ECO	European Communications Office
ECP	European Common Proposal
EDT	Energy Detect Threshold
EESS	Earth exploration-satellite service
EFIS	ECO Frequency Information System
e.i.r.p.	Effective Isotropic Radiated Power
EPO	Error Performance Objective
ES	Earth Station

Abbreviation	Explanation
ESV	Earth Stations on-board Vessels
ETSI	European Telecommunications Standards Institute
FABDEM	Forest And Buildings removed Copernicus Digital Elevation Model
FDD	Frequency Division Duplex
FDP	Fractional Degradation in Performance
FS	Fixed service
FSS	Fixed-satellite service
GSO	Geostationary orbit
IEEE	Institute for Electrical and Electronics Engineers
IGN	The National Institute of Geographic and Forest Information
IMT	International Mobile Telecommunications
I/N	Interference to Noise ratio
ISD	Inter Site Distance
ISR	Intelligence, Surveillance and Reconnaissance
ITS	Intelligent Transport Systems
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union for Radiocommunications
LOS	Line-of-Sight
LPI	Low Power Indoor
LPR	Level Probing Radar
MERLIN	Multi-Element Radio-Linked Interferometer Network
MCL	Minimum Coupling Loss
MFCN	Mobile/Fixed Communications Network
N/A	Not Applicable
NFD	Net Filter Discrimination
NFM	Net Fade Margin
NLOS	Non-Line of Sight
OBUE	Operating Band Unwanted Emissions
OFDM	Orthogonal Frequency Division Multiplexing
PCMAX	Maximum user terminal output power
PD	Power Density
PL	Path Loss
P-MP	Point-to-Multipoint
PMSE	Programme Making and Special Event
P-P	Point-to-Point

Abbreviation	Explanation
PUSCH	Physical Uplink Shared Channel
Ra	Ratio of hotspot areas to areas of cities/built areas/districts
RAS	Radio astronomy service
Rb	Ratio of built areas to total area of region
RB	Resource Block
RLAN	Radio Local Area Networks
RR	Radio Regulations
Rx	Receiver
QAM	Quadrature Amplitude Modulation
SCS	Subcarrier Spacing
SEM	Spectrum Emission Mask
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SINR	Signal to Interference plus Noise Ratio
SRS	Space research service
SST	Sea Surface Temperatures
TDD	Time Division Duplex
TLRP	Tank Level Probing Radar
TRP	Total Radiated Power
TT&C	Tracking, Telemetry and Control
TX	Transmitter
UE	User Equipment
UL	Uplink
Umea	Urban Macro
UWB	Ultra Wideband
VLBI	Very Long Baseline Interferometry
VLP	Very Low Power
VSAT	Very Small Aperture Terminal
WAS/RLAN	Wireless Access Systems including Radio Local Area Networks
WP	Working Party
WRC	World Radiocommunications Conference
WP 5D	ITU-R Working Party 5D

1 INTRODUCTION

CEPT was tasked by the European Commission "to study feasibility of and develop harmonised technical conditions for the efficient use on a shared basis of the 6425-7125 MHz (‘upper 6 GHz’) frequency band for the most recent and future technologies for terrestrial systems capable of providing wireless broadband (WBB) electronic communications services (ECS) and for wireless access systems including radio local area networks (WAS/RLANs)". This Report supports the CEPT response to Task 1 of this Mandate from the European Commission.

This Report studies and assesses scenarios for compatibility and coexistence between mobile/fixed communication networks (MFCNs) and identified relevant existing services in the 6425-7125 MHz frequency band i.e. the fixed satellite service (FSS) downlink, fixed service (FS), and radio astronomy service (RAS), as well as the Ultra-Wideband (UWB) application which operates on a non-interference non-protected basis. Earth exploration-satellite service (EESS - passive) and FSS uplink are not addressed in this Report.

This Report also assesses scenario related to WAS/RLANs operating below 6425 MHz.

2 SERVICES AND APPLICATIONS IN THE FREQUENCY BAND 6425-7125 MHZ AND ADJACENT BANDS

2.1 PRIMARY SERVICES IN THE FREQUENCY BAND 6425-7125 MHZ

The European Common Allocation (ECA) Table in the ECO Frequency Information System (EFIS) holds the allocation of services and applications for the frequency range 5925-7250 MHz (see Annex 1).

2.1.1 Fixed service

Fixed service (FS) is a primary user of the 6425-7125 MHz frequency band in Europe.

The band is used in CEPT countries for long-haul, high-capacity fixed links supporting a variety of applications such as mobile networks backhaul supporting the development of mobile broadband, utilities networks, broadcasting backhaul, specific communication networks (for private and industrial purposes), and governmental uses. Few alternative bands well-suited to FS offer similar propagation characteristics.

The situation in CEPT countries differs significantly both in their current use and regarding the possible future developments of the fixed service in this band. Some countries consider the FS links will remain important in the future for applications such as long-distance fixed links including for mobile backhaul and Public Protection and Disaster Relief (PPDR) networks and feeder links for FM Radio stations and digital terrestrial television stations. Other countries have reported a continued decline in the number of these FS links, driven by the transition from radio links to alternative technologies such as fibre, or by the migration of FS links to other frequency bands.

According to the latest revision of ECC Report 173 [1] on "Fixed Service in Europe Current use and future trends post 2022", published in June 2023, 20 European countries operate a total of 12554 links within the 6425-7125 MHz frequency range (not evenly distributed in Europe). The 5.9-7.1 GHz frequency range has been traditionally used in Europe for Point-to-Point (P-P) links for a long time although Point-to-Multipoint (P-MP) use is also allowed and after a downward trend in numbers towards the end of the 20th century, mainly due to the migration from analogue to digital links, numbers stabilised until 2010 following which there was a significant increase in the overall numbers up to the present day. In some CEPT countries, it is not expected that fixed service usage in this band will decline in the near future.

In response to Resolution 220 (WRC-23) ITU-R developed Report ITU-R M.2560 [52] "Guidance for national and bilateral coordination of stations in the fixed service with IMT stations in the frequency band 6 425-7 125 MHz". This Report provides methodologies and some example calculations of coordination areas around FS stations and IMT BS, in order to address potential interference into FS and IMT BS receivers, respectively.

2.1.2 Fixed satellite service (Earth-to-space)

Fixed satellite service (FSS) (Earth-to-space) operates as primary service in the 6425-7075 MHz frequency band. A selection of satellites has been taken as representative of those requiring protection in the visible portion of the geostationary orbit from Europe. In these frequency bands, the satellite beams cover very large areas of the Earth (using global, hemispherical, zonal or regional beams).

The frequency band 6425-7075 MHz is widely used by FSS networks globally, so its protection should align with international regulatory frameworks. Most satellites and earth stations operating in the satellite “C-band” over Europe use the core FSS uplink band 5925-6425 MHz paired with the downlink band 3700-4200 MHz.

2.1.3 Fixed satellite service (space-to-Earth)

The frequency band 6700-7075 MHz is allocated to FSS (space-to-Earth) globally for feeder links geostationary satellite systems of the mobile satellite service (MSS). The use of this band by feeder links for non-geostationary satellite systems in the mobile satellite service is not subject to provision RR No. 22.2 as per footnote 5.458B in ITU-R Radio Regulations.

There are currently a limited number of earth stations (space-to-Earth) in the frequency bands 6725-7025 MHz and 7025-7075 MHz, operating with low earth orbit (LEO) and medium earth orbit (MEO) satellites.

Due to the foreseen satellite usage, the total number of receiving earth stations using the 6700-7075 MHz feeder link allocation is expected to increase but will remain limited in Europe.

In response to Resolution 220 (WRC-23), at the time of writing this Report, an ITU-R Recommendation is being developed in WP 5D, on coordination between fixed satellite service (FSS) non-GSO (space-to-Earth) earth stations operating in the frequency band 6700-7075 MHz and IMT BS operating in the frequency band 6425 - 7125 MHz.

2.2 OTHER SERVICES AND APPLICATIONS IN THE FREQUENCY BAND 6425-7125 MHZ

2.2.1 Earth exploration-satellite service (passive)

Regarding sea surface temperatures (SST) measurements, the introduction of the European Common Proposal (ECP) on WRC-23 AI 1.2 for the band 6425-7125 MHz [2] stated that:

“Some studies submitted to ITU-R Working Party 7C indicate that the introduction of high-density deployments of applications in the mobile service in the frequency range 6425-7125 MHz, depending upon the application, could interfere with SST measurements in locations up to several thousand kilometres [1] from the coast.

These studies indicate that, SST measurements by satellite in the frequency range 6425-7125 MHz could be significantly degraded in the next years due to the amount of interference from the foreseen increased usage under the existing mobile allocation.

The SST is a vital component of climate system as it exerts a major influence on the exchange of energy momentum and gases between ocean and atmosphere. SST largely controls the atmospheric response of the ocean to meteorological and climatic time scales. Continuous measurements are crucial to ensure the protection of populations from major climatic events. These measurements could be achieved in different frequency bands presenting similar response to SST and good situation in regards of potential interference.

Therefore, in order to achieve this continuous SST measurement in a long-term basis, due to the ongoing studies and consequently to the IMT identification of the frequency band 6425-7125 MHz, new primary EESS (passive) allocations are proposed in the 4.2-4.4 GHz and 8.4-8.5 GHz frequency bands, complementarily to the frequency ranges 6425-7075 MHz and 7075-7250 MHz.”

Agenda item 1.19 (WRC-27) was adopted by WRC-23 to consider possible primary allocations in all Regions to the Earth exploration-satellite service (passive) in the frequency bands 4200-4400 MHz and 8400-8500 MHz, in accordance with Resolution 674 (WRC-23).

At the time of writing this Report, studies are ongoing in ITU-R Working Party 7C on the compatibility between EESS (passive) and other radio services in the frequency band 6425-7250 MHz.

2.2.2 Radio astronomy service

The radio astronomy service (RAS) uses parts of the upper 6 GHz spectrum for observations of the methanol spectral line in the band 6650.0-6675.2 MHz, which is addressed in the ITU-R Radio Regulations footnote 5.149. This footnote urges Member States to take all practical steps to protect the RAS from harmful interference in the frequency band 6650-6675.2 MHz. All over the world, there is a large number of radio telescopes, which are equipped with state-of-the-art receivers to perform measurements of this spectral line and a fair share of the total observing time is invested, both with single dishes but also with telescope networks.

[1] Note: These distances apply in the case of IMT with parameters used in WRC-23 study cycle

The 6.6685192 GHz methanol (CH3OH) maser[2] line is essential to study the formation of massive stars, to perform high-precision astrometry of star forming clouds in the Milky Way, or for probing proto-stellar disks, among many other topics.

2.2.3 Video PMSE

The ERC Recommendation 25-10 [3] includes the shared use of frequency bands for programme making and special events (PMSE) applications. As per the recommendation the band 7-8.5 GHz is used in CEPT by cordless cameras, portable video links, mobile video links and temporary point-to-point video links.

No studies on this application were carried out during the development of this Report.

2.2.4 UWB

The frequency range 6425-7125 MHz is part of the UWB frequency band 6-8.5 GHz to be used on non-interference and non-protection basis. This use is harmonised in Europe through ECC Decision (06)04 [4], ECC Decision (07)01 [5] and Commission Implementing Decision (EU) 2024/1467 [6].

The major use cases standardised in FiRa[3], CCC[4] and omlox[5] operate on UWB channels 5 (6.2-6.8 GHz) and 9 (7.7-8.3 GHz). Channel 5 partly overlaps with the range under study , while more and more applications are moving to channel 9 around 8 GHz. UWB provides secured and high accuracy peer-to-peer ranging applications between various devices (consumer and industrial), for location tracking, material analysis, motion detection and object classification. UWB channel 6 (6.7-7.3 GHz) also overlaps with the studied range but is currently not widely used.

These above usages are “underlay” as UWB (ultra-wide band) technologies involving the intentional generation and transmission of radio-frequency energy that spreads over a very large frequency range, which may overlap with several frequency bands allocated to radiocommunication services (see CEPT Report 69 [7]).

2.3 SERVICES AND APPLICATIONS ADJACENT TO THE FREQUENCY BAND 6425-7125 MHZ

2.3.1 WAS/RLAN below 6425 MHz

WAS/RLAN operate in the frequency band 5945-6425 MHz ('lower 6 GHz') under ECC Decision (20)01 [8] and Commission Implementing Decision (EU) 2021/1067 [42] with the associated harmonised standard ETSI EN 303 687 v.1.1.1 [28]. When introducing MFCN within the 6425-7125 MHz frequency band, technical and operational conditions should not be adopted which would unduly restrict the continued use of WAS/RLAN in the 5945-6425 MHz frequency band in accordance with Commission implementing Decision (EU) 2021/1067.

2.3.2 Fixed service

The frequency bands 5925-6425 MHz and 7125-8400 MHz are used for fixed service (FS) by civil and governmental operations. Few alternative bands well-suited to FS offer similar propagation characteristics.

Non-governmental use primarily involves fixed point-to-point links, connecting different points in a network such as data centres or remote locations. These links are commonly used for various applications such as

[2] Microwave Amplification by Stimulated Emission of Radiation: The maser is based on the principle of stimulated emission. When atoms or molecules have been induced into an excited energy state, they can amplify radiation at a frequency particular to the atoms or molecule used as the masing medium (similar to what occurs in the lasing medium in a laser). In radio astronomy, cosmic masers are widely observed in OH, H2O, SiO, CH3OH and others.

[3] https://www.firaconsortium.org/about

[4] https://carconnectivity.org/about

[5] https://omlox.com

Internet access, for signal feeds for broadcasting transmitter sites and broadcaster IT networks, public safety and emergency services, and transportation systems.

Governmental usage includes fixed links that support governmental communications and surveillance systems. Governmental entities use these links for command and control, situational awareness, intelligence, surveillance and reconnaissance (ISR), and other applications.

ECC Recommendation (14)06 [49] and ERC Recommendation 14-01 [50] specify the channel arrangement for the 5925-6425 MHz band. ECC Recommendation (02)06 [9] specifies the channel arrangements for digital FS systems operating in the frequency range 7125-8500 MHz. Moreover, Recommendation ITU-R F.385, annex 3 [10] provides a channel plan for the 7110-7750 MHz frequency band.

Fixed point-to-point links in adjacent frequency bands 5925-6425 MHz and 7125-8500 MHz are not studied in this Report.

2.3.3 Earth exploration-satellite service

The frequency band 7125-7250 MHz is used, as part of the frequency range 6425-7250 MHz, for passive microwave sensor measurements carried out over the oceans, national territories, including the coastal areas (for further information see section 2.2.1).

The frequency band 7190-7250 MHz is used for tracking, telemetry and control (TT&C) applications of EESS only. It should be noted that footnote 5.460A applies in the frequency range 7190-7250 MHz.

2.3.4 Space research service

2.3.4.1 SRS (Earth-to-space) (deep space) in 7145-7190 MHz

The frequency band 7145-7190 MHz is used for tracking and communications with spacecraft in the space research service (deep space) (Earth-to-space).

No studies on this application were carried out during the development of this Report. In response to Resolution 220 (WRC-23) ITU-R developed Report ITU-R M.2561 "Coordination between space research service (deep space) stations operating in the band 7 145-7 190 MHz and IMT stations operating in the band 6 425-7 125 MHz". This Report provides a generic methodology and some example implementations for the calculations of coordination areas around transmitting SRS earth stations in order to address potential interference into IMT BS receivers.

2.3.4.2 SRS (Earth-to-space) (near Earth) in 7190-7235 MHz

The frequency band 7190-7235 MHz is used for tracking and communications with spacecraft in the space research service (near-Earth) (Earth-to-space). Near-Earth research satellites may operate on various orbits, including e.g. Lagrangian Points (L1, L2), lunar, highly elliptical, geosynchronous and low-Earth orbits. The space research service (SRS) may operate both unmanned and manned near-Earth research-satellites; manned research satellites especially operate on low-Earth, highly elliptical orbits towards the Moon as well as lunar orbits. It should be noted that footnote 5.460 applies in the frequency range 7190-7235 MHz.

No Studies on this application were carried out during the development of this Report.

2.3.5 Video PMSE

See section 2.2.3.

2.3.6 UWB

See section 2.2.4.

3 PARAMETERS FOR MFCN IN THE FREQUENCY BAND 6425-7125 MHZ

3.1 MFCN SYSTEM PARAMETERS

System parameters in Table 1 are taken from Working Party 5D Chairman's Report Document 5D/716, annex 4.4 [11], section 3.1.

Table 1: MFCN (5G NR) base station and user equipment characteristics in 6425-7125 MHz

No.	Parameter	Base station (AAS)	User equipment
1	Duplex Method	TDD	TDD
2	Channel bandwidth (MHz)	100 MHz (typical) (Note 1)	100 MHz (typical) (Note 1)
3	Signal bandwidth (MHz)	To be specified. Will be derived from channel bandwidth (see ETSI TS 138 104, section 5.3.2 [12])	To be specified. Will be derived from channel bandwidth (see ETSI TS 138 101-1, section 5.3.2 [13]).
Note 1: Bandwidth of 200 MHz can also be used in studies. The technical report 3GPP TR 38.922 (Annex A) provides technical clarifications on why the same parameters used for MFCN with a bandwidth of 100 MHz can also be applied to a bandwidth of 200 MHz. It is noted that this report focuses on the 7/8 GHz frequency band, however, its content can be extended to the U6 GHz band. Additionally, 3GPP is establishing the work for the support of a bandwidth of 200 MHz [RP-243292]. See also https://www.3gpp.org/Ftp/tsg_ran/TSG_RAN/TSGR_107/Docs/RP-250810.zip, the impact of MFCN systems with such a BW was not studied in this Report			

3.1.1 Studied MFCN BS unwanted emission levels

Two approaches for the modelling of MFCN BS unwanted emission levels were considered. These are defined in terms of total radiated power (TRP). Spurious emissions level of −30 dBm/MHz applies according to ERC Recommendation 74-01 [14]. Addition of 9 dB to the spurious emission levels as stipulated in ETSI TS 138 104, section 9.7.5.2.2 was not applied based on ERC Recommendation 74-01 [14].

The first approach is the application of MFCN BS ACLR absolute basic limit given in ETSI TS 138 104, table 6.6.3.2.2, with a 9 dB addition[6] for the AAS configurations studied. This results in −6 dBm/MHz and is modelled as a TRP of +7 dBm/20 MHz (see also ANNEX 2 for more details).

The second approach is the application of MFCN BS operating band unwanted emission limits for band n104 for Category B BS given in ETSI TS 138 104, table 6.6.4.2.2.1-2b and is modelled as the unwanted emissions levels presented in Table 2.

Table 2: Modelled MFCN BS unwanted emission levels (the second approach)

Frequency offset range from the edge of the MFCN channel (Δf, in MHz)	Level (dBm/MHz)
0-50	$3 - \frac{7}{50}\Delta f$
50-100	−4

[6] As described in relevant sections of ETSI TS 138 104 [12].

3.1.2 Studied MFCN UE unwanted emissions

Two approaches for the modelling of MFCN UE unwanted emission levels have been considered. Outside of the ranges of these two emission masks, the spurious emissions level of −30 dBm/MHz applies according to ERC Recommendation 74-01.

The first approach is the application of MFCN UE ACLR given in ETSI TS 138 101-1, table 6.5.2.4.1-2 [13] which is equal to 30 dB over 100 MHz for a power class 3 UE (see also ANNEX 2 for additional details).

The second approach uses equipment spectral mask limits as defined in ETSI TS 138 101-1, table 6.5.2.2-1 [13]. The resulting spectrum emission mask values are shown in the Table 3.

Table 3: Modelled MFCN UE unwanted emission level (the second approach)

Frequency offset range from the edge of the MFCN channel (Δf, in MHz)	Level (dBm/MHz)
0-1	−8.77
1-5	−10
5-100	−13
100-105	−25

3.2 MFCN DEPLOYMENT PARAMETERS

AAS (see Table 7) is considered for MFCN base stations in the frequency band 6425-7125 MHz, but not for MFCN user equipment.

The MFCN BS boresight *e.i.r.p.* values used in the studies in this Report are:

- 82.6 dBm/100 MHz (full power, equivalent to 182 kW/100 MHz);
- 56.6 dBm/100 MHz (reduced power, equivalent to 457 W/100 MHz, implemented as a 26 dB reduction in conducted power compared to the full power) as a sensitivity analysis.

Contiguous coverage by the MFCN base stations is not expected in rural areas in the 6425-7125 MHz frequency band, and any such base stations that may exist in small numbers will be isolated installations at specific locations.

3.2.1 MFCN deployment density parameters

Parameters are taken from Working Party 5D Chairman's Report Document 5D/716, annex 4.4 [11], section 3.3.

Deployment density for a large area (D_l) in sharing studies is calculated as:

$$D_l = D_s \cdot R_a \cdot R_b \quad (1)$$

where:

- D_s is density value for coverage area, i.e. density of simultaneously transmitting UE or number of BS per km^2;
- R_a (%) is ratio of coverage areas to areas of cities/built areas/districts;
- R_b (%) is ratio of built areas to total area of region in study.

The R_a value depends on frequency band and deployment environment. The R_a value for the 6-8 GHz band would be larger than for millimetre-wave bands because 6-8 GHz is mainly used for capacity enhancement by macro and small cell deployments, whereas millimetre-wave is mainly used for capacity enhancement by hotspot deployments. However, MFCN base stations in a particular band between 6 and 8 GHz will not be deployed across the entire area of a city, and an R_a value of 100% would greatly over-estimate the number of base stations.

R_b is independent from frequency band and deployment environment. When the size of area under the study is very large assuming very large satellite-footprint or countries the R_b value needs to be decreased to reflect sparse population density of the countries.

For sharing and compatibility studies concerning potential interference into a satellite space station, it is the size of the satellite footprint that is relevant rather than countries. A large satellite footprint will in most cases cover (parts of) a number of countries (unless it is entirely within a very large country), and there may in many cases also be bodies of water within the footprint.

Considering the above, for relevant studies in the 6425-7125 MHz band, the R_a and R_b values in Table 4 are used.

Table 4: Values for R_a and R_b to be used in studies involving MFCN deployments for frequency bands between 6 and 8 GHz

	Options (Note 1)	Macro	Micro
R_a	1	30% urban (area < 200000 km^2) 10% urban (area > 200000 km^2) 10% suburban (area < 200000 km^2) 5% suburban (area > 200000 km^2)	10% urban (area < 200000 km^2) 5% urban (area > 200000 km^2)
	2	45% urban, 20% suburban	10% urban
R_b (depending on the area under study)	1	5% (area < 200000 km^2) 2% (200000-1000000 km^2) 1% (area > 1000000 km^2)	5% (area < 200000 km^2) 2% (200000-1000000 km^2) 1% (area > 1000000 km^2)
	2	5% (area < 3500000 km^2) 3% (area > 3500000 km^2)	5% (area < 3500000 km^2) 3% (area > 3500000 km^2)
	3	2.5% (area < 200000 km^2) (Note 2) 2% (200000-1000000 km^2) 1% (area > 1000000 km^2)	2.5% (area < 200000 km^2) (Note 2) 2% (200 000 - 1000000 km^2) 1% (area > 1000000 km^2)

Note 1: The R_a and R_b values used in the sharing and compatibility studies should be provided together with the results of studies, for the purpose of comparison, as well as information on which specific geographical location the analysis is applicable to.
Note 2: The value is applicable for Region 1, for bands considered globally the value of 5% should be used.

3.2.2 Deployment-related parameters for bands between 6 and 8 GHz

Deployment-related parameters are based on Working Party 5D Chairman's Report Document 5D/716, annex 4.4 [11], section 3.2.1.4, and provided in Table 5 and Table 6 with the inclusion of parameter "MFCN cell size" and Notes 4 to 9 in Table 5 and Note 4 in Table 6.

Table 5: Deployment-related parameters for bands between 6 and 8 GHz

	Urban / suburban macro	Small cell (outdoor) / micro cell	Indoor (small cell)
Deployment density (Note 1)	10 BSs/km^2 urban	1-3 per urban	Depending on indoor

	Urban / suburban macro	Small cell (outdoor) / micro cell	Indoor (small cell)
	2.4 BSs/km^2 suburban (Notes 2 and 3)	macro cell <1 per suburban macro site	coverage / capacity demand
MFCN cell size (Note 5)	For full power: Typical (Note 6): 0.4 km urban / 0.8 km suburban Numerical range (Note 7): 0.2-0.8 km urban / 0.4-2.5 km suburban For reduced power: Typical (Note 8): 0.3 km urban / 0.6 km suburban range (Note 9): 0.15-0.6 km urban / 0.3-2 km suburban.	Typical value N/A	Typical value N/A
Antenna height	18 m urban 20 m suburban	6 m	3 m
Sectorisation	3 sectors	Single sector	Single sector
Frequency reuse	1	1	1
Indoor base station deployment	N/A	N/A	100%
Indoor base station penetration loss	N/A	N/A	Recommendation ITU-R P.2109 [15]
Below rooftop base station antenna deployment (Note 4)	Urban: 65% Suburban: 15%	100%	N/A
Typical channel bandwidth	100 MHz	100 MHz	100 MHz
Network loading factor (base station load probability X%) (see Working Party 5D Chairman's Report Document 5D/716, annex 4.4, section 3.1.3.2 [11] and Recommendation ITU-R M.2101 annex 1, section 3.4.1 and 6 [16])	20%, 50%	20%, 50%	20%, 50%
TDD / FDD	TDD	TDD	TDD
BS TDD activity factor	75%	75%	75%

Note 1: These density values are for small dense areas. See section 3.3 in Working Party 5D Chairman's Report Document 5D/716 Annex 4.4 [11] for densities in larger areas.
Note 2: "1 BS" = 1 sector in 3-sector cell.
Note 3: This value is calculated based on use of same grid as 3-6 GHz. It is expected that the same BS infrastructure (except for the rural case) will typically be used for networks in both 3-6 GHz and 6-8 GHz. Assuming hexagonal deployment, the deployment density (ρ) defines the inter-site distance (ISD) by the following formula: ISD= sqrt(2*sqrt(3)/ρ), and the hexagon-cell radius (long diagonal) by the formula: ISD*2/3. Note that cell size (intended coverage range) may be lower than hexagon cell radius (see Note 5)
Note 4: "below rooftop" parameter is provided for MFCN BS deployments to describe the environment surrounding the BS. The above/below rooftop ratio in this table should not be interpreted as indicating whether or not additional clutter loss should be applied. Depending on the sharing scenarios and associated guidance from SG3, relevant propagation models related to clutter loss should be used accordingly.

	Urban / suburban macro	Small cell (outdoor) / micro cell	Indoor (small cell)
Note 5: Use Recommendation ITU-R M.2101-0, section 3.4.1 [16] List item 1c to link BS with UEs; alternatively, for sharing studies requiring a specific macro cell size (i.e. intended coverage range, which could be lower than the hexagon cell radius as defined in Note 3), studies could use the values in the table. Note 6: Based on Document 5D/413, annex 4.2, table 6-1 [44] (7.125-8.4 GHz) which provides a typical value to be used associated with *e.i.r.p.* of 78.3 dBm/100 MHz. Note 7: Based on Document 5D/716, annex 4.4, table 5-1 (1-3 GHz) which provides the range to be used in combination with the typical values 0.4 km urban / 0.8 km suburban. Note 8: Based on Document 5D/716, annex 4.4, table 7-1 (6-8 GHz) which provides a typical value to be used associated with *e.i.r.p.* of around 73 dBm/100 MHz. Note 9: Based on Report ITU-R M.2292-0, table 4 [45] (3-6 GHz) which provides the range associated with the typical values 0.3 km urban / 0.6 km suburban.			

Additional Note for Table 5:

If the rural deployment environment is modelled in a sharing study, it should assume the BS density (per sector) of 0.001-0.006 BS per km^2 as well as the below rooftop base station antenna deployment of 0%. Other parameters for the rural deployment should be the same as the suburban parameters found in the column for urban/suburban macro for base station in Table 5, for UE in Table 6 and for AAS in Table 7 (macro suburban) (see Working Party 5D Chairman's Report Document 5D/716, annex 4.4 [11]).

Considerations should be given that the above BS density (per sector) values should be applied for the rural areas of the entire coverage area of the interfered system that is under study (e.g. the entire satellite footprint), taking into account the size of this entire coverage area, and the chosen value should be given together with the results of studies. These BS density (per sector) values have been derived for an area of around 100000-500000 km^2 and some initial analysis subject to further verification showed it could be applicable up to 2000000 km^2.

It should be noted that the 'R_a, R_b methodology' described in the section above needs to be further developed in order to fully accommodate the rural deployment scenario.

Regarding the MFCN BS antenna location assumptions, an analysis in section 6.26 indicated that for one city up to 99% of 3.5 GHz BS may be above local mean building heights within a sector. Further consideration would be needed to understand the relationship between local building height and application of clutter across a longer path.

The rural deployment environment may or may not be included in the sharing and compatibility studies because contiguous coverage is not expected for the 6-8 GHz range.

Table 6: User equipment parameters for bands between 6 and 8 GHz

	Urban / suburban macro	Small cell (outdoor) / Micro cell
Indoor user terminal usage	70%	70%
User equipment density for terminals that are transmitting simultaneously (Note 1)	Up to 3 UEs per sector	Up to 3 UEs per sector
UE height (Note 2)	1.5 m	1.5 m
Average user terminal output power	Use transmit power control	Use transmit power control
Typical antenna gain for user terminals	−4 dBi	−4 dBi
Body loss	4 dB	4 dB
UE TDD activity factor	25%	25%
Power control model	Refer to Recommendation ITU-R M. 2101, annex 1, section 4.1	

	Urban / suburban macro	Small cell (outdoor) / Micro cell
	[16]	
Maximum user terminal output power, PCMAX (Note 4)	23 dBm	23 dBm
Power (dBm) target value per RB, P0_PUSCH (Note 3)	−92.2	−87.2
Path loss compensation factor, (same as “balancing factor” mentioned in Recommendation ITU-R M.2101 [16])	0.8	0.8

Note 1: UEs share equally the channel bandwidth, i.e. each UE is allocated 1/3 of the channel bandwidth (see Recommendation ITU-R M.2101, section 3.4.1, item 1e-f. [16]). In sharing studies, it is assumed that the AAS BS beamforms towards each UE using the entire array.

Note 2: In principle, indoor UEs are distributed over different floors of the building. Building floor counts vary by environment and country. Moreover, the number of floors of buildings is not related to Macro BS antenna height (parameter given in the Table). In particular in small cities, sub-urban and rural areas, many or most of antennas are installed on masts. For outdoor BSs, sharing studies may simplify by modelling indoor UEs on the ground floor (consistent with WRC-23 study assumptions), or may consider a height distribution according to the distributions specified in ECC Report 364, table 3 [18] - or 3GPP TR 36.873, table 6-1 - Urban Macro cell with high UE density (3D-UMa) case, with the distribution limited to a maximum of the BS height for the case of UEs served by a BS that is defined as above rooftop (see Table 5). Additionally, the base station vertical coverage range (Row 1.11 of Table 7 below) should be taken into account, noting that UEs that are above the coverage range (i.e. UEs above the BS height for a min. coverage angle of 90 degrees) can be considered to be served by the “upper” bound of the electrical beam, i.e. beam steered towards the min. coverage angle. This may mean that some of these UEs cannot be served if the minimum required technical conditions (e.g., SINR, RSRP) are not achieved. The use of height distributions should also take into account clutter assumptions to ensure users are not distributed above the clutter.

Note 3: The target power is defined per Resource Block (RB), considering 180 kHz RB bandwidth corresponding to 15 kHz subcarrier spacing.

Note 4: Higher UE power classes (up to 29 dBm) are specified. The parameters in this Table only apply for the default UE power class 3.

3.2.3 Antenna characteristics for 5G NR AAS base stations

Antenna characteristics for 5G NR AAS base stations are given below in Table 7. Those parameters are interdependent and derived as a consistent set of assumptions, based on deployment scenarios and other requirements.

Parameters are based on Working Party 5D Chairman’s Report Document 5D/716, annex 4.4 [11], section 3.2.1.6, and provided in Table 7 with the following changes: i) for macro urban case the parameters from macro suburban are used; ii) for macro urban/suburban cases extended AAS model is used; iii) parameter "Base station output power/sector *e.i.r.p.*" is added; iv) antenna array configuration of 16 × 16 with corresponding amendments to Note 5 is added; v) Notes 11 to 15 are added.

Table 7: Beamforming antenna characteristics for 5G NR in 6425-10500 MHz

		Macro urban/suburban	Small cell urban outdoor / Micro urban
1	**Base station antenna characteristics**		
1.1	Antenna pattern	Refer to the extended AAS model in Document 5D/716 Annex 4.4, Table A of Annex 3	Refer to Recommendation ITU-R M.2101, annex 1, section 5 [16]
1.2	Element gain (dBi) (Note 1)	6.4	5.5
1.3	Horizontal/vertical 3 dB beamwidth of single element (degree)	90º for H 65º for V	90º for H 90º for V
1.4	Horizontal/vertical front-to-back ratio (dB)	30 for both H/V	30 for both H/V

		Macro urban/suburban	Small cell urban outdoor / Micro urban
1.5	Antenna polarisation	Linear ±45º	Linear ±45º
1.6	Antenna array configuration (Row × Column) (Note 2)	Configuration 1: 16 × 16 sub-arrays Configuration 2: 8 × 16 sub-arrays (Note 15)	8 × 8 elements
1.7	Horizontal/Vertical radiating sub-array or element spacing	0.5 of wavelength for H, Configuration 1: 2.1 of wavelength for V Configuration 2: 2.8 of wavelength for V (Note 15)	0.5 of wavelength for H, 0.5 of wavelength for V
1.7a	Number of element rows in sub-array	Configuration 1: 3 Configuration 2: 4 (Note 15)	N/A
1.7b	Vertical element separation in sub-array ($d_{v,sub}$)	0.7 of wavelength for V	N/A
1.7c	Pre-set sub-array down-tilt (degrees) (Note 13)	3	N/A
1.8	Array Ohmic loss (dB) (Note 1)	2	2
1.9	Conducted power (before Ohmic loss) per sub-array or element (dBm) (Notes 9 and 11)	Configuration 1: 20.3 Configuration 2: 25 (Notes 5 and 15)	16 (Note 6)
1.10	Base station maximum coverage angle in the horizontal plane (degrees)	±60	±60
1.11	Base station vertical coverage range (degrees) (Notes 3, 4, 10 and 12)	90-100	90-120
1.12	Mechanical downtilt (degrees) (Note 4)	6	10
1.13	Base station output power/sector *e.i.r.p.* (dBm) (Note 14)	82.6	60.6

Note 1: The element gain in row 1.2 includes the loss given in row 1.8. This means that this parameter in row 1.8 is not needed for the calculation of the BS composite antenna gain and *e.i.r.p.*
Note 2: 8 × 16 means there are 8 rows and 16 columns of radiating sub-arrays for macro suburban and macro urban cases. 8 × 8 means there are 8 rows and 8 columns of radiating elements for the small cell outdoor/micro urban case.
Note 3: The vertical coverage range is given in global coordinate system, i.e. 90° being at the horizon.
Note 4: The vertical coverage range in row 1.11 includes the mechanical downtilt given in row 1.12.
Note 5: For Configuration 1 (16 × 16), the conducted power per sub-array assumes 16 × 16 sub-arrays and 2 polarisations, and for Configuration 2 (8 × 16), the conducted power per sub-array assumes 8 × 16 sub-arrays and 2 polarisations
Note 6: The conducted power per element assumes 8 × 8 × 2 elements (i.e. power per H/V polarised element).
Note 7: The conducted power per element assumes 4 × 4 × 2 elements (i.e. power per H/V polarised element).
Note 8: The boresight direction is perpendicular to the ceiling.
Note 9: In sharing studies, the transmit power calculated using row 1.9 is applied to the typical bandwidth given in Table 7-1 and 8-1 respectively for the corresponding frequency bands.
Note 10: In sharing studies, the UEs that are below the coverage range can be considered to be served by the “lower” bound of the electrical beam, i.e. beam steered towards the max. coverage angle. A minimum BS-UE distance along the ground of 35 m should be used for urban/suburban and rural macro environments, 5 m for micro/outdoor small cell, and 2 m for indoor small cell/urban scenarios.
Note 11: Sharing studies can consider other levels of conducted power but the associated antenna configuration should be clearly reported. For sensitivity analysis assuming reduced *e.i.r.p.*, the parameters in Small cell outdoor / Micro urban column could be considered.
Note 12: Antennas are expected to conform to mask as detailed in Resolution 220 (WRC-23) of the Radio Regulations, which may result in some beam pointing restrictions. 3GPP completed technical report TS 38.104 V19.0.0 (section 9.9) on BS *e.i.r.p.* mask.to protect FSS UL.
Note 13: The pre-set sub array down-tilt is a fixed design parameter for a base station. It is envisaged as a passive fixed (non-varying) electrical tilt within the sub-array elements.

		Macro urban/suburban	Small cell urban outdoor / Micro urban
Note 14: The base station *e.i.r.p.* per sector is calculated as total power (including power from two orthogonal polarisations). Note 15: Parameters in rows 1.6, 1.7, 1.7a and 1.9 should be selected consistently from Configuration 1 or Configuration 2. Studies can consider either or both configurations.			

Resolution 220 (WRC-23) [17] Resolves *2* states*:* "that, in order to ensure protection for the FSS (Earth-to-space), and taking into account *considering d)*, the level of expected *e.i.r.p.* spectral density emitted by an IMT base station as a function of the vertical angle above the horizon shall not exceed the following values (No. 21.5 does not apply)". These values are presented in the Table 8.

Table 8: Level of expected *e.i.r.p.* spectral density emitted by an IMT base station [17]

Vertical angle range $\theta_L \leq \theta < \theta_H$ (vertical angle θ above horizon)	Expected *e.i.r.p.* (dBm/MHz) (see Notes 1, 2 and 3)
0° ≤ θ < 5°	27
5° ≤ θ < 10°	23
10°≤ θ < 15°	19
15°≤ θ < 20°	18
20°≤ θ <30°	16
30°≤ θ < 60°	15
60°≤ θ ≤ 90°	15
Note 1: The expected *e.i.r.p.* is defined as the average value of the *e.i.r.p.*, with the averaging being performed: – over horizontal angles from −180° to +180°, with the IMT base station beamforming in a specific direction within its horizontal and vertical steering range, – over different beamforming directions within the IMT base station horizontal and vertical steering range, and – over the specified vertical angle range θL ≤ θ < θH. Note 2: An IMT base station shall comply with the specified limits on expected *e.i.r.p.* spectral density for all mechanical tilts with which it can be deployed, taking into account considering m). Note 3: See the Annex to Resolution 220 for additional details on how the expected *e.i.r.p.* can be calculated for this frequency band.	

3.2.4 Network loading factor

Parameters are taken from Working Party 5D Chairman's Report Document 5D/716, annex 4.4 [11], section 3.4.

Network loading factors provided in this Report reflect average MFCN base station activity. In order to provide required and adequate quality of service, MFCN are designed and dimensioned to avoid undue congestion, such that, overall most of the cells are not heavily loaded simultaneously and only a small percentage of cells are heavily loaded at any specific point in time. The average loading will therefore be significantly lower when averaged over a sufficient number of MFCN transmitters.

A network loading value of 20% would normally represent a typical/average value for the loading of base stations across a network (or part thereof) and should be used for sharing and compatibility studies that are considering a relatively wide area (e.g. a large city, province, country or satellite footprint). For studies involving only a small area where there are only a few MFCN transmitters, a maximum network loading value of not more than 50% may be used.

4 PARAMETERS AND ASSUMPTIONS FOR SHARING AND COMPATIBILITY STUDIES WITH INCUMBENT AND ADJACENT BAND SERVICES AND APPLICATIONS

4.1 FIXED SERVICE

The fixed service (FS) systems operating in the frequency band 6425-7125 MHz are deployed in rural and urban (including suburban) areas. The exact deployment scenarios vary between countries.

The FS parameters used in the studies include:

- Antenna pattern;
- Antenna height;
- Antenna gain;
- Link length;
- Transmitter output power;
- Feeder/multiplexer loss;
- Receiver noise figure.

4.1.1 FS system parameters

Table 9 lists the relevant typical FS parameters in this band taken from the ECC Report 364 [18] including the values of 20 m and 60 m which were considered in WRC-23 study cycle.

Table 9:Typical FS parameters in frequency band 6425-7125 MHz

Parameter/model	Values
Antenna height (Note 1)	20, 30, 40, 60, 75 m
Antenna gain	34, 40, 46 dBi
Link length	20, 40, 60 km
Feeder loss	1.3 dB
Fade margin (FM)	13-31 dB (5^{th} percentile)
Net fade margin (NFM)	10-20 dB (5^{th} percentile), 15-32 dB (mode)
Automatic transmit power control (ATPC) Range associated to the NFM	15-20 dB
Channel spacing and receiver noise bandwidth	40 MHz
Antenna pattern	Recommendation ITU-R F.699 [19] for single-entry interference Recommendation ITU-R F.1245 [20] for aggregate interference
Receiver noise figure	4.5 dB or 5 dB
Note 1: Values of 20 m and 60 m antenna height were considered in WRC-23 study cycle.	

4.1.2 FS system protection criteria

The long-term protection criterion with a value of I/N=−10 dB (see Recommendation ITU-R F.758, table 5 [21]) that should not be exceeded for more than 20% of time.

Fractional Degradation in Performance (FDP) (ECC Report 364, annex 10 and annex 11 [18]) as given in Recommendation ITU-R F.1108 [22], annex 3 should not exceed 10%.

4.2 FIXED-SATELLITE SERVICE (SPACE-TO-EARTH)

4.2.1 FSS system (space-to-Earth) parameters

Parameters are based on Working Party 5D Chairman's Report document 5D/1776, annex 4.18, section 2.6.1.2 [23]. Only Carrier 7 was studied and parameters can be found in Table 10.

Table 10: Technical and operational characteristics of Carrier 7

Characteristic	Parameter
Frequency range, GHz	6.875-7.055
Carrier name	7
Noise bandwidth, MHz	1.23
Antenna diameter, m	5.5
Peak receive antenna gain, dBi	50
Antenna receive gain pattern	Recommendation ITU-R S.465-6 [24]
System receive noise temperature, K	130
Minimum earth station elevation angle, degrees	Acquisition – 5 degrees, Communication – 10 degrees
Earth station antenna height, m	5
Additional notes	HIBLEO-X, non-GSO satellite with circular orbit of 1414 km

4.2.2 FSS system (space-to-Earth) protection criteria

Protection criteria as available during WRC-23 study cycle taken from document 5D/734 [25] can be found in Table 11.

Table 11: FSS (space-to-Earth) system protection criteria [26]

Frequency range	Percentage of time for which the I/N value could be exceeded (%)	I/N criteria (dB)
6700-7075 MHz (s-E)	20% 0.005%	−10.5 −1.3

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. Hence studies conducted by WP 5D should only use the values presented above when evaluating the compliance with the protection criteria.

Note 2: The protection criteria specified are related to the required availability of FSS links in these bands, which is associated with time. It is appropriate to understand such percentages as percentages of time, for interference analysis where the degradation is a direct function of time (e.g. time-varying atmospheric degradation or antenna pointing).
However, Monte Carlo sharing studies conducted between satellites and IMT systems under WRC-23 agenda item 1.2 (IMT centimetre bands) may involve other considerations and calculations, based on additional variables which are not varying in the time domain (e.g. geographical locations in the space or deployment domain associated with IMT positions).
For such studies, it may be appropriate to understand percentages as being in other domains, such as time, location and probability, recognising that additional alternative measures might be needed in some cases, and that it is not possible to foresee all future modelling options.

Note 3: It is worth to mention that apportionment of the I/N protection criteria that apply to other co-primary services should be done on a case-by-case basis by WP 5D. Such apportionment decided needs to be clearly specified in the study performed. 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 could be assessed on the basis that these values were put forward by WP 4A to facilitate and complete the work for WRC-23 agenda items and these values may evolve in the future based on inputs to the ITU-R. WP 4A has not completed its work in developing short-term protection criteria, however WP 5D is invited to consider these short-term protection criteria to the extent practicable.

Note 5: Studies for non-GSO FSS systems using these long-term and short-term protection criteria could be assessed on the basis that these values were put forward by WP 4A to facilitate and complete the work for WRC-23 agenda items and these values and associated time percentages may evolve in the future based on inputs to the ITU-R. However, Working Party 4A has not completed its work in developing both long-term and short-term non-GSO protection criteria. WP 5D is invited to consider these non-GSO FSS protection criteria to the extent practicable once available.

Note 6: omitted

Note 7: The short-term interference values provided here are derived from the procedure required for the determination of coordination distance for a receiving earth station, as contained in Appendix 7 of the Radio Regulations. This procedure is used to avoid unaccepted interference between an earth station and a terrestrial station sharing the same frequency band. These short-term values were put forward by WP 4A to facilitate the work for WRC-23 agenda item 1.2 and these values may evolve prior to or after WRC-23, based on inputs to the ITU-R.

4.3 RADIO ASTRONOMY

The list of RAS stations in CEPT (see Table 12) and parameters (see Table 13) are based on ECC Report 364 [18].

Table 12: List of RAS stations in CEPT countries operating in the frequency band 6650-6675 MHz

RAS station	Country	Geographic longitude	Geographic latitude
Metsähovi	Finland	24° 23′ 36″	60° 13′ 05″
Effelsberg	Germany	06° 53′ 01.0″	50° 31′ 29.4″
Wettzell		12° 52′ 38″	49° 08′ 42″
BEST	Hungary	19° 32′ 23″	47° 54′ 22″
Medicina	Italy	11° 38′ 49″	44° 31′ 15″
Noto		14° 59′ 20″	36° 52′ 33″
Sardinia		09° 14′ 42″	39° 29′ 34″
Irbene	Latvia	21° 51′ 18″	57° 33′ 13″
Westerbork	Netherlands	06° 36′ 15″	52° 55′ 01″
Ny-Ålesund	Norway	11° 52′ 11″	78° 55′ 45″

RAS station	Country	Geographic longitude	Geographic latitude
Torun	Poland	18° 33′ 50.6″	53° 05′ 43.7″[7]
Yebes	Spain	–03° 05′ 13″	40° 31′ 28.8″
Onsala	Sweden	11° 55′ 04″	57° 23′ 35″
Jodrell Bank	UK	–02° 18′ 26″	53° 14′ 10″
Pickmere		–02° 26′ 42″	53° 17′ 20″
Darnhall		–02° 32′ 09″	53° 09′ 24″
Knockin		–02° 59′ 49″	52° 47′ 26″
Defford		–02° 08′ 39″	52° 06′ 03″
Cambridge		00° 02′ 14″	52° 10′ 01″
Goonhilly (Note 1)		–05° 11′ 00″	50° 03′ 02″
Chilbolton (Note 1)		–01° 26′ 19″	51° 08′ 42″
Note 1: Planned operations			

Table 13: Radio astronomy technical parameters

System Parameter	Value	Remarks
Integration time	2000 s	
Side lobe gain, G_r	0 dBi	According to Recommendation ITU-R RA.769-2 [26], only side lobe receptions need to be considered
Threshold interference level Spectral power, $P_{lim,v}$ Spectral pfd, $S_{lim,v}$	−176 dB (mW/MHz) −228 dB (W/(m^2 Hz))	For spectroscopic observations: interpolated from Recommendation ITU-R RA.769-2, table 2
VLBI observations (Note 1)	−199 dB(W/(m^2 Hz))	Interpolated from Recommendation ITU-R RA.769-2, table 3
Antenna height, h_{rt}	Height of focal point	The average receiving feed's height above ground of the particular telescope is to be used.
Note 1: This row is in addition to the table used in the ECC Report 364 [18].		

The term "narrowband" refers to "spectral line" observations (see Recommendation ITU-R RA.769-2, table 2 [25]).

Both, in band emissions and emissions from outside the RAS frequency band into the RAS frequency band should remain below the thresholds for detrimental interference given in Recommendation ITU-R RA.769-2, subject to Recommendation ITU-R RA.1513 [27] "Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy service on a primary basis" which provides with 2% data loss to the RAS due to interference by all stations of one service, and with an aggregate data loss of 5% in any frequency band from all services.

[7] Edition of 9 June 2026 – Torun lattitude corrected

4.4 WAS/RLAN BELOW 6425 MHZ

4.4.1 WAS/RLAN parameters

Table 14 lists the relevant typical WAS/RLAN parameters for operation in the frequency band 5945-6425 MHz based on those from the ECC Report 364 [18].

Table 14: WAS/RLAN receiver parameters

Parameter	Unit	Value
Noise figure	dB	9
Channel bandwidth (distribution)	MHz	20 MHz (10%), 40 MHz (5%), 80 MHz (30%), 160 MHz (35%), 320 MHz (20%)
Antenna gain	dBi	For AP and VLP/client absolute receiver antenna gains see statistical distributions in Table 15 - Table 17 For clients, distributions with and without body loss are provided
Height	metre	See statistical distributions in Table 18

ECC Report 364, annex 1 [18] describes in detail how the antenna gain distributions have been derived. Antenna patterns in X-Y and X-Z planes from real antennas have been either digitalized from datasheets or obtained from measurements for the access points. All antennas' data belonging to the same category (consumer, enterprise, …) have been combined and a distribution has been produced per category. Using a weighted average for each category, the final AP distribution has been computed as provided in Table 15. For client distributions, measurements of three 6 GHz equipment without and with body loss have been provided, allowing both distributions to be derived and provided in Table 16 and Table 17 respectively.

WAS/RLAN receiver selectivity is modelled in terms of adjacent channel selectivity (ACS). ACS can be derived for generic WAS/RLAN equipment from specifications of receiver selectivity defined in the harmonised standard ETSI EN 303 687 [28] or for IEEE 802.11-based WAS/RLAN equipment from specifications of adjacent and non-adjacent channel rejection levels defined in IEEE P802.11 [29].

Table 18 depicts the WAS/RLAN antenna height distribution. The derivation methodology for this distribution is available in ECC Report 364, section 3.1.2 [18].

Table 15: Absolute antenna gain distribution for WAS/RLAN AP receiver

Gmin (dBi)	Gmax (dBi)	Probability (%)
-24	-23	0.16
-23	-22	0.04
-22	-21	0.06
-21	-20	0.33
-20	-19	0.80
-19	-18	0.70
-18	-17	1.21
-17	-16	0.60
-16	-15	1.13
-15	-14	1.79
-14	-13	1.78
-13	-12	1.95
-12	-11	1.52
-11	-10	3.07
-10	-9	4.75
-9	-8	5.58
-8	-7	4.59
-7	-6	6.26
-6	-5	8.47
-5	-4	7.05
-4	-3	9.55
-3	-2	9.32
-2	-1	9.01
-1	0	8.71
0	1	5.66
1	2	2.75
2	3	1.41
3	4	1.23
4	5	0.22
5	6	0.07
6	7	0.16
7	8	0.03
8	9	0.03
9	10	0.01

Table 16: Absolute antenna gain distribution for WAS/RLAN VLP/Client receiver without body loss

Gmin (dBi)	Gmax (dBi)	Probability (%)
-25	-24	0.15
-24	-23	0.06
-23	-22	0.25
-22	-21	0.23
-21	-20	0.10
-20	-19	0.44
-19	-18	0.39
-18	-17	1.14
-17	-16	1.12
-16	-15	1.89
-15	-14	2.20
-14	-13	3.53
-13	-12	3.74
-12	-11	4.43
-11	-10	5.50
-10	-9	6.58
-9	-8	8.42
-8	-7	9.40
-7	-6	9.87
-6	-5	8.41
-5	-4	7.62
-4	-3	6.56
-3	-2	5.55
-2	-1	4.63
-1	0	3.54
0	1	2.51
1	2	1.40
2	3	0.28
3	4	0.04

Table 17: Absolute antenna gain distribution for WAS/RLAN VLP/Client receiver with body loss

Gmin (dBi)	Gmax (dBi)	Probability (%)		Gmin (dBi)	Gmax (dBi)	Probability (%)
-50	-49	0.001		-23	-22	2.026
-49	-48	0.001		-22	-21	2.265
-48	-47	0.001		-21	-20	2.549
-47	-46	0.001		-20	-19	2.569
-46	-45	0.001		-19	-18	3.905
-45	-44	0.001		-18	-17	4.853
-44	-43	0.001		-17	-16	4.455
-43	-42	0.005		-16	-15	5.800
-42	-41	0.005		-15	-14	4.995
-41	-40	0.005		-14	-13	4.004
-40	-39	0.005		-13	-12	4.353
-39	-38	0.047		-12	-11	4.804
-38	-37	0.062		-11	-10	4.753
-37	-36	0.109		-10	-9	4.513
-36	-35	0.151		-9	-8	5.334
-35	-34	0.199		-8	-7	4.838
-34	-33	0.196		-7	-6	5.252
-33	-32	0.247		-6	-5	4.516
-32	-31	0.360		-5	-4	4.409
-31	-30	0.385		-4	-3	3.755
-30	-29	0.495		-3	-2	2.620
-29	-28	0.589		-2	-1	1.932
-28	-27	0.863		-1	0	1.029
-27	-26	0.877		0	1	0.562
-26	-25	1.551		1	2	0.138
-25	-24	1.674		2	3	0.078
-24	-23	1.862				

Table 18: WAS/RLAN antenna height distribution according to ECC Report 364

Floor	Height (m)	Urban	Suburban	Rural	Outdoor
ground	1.5	32.25	53.81	71.03	95
1	4.5	23.02	25.93	25.43	2
2	7.5	13.23	7.87	1.66	2
3	10.5	9.78	5.13	1.01	0.5
4	13.5	7.19	3.06	0.52	0
5	16.5	5.11	1.41	0.13	0
6	19.5	3.86	1.09	0.1	0
7	22.5	2.78	0.81	0.07	0
8	25.5	1.83	0.56	0.04	0
9	28.5	0.99	0.34	0.01	0.5

4.5 UWB

The technical characteristics for UWB are based on IEEE 802.15.4z [46] which is the basis for FiRa, CCC and omlox specifications.

Table 19: UWB characteristics

Parameter	Units	Value	Note
Centre frequency	MHz	6490	Channel 5
UWB Bandwidth	MHz	500	
UWB Height	m	1.5	
Body loss	dB	4	
Antenna peak gain	dBi	0	
Antenna pattern	-	Omni-directional	
Maximum tolerable interference level	dBm in 500 MHz	−78	From ECC Report 302 [32]

5 PROPAGATION, SHADOWING AND CLUTTER LOSS MODELS

5.1 INTERFERING TERRESTRIAL PATH

For scenarios where the victim system is fully located within the MFCN network, some studies used the model from ETSI Technical Report (TR) 138 901, section 7.4 [37]. It should be noted that:

- The selection of specific line-of-sight (LOS) probabilities or location percentages should be justified, e.g. depending on the scenario. Additionally, models should be applied within their valid distance ranges, e.g. UMa model is valid up to 5 km.

For all other scenarios one of the following approaches has been used for path and clutter losses:

- Recommendation ITU-R P.452-18 [32], which includes a clutter loss model (using representative clutter heights, or real clutter data);
- Recommendation ITU-R P.452-17 [32] (for path loss) together with Recommendation ITU-R P.2108-1 [33] (for clutter losses when the distance is larger than 250 m). Note: In this case, the “additional loss due to protection from local clutter” of Recommendation ITU-R P.452-17 [32] should be set to 0 dB;
- Recommendation ITU-R P.2001-4 [35] (for path loss) together with Recommendation ITU-R P.2108-1 (for clutter losses when the distance is larger than 250 m).

It should be noted that measurements used in the development of statistical clutter correction in Recommendation ITU-R P.2108, section 3.2 [33] used terminal heights up to 6 metres above ground and its applicability for higher antennas heights may lead to overestimation of the clutter loss for the studied paths.

Additionally, when randomising the time percentage (Tpc) range of the Recommendation ITU-R P.452 model (version 17 and version 18) between 0-100%, the ITU-R Study Group 3 (SG3) guidance (document 6A/198 [48]) is that for Tpc > 50% the basic transmission losses are set to those at Tpc = 50%.

Regarding the time percentage of Recommendation ITU-R P.452-17, Recommendation ITU-R P.452-18 [32] and Recommendation ITU-R P.2001-4 [35], two approaches have been considered:

- Fixing the time percentage value, which ignores variations in weather conditions that cause interference enhancements or fades:
  - For single entry studies (MCL), a fixed time percentage is a reasonable choice, if the value is aligned with the data loss percentage value, which the victims have to accept;
  - For Monte Carlo studies, for victim services such as FS and RAS which have specific data loss criteria (e.g. 20% time percentage for FS, 2% in the case of RAS), applying 50% would not fully capture the criteria relevant for those services. Using 50% considers annual-median weather conditions but ignores weather conditions that lead to signal enhancements (including ducting) or possible signal fades and might overestimate the path loss on an interference path.
- Using the full CDF of propagation losses across 0-100% time (or 0-50% in the case of Recommendation ITU-R P.452, see above). This captures the variability of weather conditions, including anomalous propagation phenomena occurring with the time-probability intended by the model, which was designed using studies that quantified how often such conditions occur;

  Note: Location variability is represented through path-specific parameters of Recommendation ITU-R P.452 and Recommendation ITU-R P.2001 rather than through different time states per path. Therefore, it can be assumed that the time percentage randomly picked for a Monte Carlo time iteration applies consistently to all interference paths in that iteration for separation distances where the radio weather conditions can be assumed fixed, i.e. representing a consistent atmospheric condition (e.g. a given percentile for rain or ducting) for that snapshot.

5.2 NON-INTERFERING TERRESTRIAL PATH (I.E. BS TO UE)

Path loss and line-of-sight (LOS) probability modelling are based on ETSI TR 138 901, section 7.4 [37].

5.3 BUILDING ENTRY LOSS

For the modelling of building entry loss two approaches have been considered:

- Outdoor-to-Indoor (O2I) penetration loss is modelled according to Recommendation ITU-R P.2109-2 [15] with 70% 'Traditional' and 30% 'Thermally-efficient' buildings, using a uniformly distributed probability from 1% to 99%, as done in [30];
- Outdoor-to-Indoor (O2I) penetration loss is modelled according to ETSI TR 138 901, section 7.4.3 [37].

5.4 POLARISATION MISMATCH

A polarisation mismatch of 0 dB (i.e. no polarisation mismatch) may occur when the transmitting and victim station use the same polarisation and the signal's polarisation is not modified by propagation (e.g. reflection), or if the receiving station employs dual polarisation. In the general case where the polarisation at the receiver location is random (e.g. due to mobility), the polarisation loss is 3 dB on average. This also applies to the average polarisation of aggregate interference when the polarisation of each contribution is random (see [30]). Therefore some studies considered 0 dB while others considered 3 dB polarization mismatch.

5.5 BODY LOSS

A body loss of 4 dB is assumed for MFCN UEs (see Table 6). For WAS/RLAN clients the body loss is already included in the antenna gain distribution (see Table 17). For UWB devices a body loss of 4 dB was assumed (see Table 19). For all other radio stations modelled in the studies in this Report no body loss was assumed.

6 SUMMARY OF STUDIES

The following sections summarise the studies that have been undertaken. Some studies consider interference mitigation mechanisms and quantify the degradations of service to victim systems and associated probabilities of potential interference with/without these mechanisms.

6.1 FS, SITE-SPECIFIC STUDY IN ITALY – STUDY 1

6.1.1 Introduction

The study considers the real FS deployment in Italy and makes no assumptions about the location of MFCN BSs (i.e. the interfering system). It evaluates the separation distance and exclusion area between FS receivers and a co-frequency MFCN BS that meets the long-term FS protection criterion (see section 4.1.2). Separation distance and exclusion area are defined according to ECC Report 254 [31].

6.1.2 Scenario description

The study considers the worst-case scenario, where the MFCN BS always points towards the FS receiver (without considering mechanical or electrical downtilt of the BS). The probability of main beam to main beam coupling has not been evaluated in this study. Real terrain elevation has been taken into account in the analysis.

6.1.3 Fixed service parameters

The parameters are based on real FS deployments consisting of over 2000 FS receivers.

Table 20: FS receivers: real deployment parameters

Parameter	Value
Bandwidth	28, 40 and 80 MHz
Noise figure	2.5 to 6.5 dB
H_{FS_rx}	Real deployment
G_{FS_max}	22 to 47 dBi
FS antenna elevation	−11.6° to 11.6°
I/N maximum (Note)	−10 dB
Note: This is the long-term interference protection criteria suggested by Recommendation ITU-R F.758 [21] and should be used with a time percentage of pt = 20%.	

According to section 4.1.1, Recommendation ITU-R F.699-8 [18] was used to calculate the FS receiver antenna pattern.

6.1.4 MFCN system parameters

The MFCN BS parameters used are those defined in section 3.2.3.

Both “full power” (82.6 dBm/100 MHz) and “reduced power” (56.6 dBm/100 MHz) values were used for MFCN BS *e.i.r.p.*

Two cases were considered for the levels of *e.i.r.p.* emitted by the MFCN BS in the vertical plane above the horizon.

Case 1 (No expected *e.i.r.p*. mask applied): No limitations other than the maximum *e.i.r.p.* (i.e. 82.6 dBm/100 MHz or 56.6 dBm/100 MHz). Antenna pattern assuming peak gain and *e.i.r.p.* in the direction of victim FS receiver.

Case 2 (Expected *e.i.r.p*. mask applied): The levels of *e.i.r.p.* spectral density emitted by the MFCN BS in the vertical plane above the horizon have been considered equal to the levels defined by the expected *e.i.r.p.* mask in Resolution 220 (WRC-23) of the RR (see Table 8). Antenna pattern assuming peak gain and *e.i.r.p.* in the direction of victim FS receiver below the horizon, and assuming the expected *e.i.r.p.* mask in all directions at and above the horizon.

In this case, the mask values are applied as fixed maximum levels for *e.i.r.p.* spectral density, not as averages across azimuth and elevation ranges above the horizon.

6.1.5 Propagation model

The Recommendation ITU-R P.452-17 [32] at 20% of the time and the Recommendation ITU-R P.2108-1 [33] were used in the study. The clutter is applied on the MFCN side as follows:

- 50% of the location probability in urban and dense urban scenarios;
- 30% of the location probability in suburban scenario;
- 1% of the location probability in rural scenario.

6.1.6 Study methodology

The methodology uses the Minimum Coupling Loss (MCL) approach and I/N protection criteria.

6.1.7 Study results

For each FS receiver, the separation distance has been evaluated considering the real pointing of the FS link and the terrain information.

Results are provided as CDF show the distribution of separation distances for each FS receiver.

The two cases described in section 6.1.3. were considered for the levels of *e.i.r.p.* emitted by the MFCN BS in the vertical plane above the horizon.

Case 1 is the most conservative case to protect the FS receivers.

Case 2 does not take into account the impacts on FS receivers of the worst cases where the *e.i.r.p.* emitted by the MFCN BS exceeds the expected *e.i.r.p.* mask levels in specific angles of elevation while remaining on average below the expected mask level in the correspondent elevation range above the horizon.

The results of calculations of separation distance and exclusion area can be found in Table 21 and Table 22.

Table 21 indicates the values for the separation distance for full power and reduced power scenarios in the four environments in terms of minimum (i.e. the minimum value of the separation distances obtained), maximum (i.e. the maximum value of the separation distances obtained) and median CDF. The latter value indicates the separation distance values that are exceeded in 50% of the cases both for the full power and the reduced power scenarios.

The impact of the application of the values of the levels defined by the expected *e.i.r.p.* mask in the vertical plane above the horizon of the MFCN BS (Case 2) on the separation distance results is evident only in some instances while in other ones there are no changes. Where not otherwise stated, the values are identical whether (Case 2) or (Case 1) the mask is applied.

The separation distances vary widely due to terrain elevation, relative positions of MFCN BS and FS receivers, and FS deployment characteristics. For example, FS receivers near the coast or on small islands are associated with very short separation distances (i.e. 0.8 km in Table 21).

Table 21: Range of the separation distances (km)

Environment	Min (km)		Median CDF		Max (km)	
	Full	Reduced	Full	Reduced	Full	Reduced
Dense Urban	24.5	4.3	52.5	30.8	185.8	144.8
Urban	7.8	1.3 (Case 1)	71.3 (Case 1)	36.5	266	185
		1 (Case 2)	70.8 (Case 2)			
Suburban	10.3	4.3 (Case 1)	63.5 (Case 1)	35.8 km	315	160
		4 (Case 2)	62.5 (Case 2)			
Rural	9 (Case 1)	0.8	129.1 (Case 1)	65.8 (Case 1)	375	300
	7.5 (Case 2)		122.3 (Case 2)	61.3 (Case 2)		

Table 22 indicates for each environment and for the entire territory the percentage of Italian territory that should be excluded by the MFCN BSs deployment to guarantee the protection of FS links in both scenarios and in the two cases.

Table 22: Percentage of Italian territory to be excluded by the MFCN deployment

Environment	% of the territory for each environment	% km^2 in exclusion zone Full power		% km^2 in exclusion zone Reduced power	
		Case 1	Case 2	Case 1	Case 2
Dense Urban	0.53%	93.86%	60.8%	62.56%	42.2%
Urban	3.44%	93.46%	64.7%	68.47%	44.8%
Suburban	1.53%	95.82%	63.5%	70.20%	46.6%
Rural	94.50%	86.18%	57.7%	53.65%	34.3%
Entire territory	100%	86.6%	58%	54.46%	34.9%

The study results likely fall within the range obtained by these two cases (no mask and expected *e.i.r.p.* mask).

6.2 FS, SITE GENERIC – STUDY 2

6.2.1 Introduction

This study assesses the impact of co-channel aggregate interference from urban macro MFCN base stations operating in the 6425-7125 MHz band into fixed link receivers. This is based on an update to Study F of [34] which was a contribution during the WRC-23 cycle (referred to below as 'original study').

6.2.2 Parameters

The study considers AAS Configuration 2 from Table 7. Other MFCN parameters are as specified in section 3, with the following options/deviations:

- Network loading: 50% (worst case);
- TDD activity factor is not considered (MFCN BS transmits 100% of the time);
- MFCN cell size (intended coverage range): 300 m: hexagon cell radius: 400 m (see Table 5, note 3);
- UE height of 1.5 m;

- All MFCN BS considered within clutter (see "below rooftop base station antenna deployment" in section 2.6.1.3 of original study [34]).

The FS parameters are as follows:

- Channel spacing and receiver noise bandwidth: 40 MHz;
- Receiver noise figure: 5 dB;
- Antenna gain: 36/38 dBi;
- Antenna height: 20/60 m.

The antenna gains do not match exactly the specific values in Table 9, but fall within the range of values. All other parameters are in line with options in Table 9.

The propagation parameters are:

- Propagation model: Recommendation ITU-R P.2001-4 [35] considering 48° latitude uniformly distributed random percentage of time percentage (between 0-100%);
- Clutter loss: Recommendation ITU-R P.2108-1 [33] using a uniformly distributed random percentage of locations (between 0-100%);
- Terrain: not taken into account.

6.2.3 Study methodology

The study considers a Monte Carlo approach to determine the separation distance from an MFCN network to an FS receiver.

A hexagonal grid of 19 MFCN site cluster (57 sectors) is deployed. 3 UEs are uniformly distributed within each sector at each snapshot. The aggregate interference from all MFCN BS to FS receivers at a fixed set of separation distances from the centre of the MFCN grid is computed and combined with the antenna gain of the FS receiver, considering FS antenna orientations of 0 (main lobe) and 90 degrees (side-lobe) with respect to the main pointing direction of the MFCN grid. The average value of the distribution of interference is compared against the I/N=−10 dB threshold to determine the required separation distance.

6.2.4 Study results

The results indicate that the required separation distance between co-channel MFCN and FS is 42-56 km facing the FS main lobe, and 1.7-3.6 km facing the FS side-lobe assuming clutter applied to all links. Based on the long-term protection criterion, the distances are similar to the results from the original study [34] if assuming an *e.i.r.p.* of 82.6 dBm/(100 MHz) according to AAS Configuration 2 compared to 79.5 dBm/(100 MHz) in the original study. If considering FDP, the required separation distances can increase up to 68 km in some configuration (NFM=10 dB and FS link distance of 10 km).

6.3 FS, SITE GENERIC – STUDY 3

6.3.1 Introduction

This study uses the joint time-space Monte Carlo approach to assess the impact of a cluster of 19 MFCN base station (BS) on a fixed service receiver, both on the FS main beam and side lobes.

6.3.2 Scenario description

In this study, the MFCN network consists of a 19-site cluster where each site comprises 3 hexagonal sectors leading to 57 BS in total. The fixed service station is situated at the origin, and the MFCN cluster is moved to various distances with azimuths corresponding to the FS station's main beam or side lobes. For each distance, Monte Carlo runs are performed, and the CDF of aggregated interference values is generated. The 20% long-term percentile is derived from the CDF and compared to the protection threshold of I/N=−10 dB. For each

distance, the collected statistics are also used to compute the FDP value, which is compared against the 10% allowable degradation.

6.3.3 Technical parameters

6.3.3.1 Fixed service

The fixed service receiver parameters used in this study fall within the ranges depicted in Table 10. Link length, coordinates, heights and fade margin values align with the ones used in Group Links number 4 in study C of ECC Report 364 [18].

6.3.3.2 MFCN BS and UE parameters

The MFCN base station parameters are based on the Macro Urban case, Configuration 2, as depicted in Table 7. The UE parameters are the ones depicted in Table 6 The UE height distribution follows ECC Report 364 [18], however given that the BS elevation ranges between 90 and 100°, only electrical steering within this range is applied. Outdoor UEs are set to 1.5 m.

6.3.3.3 Propagation parameters

Recommendation ITU-R P.452-17 [32] was used for pathloss computation with a percentage of time randomly picked between 0 and 100% but caped at 50%. For clutter loss Recommendation ITU-R P.2108 [33] was used with a random percentage of location spanning all the possible range. Indoor UEs are subject to BEL in accordance with Recommendation ITU-R P.2109 [15], with a random percentage.

6.3.4 Study methodology

The aggregate interference from the MFCN system towards the FS station is due to the BS contribution or to the UE contribution. Given the TDD factor, any Monte Carlo simulation is made of 75% samples due to the BS interference and 25% due to the UE interference. In all cases, the aggregate interference is computed as follows:

$$I_{aggregate} = 10 \times log_{10}\left(\sum_{i=1}^{N} 10^{\frac{I_i}{10}}\right) \quad (2)$$

where I_i is the interference created by the interferer number i:

$$I_i = P_{tx} + Gt_i(\theta_{t_i}, \phi_{t_i}) + Gr_i(\theta_{r_i}, \phi_{r_i}) - PL_i \quad (3)$$

where:

- *N* is the total number of active MFCN BS or UE, considering a load factor of 50%;
- P_{tx} is the MFCN BS/UE conducted power;
- Gt is the MFCN BS/UE antenna gain towards the FS station in the directions θ_{t_i}, ϕ_{t_i}, bearing towards the ground station;
- Gr is the FS station gain towards each MFCN BS. In this case, computed thanks to Recommendation ITU-R F.1245 [20];
- PL_i is the loss from the propagation model based on Recommendation ITU-R P.452-17 [32] and clutter loss Recommendation ITU-R P.2108. A polarisation mismatch of 3 dB is taken into account in the propagation loss. For indoor UE, BEL is applied according to Recommendation ITU-R P.2109 [15].

6.3.5 Study results

Joint time-space Monte Carlo simulations were carried out for distances ranging between 10 and 420 km. Three scenarios were studied: i) 100% of BS are below clutter, ii) 65% of BS are below clutter and iii) 50% of BS are below clutter. This was implemented by applying the Recommendation ITU-R P.2108 [33] on the corresponding percentage of BS. The value of 50% was considered to reflect the case where the upper 6 GHz deployment would use the 3.6 GHz already existing base station's locations.

Regarding the long-term protection criterion, depending on the fixed service characteristics, the separation distance can range between 51 km and 72 km if all stations are simulated below clutter, between 67 km and 105 km if 65% of BS are simulated below the clutter and between 69 km and 123 km if 50% of the BS are simulated below the clutter.

This distance increases when considering the FDP criterion, especially for the cases where not all BS are simulated below clutter. Because FDP also accounts for very low-probability events, the required distance increases to 59-124 km if all stations are below clutter, to 244-310 km if 65% are below clutter, and to 258-321 km if 50% are below clutter.

Side lobe results range from under 3 km to 5 km if all stations are below clutter, 33-50 km if 65% are below the clutter, and between 35-51 km if 50% are below the clutter.

This distance is increased when considering the FDP criterion especially for the cases where not all BS are simulated bellow the clutter. The distance to fulfil the FDP criterion is increased to a range between 47 km to 53 km if all stations are simulated below clutter and between 48 km and 56 km if 50% of the BS are simulated below the clutter.

6.4 FS, SITE-SPECIFIC STUDY IN ITALY USING EXISTING MFCN SITES – STUDY 4

6.4.1 Introduction

The study evaluates the co-frequency coexistence between FS systems and potential interfering MFCN BSs operating in the 6425-7125 MHz frequency band, considering real FS deployments in Italy and MFCN BSs located in actual sites of BSs operating in the 3600-3800 MHz frequency band.

Results are presented in terms of I/N and maximum allowable MFCN *e.i.r.p.* to comply with the long-term FS protection criterion.

6.4.2 Scenario description

The study evaluates the impact of the interfering MFCN BSs into the FS receivers and uses real FS deployments in Italy.

MFCN BSs have been considered located at actual sites of BSs operating in Italy in the band 3600-3800 MHz, excluding rural sites because contiguous coverage is not expected in rural areas in the upper 6 GHz band, and rural BSs that may exist in small numbers will be at isolated installations at specific locations.

Real terrain elevation has been taken into account.

6.4.3 Technical parameters

6.4.3.1 Fixed service parameters: real FS deployment (over 2000 FS receivers)

FS parameters used in the coexistence analysis refer to real Italian FS deployments and match the characteristics used in FS study 1 (see section 6.1).

6.4.3.2 MFCN system parameters

Actual antenna heights, orientations, and geographical locations of the MFCN BSs deployed in Italy in the 3600-3800 MHz band have been considered. The Italian 5G MFCN infrastructure operating at 3600-3800 MHz consists of more than 20000 trisector antenna sites (17.1% in dense urban, 34.1% in urban, 9.8% in suburban, 39% in rural). Rural sites have been excluded.

The remaining MFCN BS parameters used are those defined in Table 23.

Table 23: MFCN BS parameters

MFCN BS Parameter	Suburban	Dense Urban/Urban Macro
Bandwidth	100 MHz	
MFCN BS antenna height	Real deployment: 1.5 m to 124.1 m (8% are below 20 m; 50% are below 32 m; 90% are below 40 m)	
Antenna pattern	Case 1: Recommendation ITU-R M.2101, annex 1, section 5 (dynamic electrical steering is not considered and the envelope pattern of the possible UE locations in the cell is assumed) [16] Case 2: Recommendation ITU-R M.2101, annex 1, section 5 (dynamic electrical steering is not considered and the envelope pattern of the possible UE locations in the cell is assumed) [16] + application of the values of the expected *e.i.r.p.* mask in Resolution 220 (WRC-23)	
MFCN BS *e.i.r.p.* (reduced power)	56.6 dBm/100 MHz	
MFCN BS *e.i.r.p.* (full power)	82.6 dBm/100 MHz	

The shortest antenna height of 1.5 m corresponds to few scenarios where BSs are located on terrain with significant elevation, such as hillsides.

Two cases were considered for the levels of *e.i.r.p.* emitted by the MFCN BS in the vertical plane above the horizon.

Case 1 (No expected *e.i.r.p.* mask applied): No limitations, excluding the maximum *e.i.r.p.* of the scenario considered (i.e. 82.6 dBm/100 MHz or 56.6 dBm/100 MHz) are applied.

Case 2 (Expected e.i.r.p. mask applied): The levels of *e.i.r.p.* spectral density emitted by the MFCN BS in the vertical plane above the horizon have been considered equals to the levels defined by the expected *e.i.r.p.* mask in Resolution 220 (WRC-23) of the RR (see Table 8).

In this case, the mask values are applied as fixed maximum levels for e.i.r.p. spectral density, not as averages across azimuth and elevation ranges above the horizon.

6.4.4 Propagation model

The Recommendation ITU-R P.452-17 [32] at 20% of the time and the Recommendation ITU-R P.2108-1 [33] were used in the study. The clutter is applied on the MFCN side as follows:

- 50% of the location probability in urban and dense urban scenarios;
- 30% of the location probability in suburban scenario.

6.4.5 Study methodology

The methodology to assess interference into FS P-P receivers from MFCN BSs is based on the Minimum Coupling Loss (MCL) approach and I/N protection criterion.

6.4.6 Study results

The study considers the impact of possible co-frequency interfering MFCN BSs sites located in the actual sites of BSs operating in Italy in the 3600-3800 MHz frequency band (excluding sites in rural environments because contiguous coverage by the MFCN BSs is not expected in rural areas in the upper 6 GHz band) on the actual FS receivers deployed in Italy operating in the 6425-7125 MHz frequency band.

For each BS, the I/N value at each FS receiver and the maximum *e.i.r.p.* values that can be emitted by a MFCN BS in order to guarantee the protection of the FS receivers were evaluated.

The two cases described in section 6.4.3.2 were considered for the levels of *e.i.r.p.* emitted by the MFCN BS in the vertical plane above the horizon.

Case 1 is the most conservative case to protect the FS receivers.

Case 2 does not take into account the impacts on FS receivers of the worst cases where the *e.i.r.p.* emitted by the MFCN BS exceeds the expected *e.i.r.p.* mask levels in specific angles of elevation while remaining on average below the expected mask level in the correspondent elevation range above the horizon.

Given how the two cases were considered, the actual results fall within the range of the results obtained in the two cases (i.e. no mask and applying the values of the expected *e.i.r.p.* mask).

Table 24 indicates the number and percentage of MFCN BS sectors to which mitigation techniques, such as power reduction, should be applied to meet the FS protection criterion, in both cases for the levels of *e.i.r.p.* emitted by the MFCN BS in the vertical plane above the horizon and in both scenarios.

Table 24: Number and percentage of MFCN BS sectors which need mitigation techniques to be applied

Scenario	Full power		Reduced power	
	Case 1	Case 2	Case 1	Case 2
Number	33750	22500	16875	5625
Percentage	90%	60%	45%	15%

Additionally when looking at the study results in more detail they indicated that when assuming no other mitigation techniques are applied, more than 60% of MFCN BS full power sectors would need to reduce transmit power by more than 20 dB to meet the I/N requirement in Case 1 (more than 25% in Case 2).

6.5 FS, SITE GENERIC – STUDY 5

6.5.1 Introduction

This study provides an evaluation of the coexistence between FS and MFCN, assuming a typical site deployment scenario in the upper 6 GHz band.

6.5.2 Scenario description

The study employs a Monte Carlo simulation methodology to statistically evaluate interference scenarios. For a FS link under consideration, interference is modelled as originating from MFCN base station(s) transmitting in downlink mode, positioned at various distances and orientations relative to the victim FS receiver.

Two deployments are analysed in this study presented by Figure 1.

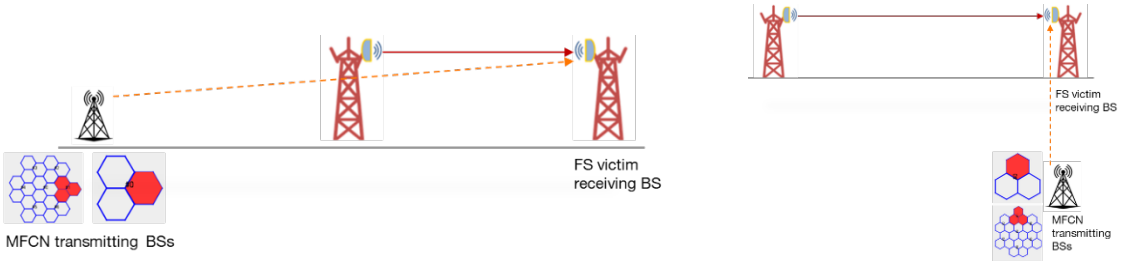


Figure 1: Main lobe case (Left), Side lobe case (right)

Additionally, two operational configurations are analysed: co-channel and DL symbol blanking case indicated by Figure 2.

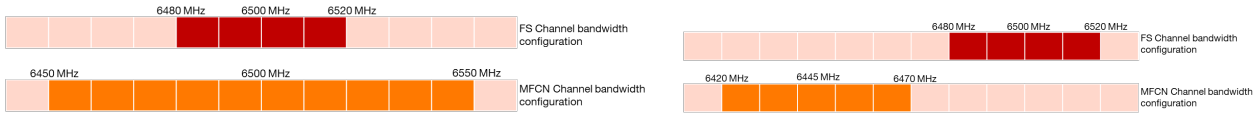


Figure 2: Co-channel configuration (Left), DL symbol blanking configuration (right)

6.5.3 Simulation Parameters

Table 25 below summarises the FS parameters utilized in this coexistence analysis, which are based on the parameters outlined in Table 9.

Table 25: FS parameters

Parameter/model	Values
Antenna height	20 m
Antenna gain	34 dBi
Link length	20 km
Channel spacing and receiver noise bandwidth	40 MHz
Centre frequency	6500 MHz
Receiver noise figure	5 dB
Antenna pattern	Recommendation ITU-R F-1245 [20]

The long-term protection criterion with a value of I/N=−10 dB that should not be exceeded for more than 20% of time.

Regarding MFCN parameters, single BS and 7-site cluster urban macro scenarios with a BS height of 18 m is analysed in this study. All MFCN BSs are assumed to be positioned above building rooftops, and no clutter effects are applied to 100% of the BSs. The simulation accounts for a network loading factor of 50% and employs TDD duplex mode, with 75% of the transmission time allocated to downlink. To reflect these two aspects, the total conducted power of the BSs is reduced by 4.2 dB. The vertical coverage angle of the base stations ranges from 93° to 103°. In case of applying sub-carrier downlink blanking, the ACLR requirement is applied.

The channel model employed in the simulations of this study is based on Recommendation ITU-R P.452-17 [32]. The model incorporates a random time percentage uniformly distributed between 0% and 50%.

6.5.4 Simulation Result

Table 26 summarises the results for various configurations, outlining the required separation distances necessary to ensure coexistence under each scenario assuming only the long-term protection criterion. Both single-BS and seven-site cluster deployment results are presented.

Table 26: Summary of simulation results

Scenario	Co-channel						MFCN DL symbol blanking					
Case	Main lobe			Side lobe			Main lobe			Side lobe		
Additional mechanical downtilt (degrees)	6	9	12	6	9	12	6	9	12	6	9	12
MFCN - Victim FS receiver distance (km) for single BS scenario	52	50	46	20	15	9	17	13	8	0.4	-	-
MFCN - Victim FS distance (km) for seven site cluster scenario	87	70	59	36	33	30	34	32	29	1.2	0.7	0.35

The simulation results underscore the critical role of various parameters, deployment strategies, and mitigation techniques in ensuring effective coexistence between MFCN and FS systems within the 6425-7125 MHz frequency band. The most challenging coexistence occurs when an MFCN base station points directly at an FS receiver on the same channel, requiring about 52 km separation for a single BS and 87 km for a seven-site cluster deployment. Adjusting the antenna's mechanical downtilt can reduce this to 59 km in a seven sites cluster scenario. By only changing the antenna orientation in case of side lobe configuration, the separation distance is reduced to 36 km in seven sites cluster scenario. Using MFCN downlink sub-carrier blanking further cuts the needed distance down to 17 km for single BS and 34 km for seven site cluster deployment. The best coexistence is achieved by combining downlink blanking with side lobe use, reducing the separation to about 1 km, demonstrating that antenna orientation and dynamic resource management can enable efficient spectrum sharing with minimal geographic separation.

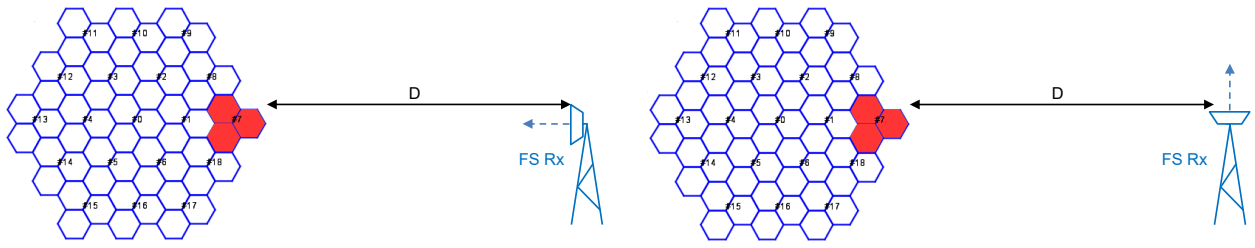
6.6 FS, SITE GENERIC – STUDY 6

6.6.1 Introduction

This study assesses coexistence between fixed service (FS) and Mobile/Fixed Communications Network (MFCN) assuming a site general deployment in the upper 6 GHz band through joint location/time Monte Carlo simulations.

6.6.2 Scenario description

In a macro urban environment, an interfering MFCN deployment is considered which consists of 19 tri-sector sites, resulting in 57 cells or base stations (BSs). The FS receiver is placed at various distances D from the edge of the MFCN network, pointing either: (a) toward the main beam of some BSs, or (b) perpendicular to them, as indicated in Figure 3.



(a) (b)

Figure 3: FS-MFCN deployment scenario (a) "Main" beam, (b) "Side" beam

For each simulated distance D, both the long-term protection criterion (I/N below −10 dB for 20% of the time) and the fractional degradation in performance (FDP) exceedance criterion (above 10%) are evaluated. While this study is site-general, a geographical position is nonetheless needed to assess FDP. The geographical position from study D from ECC Report 364 [18] was used for this purpose (longitude: −3.70261°, latitude: 40.4165°).

6.6.3 Technical parameters

6.6.3.1 FS parameters

FS parameters used in this study are taken from Table 9. The FS link length is 40 km, with transmitter and receiver antennas located at a height of 40 m. Recommendation ITU-R F.1254 [20] was considered for the antenna pattern, each FS antenna having a peak gain of 40 dBi. Based on the FS link characteristics and its selected location, a fade margin (FM) of 40.82 dB is needed to achieve a 99.99% availability under Recommendation ITU-R P.530-18 [36].

6.6.3.2 MFCN parameters

MFCN parameters for urban macro deployment are taken from Table 5 to Table 7:

- MFCN full power BS with an ISD of 1.2 km;
- AAS with Configuration 2 (49.1 dBm of total conducted power);
- Network loading factor of 50%;
- BS TDD factor of 75%;
- 1 UE per cell with a maximum transmit power of 23 dBm (power class 3).

For consistency with ECC Report 364 [18], the same building height was used when considering both indoor and outdoor UEs. Since the BS height is 18 m in the urban macro scenario, the maximum UE height was capped at the nearest lower floor (16.5 m) to allow a 90-100° electrical elevation range. Probabilities for floors above 16.5 m were redistributed among lower floors.

6.6.3.3 Coexistence parameters

MFCN and FS are assumed to have the same centre frequency of 6495 MHz. Propagation modelling was used with the following:

- Recommendation ITU-R P.452-18 [32] was used assuming a default dense urban clutter (20 m) on all interfering paths and a flat terrain;
- Recommendation ITU-R P.2109 [15] was used for the building entry loss with a probability uniformly distributed between 1% and 99%;

- A polarisation mismatch of 3 dB was assumed.

6.6.4 Study methodology

Joint location/time Monte Carlo simulations as defined in ECC Report 364 [18] are used to assess coexistence between FS and MFCN systems. For a given MFCN-FS receiver separation distance, both downlink and uplink simulation are run, each one accounting for 75% and 25% of the total interference samples, respectively. The aggregated I/N statistic is computed to assess both long-term protection and FDP criteria and determine the minimum separation distance for each criterion.

The network loading factor is simulated according to Recommendation ITU-R M.2101 [16], i.e. only a subset of BSs is randomly chosen to actively transmit or receive in each event.

6.6.5 Study results

In the ”main” beam scenario, a minimum separation distance of 165 km and 314 km is needed for the long-term protection criterion and the FDP to not exceed 10% to be fulfilled, respectively, as shown in Figure 4.

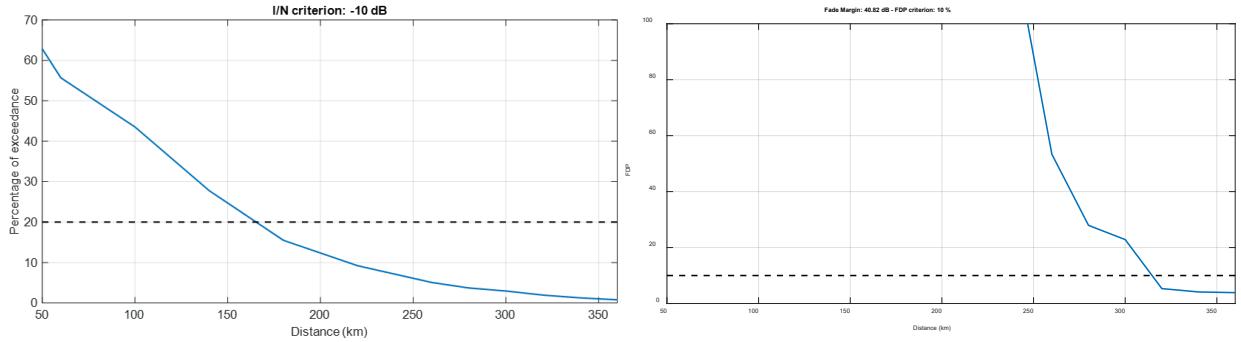


Figure 4: FS-MFCN vs distance for long-term protection criterion (left) and FDP (right) (main beam)

When assessing the ”side” beam scenario, these minimum distances reduce to 8.5 km and 7.5 km, respectively. However, such results are obtained assuming all BSs to be below the clutter (18 m vs 20 m). When all BSs are at 22.5 m, so above the clutter, the minimum separation distances needed for each protection criterion to be respected increase to 29 km.

The use of Recommendation ITU P.452-17 [32] in conjunction with clutter model of Recommendation ITU-R P.2108 [33] and 65% of BSs above the clutter in the ”side” beam scenario increases the minimum separation distance to 38 km and 44 km for long-term and FDP protection criteria, respectively, compared to Recommendation ITU-R P.452-18 [32].

This study indicates the importance of evaluating both the long-term criterion and also the FDP to derive adequate separation distance between MFCN and FS. The distance result varies as much as getting double depending on the criterion chosen, e.g. 165 km vs 314 km in the "main" beam scenario. Coexistence assessment between FS and MFCN in site general study depends greatly on the propagation model used, especially the clutter contribution, which needs to be correctly reflected to avoid underestimating separation distances. The average height of the MFCN BS and its relation to the clutter is also an important parameter to consider.

6.7 FS, SITE GENERIC WITH SEPARATED LOCATION/TIME METHODOLOGY – STUDY 7

6.7.1 Introduction

This study applies the separated location/time Monte Carlo method, in which time-dependent and location-dependent random variables are treated independently. For each location iteration, the time-dependent variables are processed to generate the time-wise I/N statistics at the FS receiver. Based on these results, the

protection criteria are evaluated for both long-term and fractional degradation of performance (FDP), and statistics on pass/fail outcomes are compiled for each location iteration.

6.7.2 Scenario description

All scenarios studied in Study 3, see section 6.3, are repeated.

6.7.3 Technical parameters

The same MFCN, FS and propagation parameters from Study 3, see section 6.3, are used in this study.

6.7.4 Study methodology

This study is based on the separated location/time approach, according to which, in the Monte Carlo runs, time dependant and location dependant variables are randomised in two separated loops called location loop (or configuration loop) and time loop, respectively. In the interference link budget the only location dependant parameters are clutter loss and the distance between the MFCN cluster and the FS station. The clutter loss depends on a probability of location, thus probabilities for each base station needs to be set and fixed for each morphology before running the time loop. In addition, in the case of a scenario where not all BS are below clutter, the above/below clutter configuration of the BS also needs to be fixed.

The study methodology is as follows:

1 Fix the distance between the MFCN cluster and the FS station

2 **Initiate the location dependent loop**

- a Assign each BS an above/below clutter status (without/with clutter)
- b Assign each BS below clutter a random probability of location to be used for the clutter loss model
- **c Initiate the time dependent loop and at each time iteration, do**
  - Assign a random probability Tpc for the Recommendation ITU-R P.452 propagation model. This random probability is fixed for all BSs in the cluster;
  - Based on the load factor, decide statistically which BS is active/inactive;
  - Set each BS's electrical steering (θ_e, ϕ_e) according to randomly deployed UEs within the allowed elevation steering range;
  - Calculate the aggregated interference into the FS receiver;
  - Repeat for several time iterations (e.g. 100000);
  - **End time loop.**
- d Collect the I/N values obtained from the time loop
- e Assess the protection criteria (long-term and FDP) based on the I/N statistics for the current location iteration
- f Repeat for several location (configuration) iterations (e.g. 1000)
- **g End location loop**

3 Gather statistics on the spatial iterations that have passed/failed the protection criteria from all the tested spatial iterations.

The above steps apply only on the downlink contribution into the interference (75% of the statistics). Given that the UEs are mobile and change location over time, the uplink portion (25% of the statistics) is simulated using a joint location/time Monte Carlo approach, varying all parameters at each step.

6.7.5 Study results

Simulations were carried out for 1000 "location" iterations each one considering 100000 "time" iterations. Considering the results achieved in the Study 3 (joint location/time approach), presented in section 6.3, the study analysed only those separation distances necessary to fulfil the long-term or FDP protection criteria. Also, only the scenarios where 65% of the base stations are below clutter was assessed. Results indicate that

even when meeting the separation distances required for long-term or FDP protection (as obtained by the joint location/time approach), the separated location/time approach reveals several location configurations that fail to meet the criteria. This exceedance rate ranges between 28% and 50% of the studied configurations.

Table 27 contains the obtained statistics for the main beam case. Even when the MFCN cluster is at distances calculated using the joint location/time approach to meet the long-term protection criterion, the long-term exceedance rate over location morphologies ranges between 40% and 50% of the studied configurations, while the FDP exceedance rate is always at 100% of configurations. When assessing FDP at the separation distance needed for the FDP to not exceed 10% (as obtained by the joint location/time approach), the separated location/time approach indicates that 28% to 51% of topologies fail to meet this criterion.

Table 27: Obtained statistics for the separated location/time approach, FS main beam by distance obtained through the joint location/time approach

FS link	Separation distance obtained by the joint location/time approach		Exceedance rate for long-term protection criterion (% of morphologies)	Exceedance rate for FDP criterion (% of morphologies)
FS N° 1	Long-term	68 km	40%	100%
	FDP	250 km	0%	28%
FS N° 2	Long-term	97 km	50%	100%
	FDP	325 km	0%	41%
FS N° 3	Long-term	99 km	49%	100%
	FDP	303 km	0%	34%
FS N° 4	Long-term	105 km	47%	100%
	FDP	312 km	0%	51%

Table 28 contains the obtained statistics for the side lobe case. It can be observed that even if the MFCN cluster is at distances calculated with the joint location/time methodology to fulfil the long-term protection criterion, the long-term exceedance rate over the location morphologies ranges between 45.7% and 51.3% of the studied configurations, while the FDP exceedance rate for this distance is always at 100% of configurations. When assessing the FDP at the separation distance needed for the FDP to not exceed 10% obtained through the joint location/time approach, the separated location/time approach indicates that between 43.3% and 51.5% topologies do fail to respect the FDP below 10%.

Table 28: Obtained statistics for the separated location/time approach, FS side lobe by distance obtained through the joint location/time approach

FS link	Separation distance obtained by the joint location/time approach		Exceedance rate for long-term protection criterion (% of morphologies)	Exceedance rate for FDP criterion (% of morphologies)
FS N° 1	Long-term	39 km	51%	94%
	FDP	42 km	0.3%	51%
FS N° 2	Long-term	37 km	50%	88%
	FDP	39 km	3%	43%
FS N° 3	Long-term	40 km	51%	90%
	FDP	42 km	6.5%	52%
FS N° 4	Long-term	50 km	46%	83%
	FDP	52 km	9.7%	52%

6.8 FS, SITE-SPECIFIC STUDY IN FRANCE USING EXISTING MFCN SITES - STUDY 8

6.8.1 Introduction

This study considers real FS deployment in France in the frequency band 6425-7125 MHz, as well as mature MFCN deployments re-using MFCN sites actually deployed in the 2.6 GHz and 3.5 GHz frequency bands . The simulations are site-specific and use terrain and building databases for clutter modelling and indoor UE placement.

6.8.2 Scenario description

This study considers the real FS deployment in the frequency band 6425-7125 MHz in France and assumes mature MFCN deployments re-using the actual MFCN sites in the frequency bands 2.6 GHz and 3.5 GHz.

6.8.3 Technical parameters

For the FS deployment, the following parameters are used:

- the fade margin is taken as the middle of the range given in Table 9, i.e. 28 dB;
- a receiver noise figure of 4.5 dB;
- an antenna pattern following the model of Recommendation ITU-R F.1245 [20].

For the MFCN deployment, the following parameters are used:

- 6° downtilt elevation (urban macro);
- AAS vertical coverage range was not considered in this study;
- Cell size: 400 m (urban macro);
- Antenna configuration: Configuration 1 (urban macro, without vertical coverage range limitation);
- 3 UEs per cell.

Other technical parameters:

- Propagation model: Recommendation ITU-R P.452-17 [32] (with terrain and clutter);
- Data source for MFCN and FS deployments: ANFR open data[8];
- Data source for terrain: IGN RGE ALTI®[9];
- Data source for clutter classification: CORINE Land Cover[10];
- Data source for building height: IGN BD TOPO®[11].

6.8.4 Study methodology

In this study 110 FS receivers from the national French database were used.

As per the MFCN urban macro parameters, 3 UEs are deployed in each cell (modelled as hexagons). Outdoor UEs are placed where there is no building, and indoor UEs are placed in buildings. The probability of being in a building is proportional to area of the building multiplied by the number of floors in the building. The altitude of UEs in their building is uniformly distributed between 0 m and the height of the building.

[8] https://www.data.gouv.fr/datasets/donnees-sur-les-installations-radioelectriques-de-plus-de-5-watts-1/

[9] https://geoservices.ign.fr/rgealti

[10] https://land.copernicus.eu/en/products/corine-land-cover/clc2018 (https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0)

[11] https://geoservices.ign.fr/bdtopo

The simulation zone has the shape of the FS antenna pattern (not tilted) projected on the ground and stretched to 500 km in the main lobe direction to capture interference from distant MFCN BSs aligned with the main lobe.

The simulation considers a synchronized TDD network using a DDDSUUDDDD frame, with the time delay due to the distance taken into account. Interference coming from UEs is not computed and is set to 0 W.

Each base station is randomly selected to be active following a Bernoulli distribution with a 20% probability (corresponding to the BS loading factor).

FS receivers are intended to receive on a single polarisation. Polarisation losses follow $-10\log_{10}\left(\cos\left(\mathcal{U}_{[0;\pi/2[}\right)^2\right)$ for the horizontal polarisation and $-10\log_{10}\left(\sin\left(\mathcal{U}_{[0;\pi/2[}\right)^2\right)$ for the vertical polarisation, rather than using the −3 dB expected value in the linear domain.

France has 4 main mobile network operators. By considering two deployments (2.6 GHz and 3.5 GHz), this leads to 8 configurations per FS station.

With 110 FS receivers, 8 configurations per station and two polarisations, a total number of 1760 configurations were investigated. For each configuration, a total of 1000 time steps are simulated.

6.8.5 Study results

Noting that the I/N criterion aims at assessing the long-term impact, FDP provides a meaningful measure of performance degradation and indicates a stronger impact. 28.27% of investigated configurations meet the long-term protection criterion (I/N<−10 dB less than 20% of the time), while 21.62% of investigated configurations meet the FDP protection criterion (FPD<10%).

6.9 RAS – STUDY 1

6.9.1 Introduction

This study evaluates co-channel coexistence between Mobile/Fixed Communications Networks (MFCN) operating in the 6425-7125 MHz band and the Radio Astronomy Service (RAS) operating in the 6650-6675.2 MHz band. The focus is on aggregated interference from MFCN base stations (BSs) to RAS receivers across the UK.

6.9.2 Scenario description

A site-generic scenario was used, by combining interference estimates from six RAS stations. All RAS sites are at 25 m above ground, except the sites in Cambridge (32 m) and Jodrell Bank (20 m). MFCN BSs, equipped with Configuration 1 antennas (as defined in Table 7), were distributed up to 200 km from each station. Real BS locations and heights were used for UK deployments, while synthetic networks based on population density were used elsewhere. Terrain and clutter data was used in the study. Separation distances were varied to determine the minimum separation required to meet the RAS protection criterion.

6.9.3 Technical parameters

The following technical parameters were considered in addition to those outlined in the Report:

- MFCN deployment classification as urban (81%), suburban (13%), rural (6%), based on inter-site distances;
- One BS per MFCN 3-sector site;
- Indoor MFCN UEs are placed within buildings, with building heights defined by the clutter map. This is the same clutter map used to assess obstruction due to clutter in the propagation model;
- Recommendation ITU-R P.2001-5 [35] was used, with clutter heights added along the path profile. Elevation of departure angles for tropospheric paths were based on the first side lobe above the horizon.

The same $T_{pc1} \sim \mathcal{U}(0,100)$ was used in all paths in each Monte Carlo iteration, and T_{pc1}, T_{pc2}, and T_{pc3} were not correlated;

- Terrain/clutter data: Bluesky/Siradel (UK), FABDEM/WorldCover (outside UK).

6.9.4 Study methodology

Monte Carlo simulations (10000 iterations) were used to assess aggregate interference from MFCN BSs to RAS receivers. BSs within a distance (varied from 0 to 120 km) were excluded. For the MFCN cell sizes, the range of values provided in this Report was used. Indoor UEs are placed within buildings whose heights are defined by the clutter map. The protection threshold was set at −218.1 dBW/50 kHz, not to be exceeded 98% of the time.

6.9.5 Study results

Separation distances required to protect RAS stations are summarised in Table 29.

Table 29: Separation distances to ensure protection of RAS

Power scenario	Separation distance
Full power MFCN	130 km
Reduced power MFCN	78 km

As a sensitivity case, a threshold for the UK spectral line measurements with the Multi-Element Radio Linked Interferometer Network (e-MERLIN) operation (−189.1 dBW/50 kHz, 29 dB higher than single dish) was considered. Separation distances of 68-84 km for full power MFCN and of 10-55 km for reduced power were found.

6.10 RAS – STUDY 2

6.10.1 Introduction

Compatibility and sharing studies between MFCN in the band 6425-7125 MHz and RAS in the band 6650-6675.2 MHz were carried out.

6.10.2 Scenarios description

Various scenarios were tested:

- Generic (flat terrain) studies for both single-entry MCL and aggregate cases (Monte Carlo analysis);
- Site-specific scenarios for several European RAS sites, using real terrain and clutter heights, for the single-entry case, using Recommendation ITU-R P.452-18 [34] with precise LiDAR data and Corine Land Cover (MCL analysis with Tpc 2%);
- In addition, the effectiveness of potential mitigation measures was investigated within the generic aggregation scenario framework.

6.10.3 Study methodology

The study is based on the technical parameters provided in section 3 and section 4.3, with few differences, which are discussed below. For the clutter treatment, the model provided in Recommendation ITU-R P.452-18 [34] (which adds effective clutter heights along the whole propagation path) was combined with the end-point clutter model defined in Recommendation ITU-R P.2108-1 [33] that is applicable to urban and suburban MFCN equipment "below the roof-tops". As this condition may not apply for rural macro-cell BSs and for antennas installed significantly above local effective clutter heights, scenarios with and without

Recommendation ITU-R P.2108 clutter losses were considered. In the aggregation cases, it was assumed that a certain fraction of the BS is unaffected by clutter. For comparison, calculations were also performed assuming that all BS experience full Recommendation ITU-R P.2108 clutter losses. Combining Recommendation ITU-R P.452-18 clutter along the propagation path with P.2108 end-point clutter significantly overpredicts real clutter losses.

Other (more minor) points, which deserve a mention, are:

- Beamforming efficiency for adjacent and spurious cases was set to 100%;
- For the adjacent band studies, only row 2 of Table 2 was considered, i.e. a "guard band" of 50 MHz was in place;
- In the aggregation studies, the UE (radial) distances were assumed to follow a Rayleigh distribution. Furthermore, rural deployment was included, but the BS densities are rather insignificant to play an important role;
- The impact of a UE height distribution compared to a constant UE height of 1.5 m was tested;
- Beam avoidance and switching off BS sectors below certain angular separations to the direction to the RAS site was investigated.

6.10.4 Study results

The results of generic aggregation scenarios are indicated in Figure 5.

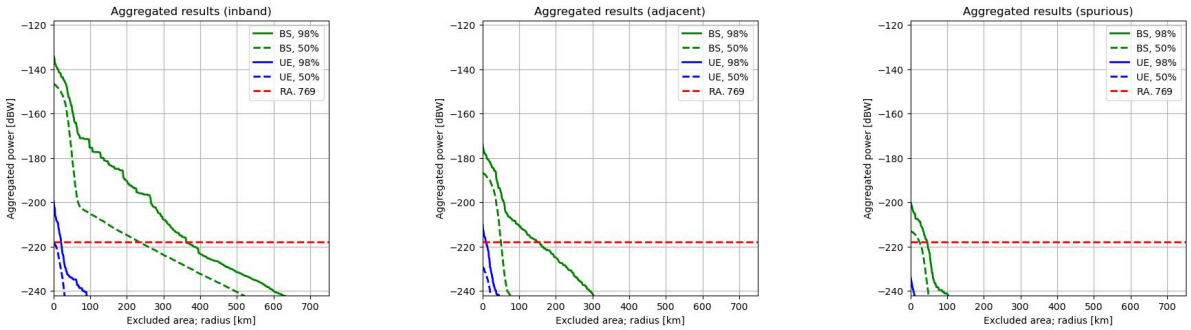


Figure 5: Results for the aggregated scenario MFCN vs RAS in the 6425-7025 MHz band

As in all cases the RAS thresholds were violated, an increasingly larger area in the centre of the simulated box was left out of the aggregation of the received powers, which yields values as a function of an "exclusion area radius". Excluding an area in the simulation does not imply that a regulatory "exclusion area" would be required. With appropriate coordination, MFCN equipment may be placed within these areas. Figure 5 indicates the distribution percentiles of the simulations. As the simulation was repeated many times to assess the statistical scatter in the results, the 98% percentile curves indicates the worst 2% of the results, which refers to the maximum data loss of 2% that the RAS has to accept (according to Recommendation ITU-R RA.1513 [27] for cases where radioastronomy has a primary status). The 50% curve is irrelevant for the results but provides insight into the magnitude of the variance (statistical scatter) of the results.

For the in-band (sharing) case, separation distances of almost 400 km would be necessary to protect RAS operations. For the adjacent channel and spurious domain cases, the resulting separation distances were 100 km and 25 km respectively calculated based on the second approach described in 3.1.1 for the modelling of MFCN BS unwanted emissions and first approach described in section 3.1.2 for the modelling of MFCN UE unwanted emissions. Even for the spurious cases, the distances approach 50 km. The UE are insignificant for the total aggregated received power. A noteworthy detail which Figure 5 reveals is that the received power is a very steep function of exclusion zone radius. That means that significant changes in the power levels would be required to reduce the coordination zone sizes substantially. For example, even with 30 dB reduced power, in-band separation distances would still be of the order of 200 km and a 50 dB reduction would be needed to achieve less than 100 km. Of course, in reality terrain will play a role, but a fair number of RAS stations are in rather flat terrain. In all cases, the user equipment is negligible.

In the site-specific scenarios, the results depend strongly on the terrain in the vicinity of the RAS stations. Separation distances of up to 250-350 km could be required in the sharing scenario or even much more if the MFCN base stations are not subject to full clutter losses (with a typical value of 27 dB). An exception is the 100-m telescope at Effelsberg in Germany, for which natural terrain shielding is more efficient. For the adjacent and spurious compatibility, the results are still large enough that for some sites, cross-border coordination could be required, but this depends a lot on whether full P.2108 [33] clutter or no clutter loss is assumed. It is noted that this does not depend on the maximum *e.i.r.p.* value of the carriers, as the OOB powers were considered independent on the carrier powers.

Several mitigation techniques were investigated. The most important factor is the clutter loss. Whether P.2108 fully applies or not changes the resulting distances by up to almost 50%, as P.2108 indicates an average clutter loss of 27 dB at 6.7 GHz. However, it is not clear if this would be realistic as in many European deployment scenarios, BS antennas at elevated installation heights are probable. Avoiding the RAS station location (either by steering of AAS BS beams away from RAS or by not deploying some sectors) can reduce separation distances but would require large angular separations. In the default aggregation study, the UE heights were assumed to be constant with 1.5 m. If a height distribution is considered, the resulting separation distances go up by about 30 km (in-band) and 70 km (adjacent), respectively, owing to the comparably higher beam elevation angles.

In all cases, the most important factor is the actual clutter loss that is considered for the studies. The applicability of Recommendation ITU-R P.2108 [33] to all BSs depends heavily on the actual deployment scenario.

6.11 RAS – STUDY 3

6.11.1 Introduction

This study assesses the minimum separation distance required to ensure the protection of a radio astronomy service (RAS) station from the aggregated interference from a surrounding macro-cellular urban MFCN. The MFCN base stations (BSs) are assumed to be operating in the 6425-7125 MHz band, with the RAS receiver operating at 6650.0-6675.2 MHz, where observations of methanol maser lines are conducted.

6.11.2 Scenario description

The scenario is related to the impact of aggregate co-channel interference from urban macro-cellular MFCN BSs operating in the 6425-7125 MHz band on stations in radio astronomy service (RAS) operating at 6650.0 - 6675.2 MHz.

6.11.3 Technical parameters

The MFCN is assumed to be deployed in a ring with an area of 360000 km^2 around a RAS station, with MFCN BS densities of R_a Option 1 and R_b Option 3 in Table 4.

Each MFCN BS is modelled as transmitting within a channel of 100 MHz at a maximum *e.i.r.p.* of 82.6 dBm/(100 MHz) and with AAS Configuration 1 (Table 7) at a height of 18 m, and forming beams towards 3 UEs located with a uniform distribution within its cell each at a height of 1.5 m. A network loading factor of 20% is assumed (given the large area covered by the model), along with a MFCN TDD DL:UL ratio of 3:1. The RAS characteristics are aligned with those in Table 13. The height of the RAS antenna is assumed to be 50 m. In practice, most RAS antennas are located at lower height, which can further facilitate coexistence. Only spectral line measurements are considered for the RAS, as this type of measurement has a more stringent protection requirement.

A fixed time percentage of 50% was applied to the propagation model of Recommendation ITU-R P.2001-4 [35] (see section 5.1).

Clutter loss is modelled as specified in Recommendation ITU-R P.2108-1 [33] and is applied to emissions from all MFCN BSs with a random location probability in the range 0 to 100%.

The case where 65% of BS are affected by clutter has been considered as well as a sensitivity analysis.

Polarisation loss of 3 dB is also considered in this study.

6.11.4 Study methodology

The study uses Monte Carlo simulations to calculate the CDF of aggregate co-channel interference spectral density across various random MFCN BS beamforming angles and separation distances from the RAS site. The 98th percentile of the aggregate interference is then compared with the RAS protection threshold of −175.1 dBm/MHz in order to determine the required separation distance.

The MFCN loading factor of 20% is modelled according to Recommendation ITU-R M.2101 [16] whereby at each Monte Carlo trial 20% of the MFCN BSs are randomly selected to transmit and the rest do not transmit. The TDD downlink factor of 75% is modelled as a 1.25 dB reduction in the MFCN BS *e.i.r.p.*

6.11.5 Study results

The minimum separation distance required to ensure in-band coexistence between RAS spectral line measurements and urban macro-cellular MFCN BSs is obtained by comparing the 98th percentile of the interference levels at the RAS station receiver for different separation distances from the RAS site, and by comparing these with the protection criterion of −175.1 dBm/MHz.

The results indicate that the protection criterion with 100% clutter loss can be met at a separation distance of 59 km. The sensitivity analysis with 65% clutter loss gives a separation distance of 148 km.

Additional factors – such as location-specific clutter, terrain features and the use of potential mitigation techniques – should be considered to facilitate coexistence.

6.12 RAS – STUDY 4

6.12.1 Introduction

Compatibility and sharing studies between MFCN base stations and RAS in the 6650-6675.2 MHz band were conducted.

6.12.2 Scenario description

A site generic scenario with flat terrain was studied, aggregating the interference from MFCN BSs over a large area around the RAS station. Scenarios with 100% and 65% of MFCN BSs within clutter were considered.

6.12.3 Study methodology

The Monte Carlo study is based on the technical parameters provided in section 3 and in section 4.3. A simulation area of 360000 km^2 was used, with MFCN clusters randomly placed in a ring area with the RAS station in the centre for each snapshot. A base station density of 10 BS/km^2 with R_a = 0.1 and R_b = 0.02, according to Table 5, was used. Table 30 summarises additional MFCN parameters.

Table 30: MFCN parameters

Parameter	Value
MFCN bandwidth	100 MHz
ISD	588.6 m
Network loading factor	20%

Parameter	Value
AAS configuration	Configuration 1
Base station output power/sector *e.i.r.p.*	82.6 dBm

The choice of the network loading factor is aligned with section 3.2.4. The protection criterion for the RAS station, with an antenna gain of 0 dBi and 50 m antenna height, is the aggregate interference below −175.1 dBm/MHz at the 98th percentile, based on 3000 snapshots per Monte Carlo run. The RAS station receiver was modelled with a 50 kHz bandwidth.

Propagation model from the Recommendation ITU-R P.2001 [35] was used. The RAS station was assumed at 50°N, 7°E. For the parameter "Percentage of average year for which the predicted basic transmission loss is not exceeded" 50% was assumed. Clutter loss model according to The Recommendation ITU-R P.2108 section 3.2 [33] was used at the MFCN BS side only, i.e. no clutter loss was applied for the RAS station. The "percentage of locations" parameter in ITU-R P.2108 was modelled as a uniform random value between 0% and 100%. A polarisation mismatch of L_{pol} = 3 dB was assumed.

The MFCN BS bandwidth was assumed to be fully overlapping with the bandwidth of the RAS station.

6.12.4 Study results

Table 31 summarises the required separation distances to ensure the interference criterion of −175.1 dBm/MHz is not exceeded 98% of the time.

Table 31: Required separation distances

Percentage of clutter	Dsep
100%	60 km
65%	170 km

The results indicate that for the protection of RAS stations separation distances of 60 km might be required when deploying MFCN co-channel with RAS stations and assuming 100% clutter loss at the BS side. When assuming 65% clutter loss at the BS, the separation distances increase to 170 km. All results assume unconstrained MFCN deployment, i.e. no additional measures are applied to the MFCN.

Within the coordination area, mitigation measures like subcarrier symbol blanking can be used to protect RAS stations. For adjacent channel operation of MFCN with RAS, separation distances will be lower due to the reduced BS out-of-band power, in accordance with the unwanted emission limits summarised in Table 2.

6.13 RAS – STUDY 5

6.13.1 Introduction

This study evaluates in-band sharing between MFCN and RAS, assessing the separation distance required to meet the RAS interference criterion.

6.13.2 Scenario description

The MFCN network consists of a 19-site cluster, each with 3 hexagonal sectors, leading to 57 base stations (BS). The radio astronomy station is placed in the centre of the reference frame, and the MFCN cluster is moved to various distances along a single azimuth, with the radio astronomy gain fixed at 0 dBi. For each distance, several Monte Carlo runs were performed, and the CDF of aggregate interference values is

generated. The interference value corresponding to the 2th percentile is read off the CDF and compared to the protection threshold of −206 dBW/MHz.

6.13.2.1 RAS parameters

The radio astronomy receiver parameters are provided in Table 13. The station was set at a latitude of around 50° which is used as a parameter for propagation modelling.

6.13.2.2 MFCN BS and UE parameters

The MFCN base station parameters are based on the Macro Urban case, Configuration 1, as depicted in Table 7. The UE parameters are the ones depicted in Table 6. The UE height distribution follows ECC Report 364 [18], however, given the elevation range of 90-100°, only electrical steering within this range is performed. Outdoor UEs are set at a height of 1.5 m.

6.13.2.3 Propagation parameters

Recommendation ITU-R P.452-17 [32] was used for pathloss computation with a percentage of time randomly picked between 0 and 100% but capped at 50%. For clutter loss Recommendation ITU-R P.2108-1 [33] was used with a random percentage of location spanning all the possible range. Indoor UEs are subject to BEL in accordance with Recommendation ITU-R P.2109 [15], with a random percentage.

6.13.3 Study methodology

The aggregate interference from the MFCN system towards the RAS station is due to the BS contribution or to the UE contribution. Due to the TDD factor, each Monte Carlo simulation is made of 75% samples from BS interference and 25% from UE interference. In all cases, the aggregate interference is computed as follows:

$$I_{aggregate} = 10 \times log_{10}\left(\sum_{i=1}^{N} 10^{\frac{I_i}{10}}\right) \quad (4)$$

where:

- I_i is the interference created by the interferer number i:

$$I_i = P_{tx} + Gt_i(\theta_{t_i}, \phi_{t_i}) + Gr_i(\theta_{r_i}, \phi_{r_i}) - PL_i \quad (5)$$

where:

- N is the total number of active MFCN BS or UE, considering a load factor of 50%;
- P_{tx} is the MFCN BS/UE conducted power;
- Gt is the MFCN BS antenna gain towards the RAS station in the directions θ_{t_i}, ϕ_{t_i}, when bearing towards the UE or the antenna gain of the UE towards the RAS station;
- Gr is the RAS station gain towards each MFCN BS. In this case, this gain is considered to be 0 dBi;
- PL_i is the loss from the propagation model based on Recommendation ITU-R P.452-17 [32] and clutter loss Recommendation ITU-R P.2108 [33]. A polarisation mismatch of 3 dB is also taken into account. Building Entry Loss (BEL), when applicable on the UE side, according to Recommendation ITU-R P.2109 [15].

6.13.4 Study results

Simulations were carried out for distances between 50 and 400 km. Three scenarios were studied: i) 100% of BS below clutter, ii) 65% of BS below clutter and iii) 50% of BS below clutter. This was implemented by applying the Recommendation ITU-R P.2108 [33] on the corresponding percentage of BS. The 50% value was included as a sensitivity analysis to reflect the case where the upper 6 GHz deployments reuse existing 3.6 GHz locations.

The obtained results are depicted in Figure 6. The required distance to protect the RAS station when all BS are subject to clutter is 170 km. This distance increases to 369 km when 65% of BSs are below clutter and to 384 km when 50% are below clutter.

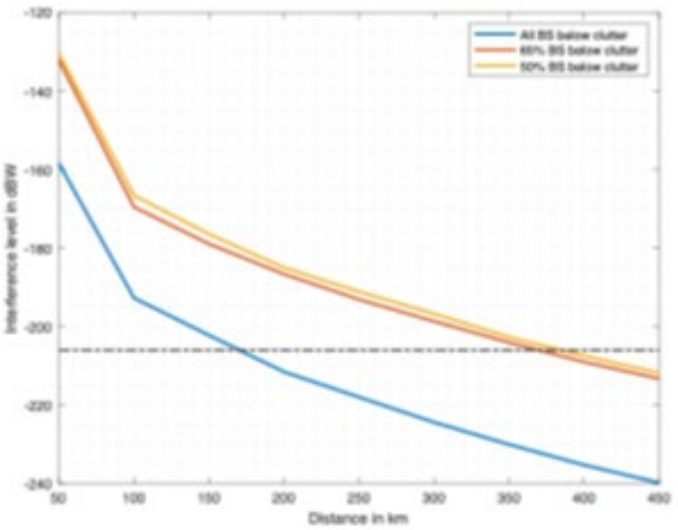


Figure 6: Simulation results, interference level vs distance for different percentages of BS below

6.14 RAS – STUDY 6

6.14.1 Introduction

This study evaluates co-channel aggregate received power levels from MFCN BSs operating at full power to a RAS station. Only urban scenarios are considered, as these are the most likely sources of interference.

6.14.2 Scenario description

This study considers a radio astronomy telescope located at 50° N, 7° E. The MFCN network consists of a 19-site cluster, each with 3 hexagonal sectors, totalling 57 BSs. In each Monte Carlo snapshot, 3 UEs are randomly and uniformly distributed within each sector, maintaining a minimum ground distance of 35 m from the BS. This deployment represents a worst-case scenario, as several BSs are directly facing the RAS station.

6.14.3 Technical parameters

The MFCN BS parameters are based on the Macro Urban, Configuration 1 case, as detailed in Table 7. The UE parameters are provided in Table 6.

The RAS parameters are detailed in Table 13. The threshold interference level for the RAS receiver is set at −218.1 dBW/50kHz (equivalent to −175.1 dBm/MHz), which must not be exceeded more than 2% of the time.

6.14.4 Study methodology

Monte Carlo simulations are performed to assess aggregate interference from multiple MFCN BSs to a RAS station at a fixed distance. The MFCN network modelling is based on Recommendation ITU-R M.2101 [16]. The simulations are structured as follows:

- Simulation Setup:
  - The propagation model in Recommendation ITU-R P.452-17 [32] is used for links between stations on the Earth's surface. A smooth terrain profile is assumed in the Monte Carlo simulations;

- When considering a random time percentage (Tpc), the simulation runs through 2000 outer loops. In each loop, a new random Tpc value is generated for all BSs. Each of these outer loops consists of 1000 snapshots, simulating various network conditions, e.g. different UE locations and clutter loss model percentage of locations;
- Each outer loop consists of 1000 snapshots, simulating various network conditions, e.g. UE different locations, clutter loss model percentage of locations;
- Clutter losses for terrestrial paths are determined using Recommendation ITU-R P.2108-1 [33], using a uniformly distributed random percentage of locations. Clutter losses are applied to all paths;
- A 3 dB polarisation loss is considered.

- For each snapshot, the following steps are followed:
  - A hexagonal cell macro network with 19 sites is generated. Each site has 3 sectors, and 3 UEs randomly located within each sector (uniformly distributed);
  - The active MFCN BSs are determined based on the MFCN network loading factor;
  - Coupling loss between the MFCN BSs and the RAS station is calculated, including path loss, clutter loss, and antenna gains for both the MFCN BSs and the RAS station;
  - The aggregate interference from all MFCN BSs at the RAS station receiver is calculated, considering the TDD activity factor. The aggregate interference is calculated as follows:

$$I_{External} = \sum_j \sum_k I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) \quad (6)$$

where:

- $I_{External}(TX_{BS_j}^{UE_k}, RX^{victim})$ is inter-system interference from BS_j (when its k-th UE is served) / UE_k (served by BS_j) to the interfered receiver;

The interference per BS is calculated as follows:

$$I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) = PD_{tx} + G_{tx}(\theta_{tx}, \varphi_{tx}) - PL + G_{rx}(\theta_{rx}, \varphi_{rx}) \quad (7)$$

where:

- PD_{tx} is transmit station signal power density (dBm/MHz);
- $Gtx(\theta_{tx},\varphi_{tx})$ is transmit station antenna gain in the direction of the receiver station (dBi);
- PL is path loss including clutter, polarisation, building entry, and body losses (when applicable) (dB);
- $G_{rx}(\theta_{rx},\varphi_{rx})$ is receiver station antenna gain in the direction of the transmit station (dBi).

6.14.5 Study results

In this study, the assumed single MFCN cluster close to the RAS station would appear to be the dominant source of interference, resulting in separation distances of approximately 60-120 km to meet the interference threshold level of the radio astronomy telescope. However, through mitigation measures, e.g. when the BS is not facing the RAS station, these distances could be reduced to approximately 70 km. Such assessments should be done on a case-by-case basis, as the environment and operational characteristics (such as terrain, clutter, and antenna properties), can vary significantly.

6.15 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE – STUDY 1

6.15.1 Introduction

This study examines the requirement for an edge-to-edge frequency separation (“guard-band”) between WAS/RLANs operating in the lower 6 GHz band and MFCNs in the upper 6 GHz band, focusing on interference from outdoor MFCN base stations (BSs) to WAS/RLAN equipment.

6.15.2 Scenario description

The scenario relates to interference from MFCN BSs operating in the upper 6 GHz band to WAS/RLAN equipment in the lower 6 GHz band across the 6425 MHz frequency boundary. The interference is characterised in terms of a) blocking of WAS/RLAN receivers caused by (carrier) emissions from MFCN BSs and the finite adjacent channel frequency selectivity of WAS/RLAN receivers, and b) unwanted out-of-block emissions from MFCN BSs due to finite adjacent channel frequency selectivity at their transmitters.

6.15.3 Technical parameters

The operation of the MFCN and WAS/RLAN equipment is modelled at a frequency of 6425 MHz and according to the parameters described in section 3 and section 4.

The MFCN is modelled with a channel bandwidth of 100 MHz, network loading factor of 50%, TDD DL:UL ratio of 3:1, BS ISD of 600 m, BS height of 18 m, and UE height of 1.5 m. The MFCN BSs are modelled as operating at a maximum *e.i.r.p.* of 82.6 dBm/100 MHz with AAS Configuration 1, a coverage range of 90-100º in the vertical plane, and adjacent channel leakage ratio (ACLR) values of 38, 35, 32, 31 and 31 dB for WAS/RLAN bandwidths of 20, 40, 80, 160 and 320 MHz, respectively (derived from the ACLR absolute basic limit specification equivalent to −6 dBm/MHz and modelled as +7 dBm/20 MHz for a measurement bandwidth of 20 MHz consistent with the minimum WAS/RLAN channel bandwidth studied. See the MFCN BS unwanted emission levels based on the first approach described in section 3.1.1 (see also Annex 2 for details of how the ACLR values are derived from 3GPP/ETSI specifications).

WAS/RLAN receivers are modelled at heights drawn from distributions specified in ECC Report 364 [18] for indoor and outdoor equipment, with antenna gains modelled as random variables according to the distributions in section 4.4.1, polarisation mismatch of 3 dB, noise figure of 9 dB, and IEEE-compliant adjacent channel selectivity (ACS) values of 36, 33, 30, 29, and 29 dB for WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz, respectively (derived from ACS specifications of 29 dB and 45 dB in the first and second adjacent channels based on IEEE specifications).

Radio propagation from MFCN BSs to WAS/RLAN equipment, including path loss, shadowing loss, and building penetration loss (where applicable), is modelled according to the urban macro (UMa) scenario specified in ETSI TR 138 901 [37].

6.15.4 Study methodology

The statistics of interference at WAS/RLAN receivers are derived by calculating the CDF of the signal power received over-the-air from an MFCN of 19 BS sites (57 BSs in total), with each BS forming a beam towards a UE that is randomly located within its serving cell, and with the WAS/RLAN receiver randomly located within the central cell. Building penetration loss is modelled as ‘low loss’ and ‘high loss’ with probabilities of 80% and 20%, respectively, at each Monte Carlo trial (where applicable).

The MFCN loading factor of 50% is modelled probabilistically as specified in Recommendation ITU-R M.2101 [16]. The MFCN TDD downlink factor of 75% is modelled by setting the *e.i.r.p.* of the synchronised MFCN BSs to zero with a probability of 0.25 at each Monte Carlo trial.

6.15.5 Study results

Figure 7 indicates the CDFs of I/N at WAS/RLAN receivers due to a) receiver blocking (left figure), and b) MFCN BS unwanted emissions (right figure). The CDFs are the weighted average of individual CDFs for 1) bandwidths of 20, 40, 80, 160 and 320 MHz with probabilities (weights) of 10%, 5%, 30%, 35% and 20%, respectively (see ECC Report 364 [18]), and 2) indoor APs without body loss, indoor STA/VLP devices with body loss, outdoor STA/VLP devices with body loss, and indoor STAs without body loss with probabilities (weights) of 66.32%, 30.1%, 1.21% and 2.37%, respectively (see ECC Report 364).

An additional analysis with UE heights based on the statistical distributions specified in ECC Report 364 (instead of a fixed 1.5 m) indicates a 0.5% increase in exceedance probabilities at I/N=0 dB. More specifically, the results indicate that WAS/RLAN LPI APs experience an I/N which exceeds 0 dB and −6 dB with

probabilities of 1.5% and 3%, respectively. Furthermore, results aggregated for different WAS/RLAN receiver types (see above for the types and their statistical distribution as specified in ECC Report 364) indicate that WAS/RLANs experience an I/N which exceeds 0 dB and −6 dB with probabilities of 1.2% and 2.4%, respectively. Note that the above results correspond to the statistical distribution of WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz as specified in ECC Report 364.

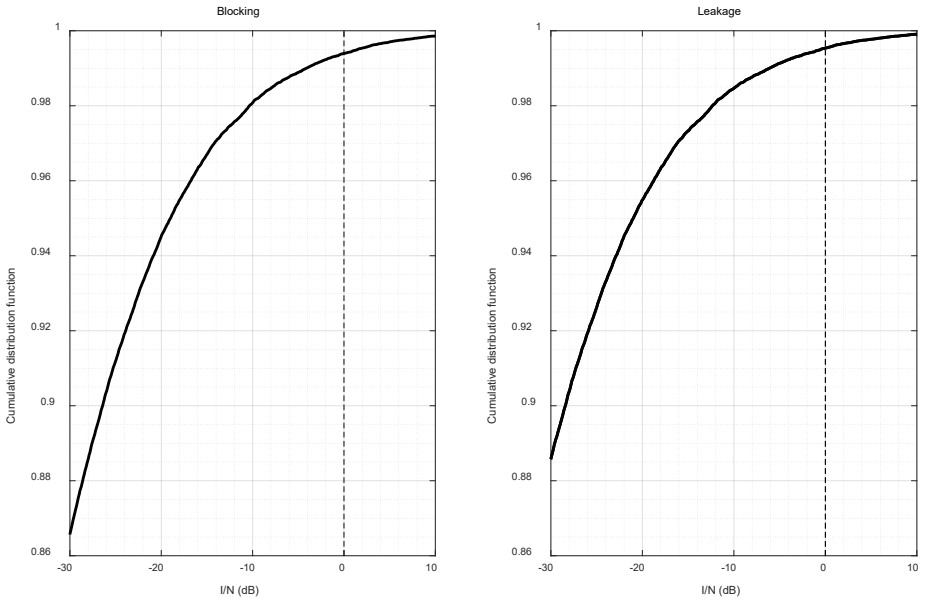


Figure 7: I/N of WAS/RLANs in the lower 6 GHz band due to (a) receiver blocking by wanted emissions of MFCN BSs (left), and (b) unwanted emissions of MFCN BSs (right), with the MFCN operating in the upper 6 GHz band. A zero guard-band is assumed, along with standard WAS/RLAN ACS and MFCN BS ACLR, and a maximum MFCN BS *e.i.r.p.* of 82.6 dBm/100 MHz

The study results indicate that for a maximum MFCN BS *e.i.r.p.* of 82.6 dBm/100 MHz, and a guard-band of 0 MHz between MFCNs and WAS/RLANs, the I/N at WAS/RLAN receivers is less than 0 dB and -6 dB with a probability exceeding 90%, and is typically around 99% and 98%, respectively.

6.16 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE – STUDY 2

6.16.1 Introduction

This site-general study evaluates the aggregate received power levels from full power MFCN base stations (BSs) into WAS/RLAN in an adjacent-channel directly next to the MFCN operating channel. System and deployment parameters are based on those defined in this Report. Only urban scenarios are considered, as these are where interference is most likely to occur.

6.16.2 Scenario description

The MFCN network consists of a 19-site cluster where each site comprises 3 hexagonal sectors leading to 57 BSs in total. In each Monte Carlo snapshot, 3 UEs are randomly located within each sector with a uniform distribution and a minimum ground distance of 35 m from the BS. Furthermore, 2000 WAS/RLAN APs are deployed within the central MFCN cell to capture aggregate interference from all BSs. For each AP, 2000 snapshots are evaluated to determine the received power at each AP. This approach accounts for the power levels experienced by each AP across various locations and conditions, accounting for variability in MFCN BSs beamforming patterns. All APs are assumed to be indoors, and each AP is associated with a constant building entry loss value across all snapshots.

6.16.3 Technical parameters

The MFCN BS parameters are based on the Macro Urban as detailed in Table 7. The UE parameters are provided in Table 6. The WAS/RLAN parameters are detailed in section 4.4. MFCN BS adjacent channel leakage ratio (ACLR) and WAS/RLAN adjacent channel selectivity (ACS) values are based on current standards (ETSI TR 138 104 V18.5.0 [40] and IEEE Std 802.11ax-2021 [29], respectively). See the MFCN BS unwanted emission levels based on the first approach described in section 3.1.1. Simulations are conducted to evaluate both the MFCN blocking interference and interference due to MFCN unwanted emissions.

6.16.4 Study methodology

Monte Carlo simulations are performed to assess the aggregated interference from multiple MFCN BSs to randomly deployed WAS/RLAN APs. The MFCN network modelling is based on Recommendation ITU-R M.2101 [16]. The simulations are structured as follows:

- Simulation Setup:
  - Urban macro (UMa) pathloss, line-of-sight (LOS) probability, and clutter loss modelling is based on ETSI TR 138 901 V18.0.0, section 7.4 [37];
  - The simulation consists of 2000 outer loops, each generating a random AP location and building entry loss. Each outer loop consists of 2000 snapshots, simulating various network conditions, e.g. UE different locations;
  - Building entry loss is determined using Recommendation ITU-R P.2109-2 [38] with 70% “Traditional” and 30% “Thermally efficient” buildings, and with a uniformly distributed probability from 1% to 99%;
  - A 3 dB polarisation loss is considered (aggregate interference);
  - To compute the I/N ratio, noise and interference are calculated in a reference bandwidth of 1 MHz.
- For each snapshot, the following steps are followed:
  - A hexagonal cell macro network with 19 sites is generated. Each site has 3 sectors, and 3 UEs randomly located within each sector (uniformly distributed);
  - The active MFCN BSs are determined based on the MFCN network loading factor;
  - The coupling loss between the MFCN BSs and the AP is calculated, including path loss, clutter loss, building entry loss, and antenna gains of both the BS and AP receiver;
  - The aggregate interference from all MFCN BSs at the AP receiver is calculated as follows and additionally compared against the EDT threshold, considering the TDD activity factor:

$$I_{External} = \sum_j \sum_k I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) \quad (8)$$

where:

- $I_{External}(TX_{BS_j}^{UE_k}, RX^{victim})$: Inter-system interference from BS_j (when its k-th UE is served) / UE_k (served by BS_j) to the interfered-with receiver.

The interference per BS is calculated as follows:

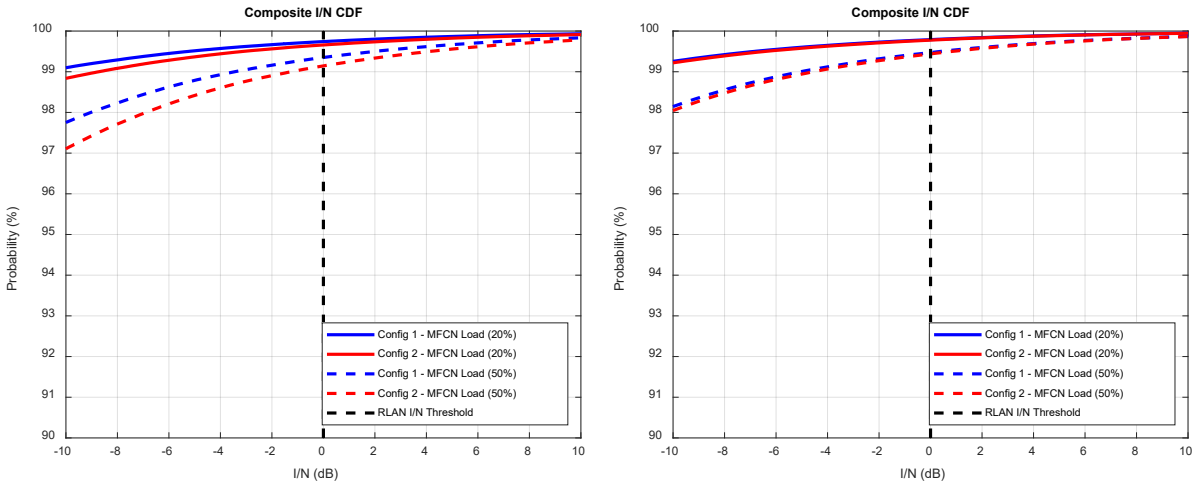
$$I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) = PD_{tx} + G_{tx}(\theta_{tx}, \varphi_{tx}) - PL + G_{rx}(\theta_{rx}, \varphi_{rx}) \quad (9)$$

where:

- PD_{tx} is transmit station signal power density (dBm/MHz);
- $G_{tx}(\theta_{tx}, \varphi_{tx})$ is transmit station antenna gain in the direction of the receiver station (dBi);
- PL is path loss including clutter, polarisation, building entry, and body losses (when applicable) (dB);
- $G_{rx}(\theta_{rx}, \varphi_{rx})$ is receiver antenna gain based on distributions in ECC Report 366, section 2.2.1 [43] (dBi).

6.16.5 Study results

For both MFCN BS antenna configurations with 20% and 50% network loading factors, the probability of exceeding an I/N value of 0 dB is below 0.9% for MFCN blocking interference and below 0.6% for MFCN unwanted emissions. For the lower I/N value of −6 dB, the interference levels remain below 1.8% and 1.2%, respectively. Including indoor and outdoor VLP devices results in negligible differences compared to considering only indoor APs.



(a) (b)

Figure 8: Composite I/N due to MFCN BS: (a) blocking interference, and (b) unwanted emissions interference

Furthermore, in all cases considered, the WAS/RLAN EDT is exceeded with a probability of less than 0.06%. The EDT is not exceeded for 99.94% of the simulations that has been performed.

6.17 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE – STUDY 3

6.17.1 Introduction

This study evaluated adjacent band coexistence between WAS/RLAN deployments in lower 6 GHz and MFCN deployments in upper 6 GHz, assuming that no guard band is introduced to increase the frequency separation between the edge channels of the two technologies.

6.17.2 Scenario description

The interference direction considered was the downlink transmission from MFCN BS towards MFCN UEs. The four different victim receiver scenarios analysed covered the case of WAS/RLAN APs deployed indoor, WAS/RLAN clients deployed indoor (with and without body loss) and WAS/RLAN clients deployed outdoor. These four scenarios do not carry the same weight in terms of overall victim system impact, as their relative distribution presents a large majority of indoor deployments (i.e. 98.79%) versus outdoor deployment (i.e. 1.21%).

6.17.3 Technical parameters

The following parameters have been derived and used in the simulations to calculate the interference, according to the methodology shown in the next section, assuming 0 MHz guard band, and the MFCN BS unwanted emission levels based on the first approach in section 3.1.1.

Table 32: WAS/RLAN ACS for blocking results

WAS/RLAN Bandwidth (MHz)	WAS/RLAN ACS (dB)	Thermal Noise Level (dBm)
20	36	−92
40	33	−89
80	30	−86
160	29	−83
320	29	−80

Table 33: MFCN ACLR for unwanted emissions results

WAS/RLAN Bandwidth (MHz)	NR ACLR (dB)	Thermal Noise Level (dBm)
20	38	−92
40	35	−89
80	32	−86
160	31	−83
320	31	−80

6.17.4 Study methodology

Two methodologies were used: one based on the joint location/time Monte Carlo approach, and the other separating time and space Monte Carlo loops to generate statistics for different victim locations.

In the first approach, results are generated for multiple independent realisations of the MFCN deployment, in which UE locations, UE scheduling, BS beam orientation, and WAS/RLAN locations are randomly sampled in time and space and processed to infer their statistical properties. The results in this study are based on 250 realisations.

The second approach considers time and location separately. The first loop (morphology loop) creates a random deployment of fixed-location victims. Within this morphology realisation, the second loop (time loop) runs multiple Monte Carlo time snapshots, where non-fixed device locations (e.g. NR UEs) are drawn from a random uniform distribution within the coverage area. Results are then collected for each fixed victim location, and the percentage of WAS/RLAN AP locations exceeding a given protection criterion is collected.

The interference received at the WAS/RLAN receiver is split in two different components: 1) receiver blocking by the aggressor's fundamental spectrum emission (driven by the victim's ACS performances), and 2) in-band interference caused by the aggressor's out-of-band emissions (driven by the aggressor's ACLR).

6.17.5 Study results

The results for the joint location/time Monte Carlo approach show that the probability of exceeding the I/N protection criterion is in the low single digit percentage range for all cases, and negligible for indoor deployments (which account for the ~99% of the total WAS/RLAN deployments).

Specifically, for blocking interference, I/N < 0 dB is achieved at least 99% of the time for indoor devices and at least 96% of the time for outdoor devices. For unwanted emissions, I/N < 0 dB is achieved at least 99% of the time for indoor devices and at least 96% of the time for outdoor devices.

For indoor devices, the tail of the I/N distribution flattens in the region of interest, thus whether the I/N target is 0 dB, −3 dB or −6 dB does not materially change the study's conclusions.

Results for the separated location/time Monte Carlo approach strongly depend on the time percentage associated with the protection criteria, which require a deeper evaluation based on receiver performance.

Both approaches, based on the same underlying Monte Carlo modelling, consistently indicate low probabilities of exceeding an I/N of 0 dB.

6.18 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE – STUDY 4

6.18.1 Introduction

The study presents numerical simulations using the Monte Carlo method to quantify the probability of interference and throughput loss suffered by WAS/RLAN under interference from MFCN considering that both systems operate in adjacent channels with no guard band at the frequency edge 6425 MHz.

6.18.2 Scenario description

The study considers an MFCN BS operating in 6425-6525 MHz and RLAN operating immediately below the boundary of 6425 MHz at different bandwidths. The RLAN system is randomly located within the MFCN network.

6.18.3 Technical parameters

Technical parameters are as specified in section 3.2 for MFCN and 4.4 for RLAN, with the exception of those discussed further in the detailed study, including the MFCN BS unwanted emission levels based on the first approach described in section 3.1.1.

6.18.4 Study methodology

The simulation scenario is composed of 19 sites in a hexagon grid with ISD = 600 m and 3 sectorized BSs per site leading to a total of 57 BSs. In each Monte Carlo iteration, 3 UEs and 2 Wi-Fi nodes are randomly deployed within each BS coverage area. The Wi-Fi nodes are always deployed together (AP and STA) in a square region with dimension of 10 x 10 m.

After deployment, the beamforming on all active [12] BSs is determined based on the location of the UEs served by those BSs. Next, the aggregated interference generated by all active BSs to the Wi-Fi receivers in the central site is determined.

9000 Monte Carlo simulations are performed to capture changes in path loss, beamforming, UE/RLAN heights and indoor/outdoor status.

6.18.5 Study results

The results indicate that for an I/N threshold of 0 dB, WAS/RLAN receivers are interfered in less than 0.5% of all simulated cases. Furthermore, the blocking interference contributes significantly more to the total interference (3.7 dB to 13.47 dB) when compared to the MFCN BS unwanted interference. This result indicates that blocking interference has a greater effect as the WAS/RLAN ACS specification is approximately 6 dB lower than MFCN BS ACLR specification. On the other hand, the unwanted interference is at least 10 dB below

[12] Active BSs beamform to the UEs and generate interference to the Wi-Fi nodes. BSs are active with probability equal to the network loading factor (20% and 50%).

noise at 99th percentile of the CDF, which indicates that no further improvement in the MFCN-BS ACLR is needed to protect WAS/RLAN from interference.

Finally, the throughput loss at WAS/RLAN STA never exceeds 0.65% and is restricted to the STAs with low SNR and large bandwidth (320 MHz).

6.19 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE - LPI AP – STUDY 5

6.19.1 Introduction

This study assesses compatibility between wireless access system including radio local area network (WAS/RLAN) low power indoor (LPI) access point (AP) already operating in the lower 6 GHz band and Mobile/Fixed Communications Networks (MFCNs) envisaged in the upper 6 GHz band through separated location and time Monte Carlo simulations assuming a site generic deployment.

6.19.2 Scenario description

A macro urban environment is considered where an interfering MFCN is deployed in the upper 6 GHz band. The network consists of 19 tri-sector sites, leading to 57 cells or base stations (BSs). MFCN UEs are dropped both indoor and outdoor. WAS/RLAN LPI APs operating in the lower 6 GHz band are dropped inside one sector of the MFCN centre cell.

6.19.3 Technical parameters

6.19.3.1 WAS/RLAN parameters

WAS/RLAN parameters are taken from Table 14. Only LPI APs are considered with an operating channel bandwidth of 20 MHz in the lower 6 GHz band. LPI APs are dropped in height according to Table 18, assuming only indoor devices per definition. To simplify the simulations, only the average antenna gain of an LPI AP is considered and equal to −2.96 dBm (linear averaging of the data in Table 15).

ECC Report 310, equation 9 [47] in conjunction with ETSI EN 303 687 (v1.1.0) [28] are used to derive the WAS/RLAN adjacent channel selectivity (ACS) and thus receiver mask.

6.19.3.2 MFCN parameters

MFCN parameters for urban macro deployment are taken from Table 5 to Table 7:

- MFCN full power BS with ISD of 600 m;
- AAS with Configuration 2 (49.1 dBm of total conducted power);
- Network loading factor of 50%;
- BS TDD factor of 75%;
- 1 UE per cell with a maximum transmit power of 23 dBm (power class 3).

For consistency with ECC Report 364 [18], the same building height was used when considering both indoor and outdoor UEs. Since the BS height is set to 18 m in the urban macro scenario, the maximum height of a UE was capped to the immediate lowest floor below (i.e. 16.5 m) to allow a 90-100° electrical elevation range. The remaining probabilities of being in a floor above 16.5 m were redistributed among the lower floors.

6.19.3.3 Compatibility parameters

Propagation modelling with the following hypothesis was considered:

- ETSI TR 138 901 [37] (UMa) was used for the MFCN-WAS/RLAN propagation model;
  - For uplink simulations, when a UE is indoors and within 10 m of the indoor WAS/RLAN, both are assumed to be in the same building, and no building entry loss is applied. In such case 3GPP TR

36.814 (UE to HeNB) [51] propagation model is considered instead, assuming a floor separation of 3 m.

- Recommendation ITU-R P.2109 [15] was used for the building entry loss with a probability between 1% and 99%;
- A polarisation mismatch of 3 dB is assumed between MFCN and WAS/RLAN;
- Minimum separation of 10 m between BS and WAS/RLAN LPI AP was assumed;
- No minimum separation between UE and WAS/RLAN LPI AP was assumed.

In this compatibility study, MFCN occupies the immediate adjacent upper 6 GHz channel (centre frequency of 6475 MHz) while WAS/RLAN LPI AP have their 20 MHz bandwidth in the upper part of the lower 6 GHz band. Various frequency offsets from the reference 20 MHz WAS/RLAN channel were tested with a raster of 20 MHz channel as shown in Figure 9.

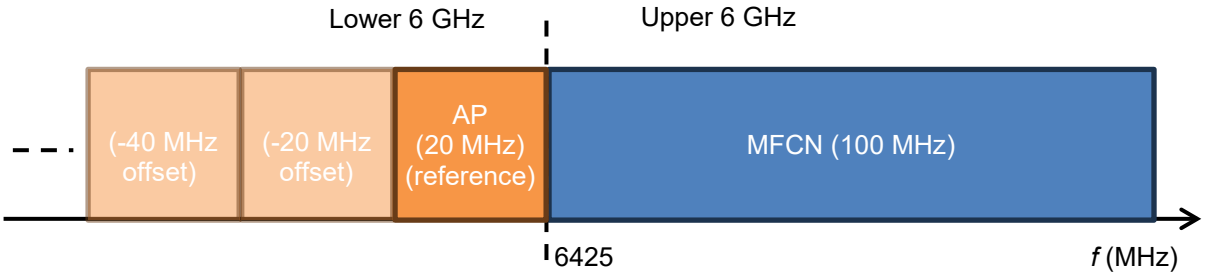


Figure 9: WAS/RLAN and MFCN spectrum configuration

Both spectrum emission mask[13] (SEM) (see 3GPP TS 38.104 (v19.1.0), table 6.6.4.2.2.1-2b and 3GPP TS 38.101-1 (v19.2.0), table 6.5.2.2-1) and adjacent channel leakage ratio (ACLR) (see 3GPP TS 38.104 (v19.1.0), subclause 6.6.3.4 and 3GPP TS 38.101-1 (v19.2.0), subclause 6.5.2.4.1) have been used to derive the unwanted transmission going into the WAS/RLAN receiver. See MFCN BS unwanted emission levels based on the first and second approaches in section 3.1.1, and MFCN UE unwanted emission levels based on the first and second approaches in section 3.1.2. For spurious domain (below 6325 MHz) the limit of −30 dBm/MHz was used according to ERC Recommendation 74-01 [14].

6.19.4 Study methodology

Separated location and time Monte Carlo simulations as defined in ECC Report 364 [18] are used to assess compatibility between one WAS/RLAN LPI AP operating in the lower 6 GHz band and the MFCN operating in the upper 6 GHz band.

For each location loop, one WAS/RLAN LPI AP is dropped at a random position within a given building type (traditional (70%) or thermal efficient (30%)) inside the designated one sector of the centre cell (one topology):

- For each topology, interference from MFCN to WAS/RLAN is collected over a time loop:
  - For downlink simulations, the propagation parameters of every MFCN(BS)-WAS/RLAN(AP) link (incl. LoS, shadowing, building entry loss) are fixed for all time-snapshots as both BS and LPI AP are static;
  - For uplink simulations, the propagation parameters of every MFCN(UE)-WAS/RLAN(AP) link change at each time-snapshot as UEs are mobile.

Network loading factor is simulated according to Recommendation ITU-R M.2101 [16], i.e. only a subset of the BSs is randomly chosen based on this probability to actively transmit or receive at each event.

[13] In accordance with Recommendation ITU-R M.2101, section 3.2 [16].

6.19.5 Study results

Table 34 summarises the percentage of WAS/RLAN AP locations for which no exceedance of I/N=−6 dB is permitted for any instance of time (0% of time), i.e. I/N is less than or equal to −6 dB all the time, due to the presence of a 100 MHz MFCN network deployed at 6475 MHz for more than 5100 topologies (2000 time snapshots per topology). The following results apply to simulations based on the MFCN spectrum emission mask.

Table 34: Percentage of WAS/RLAN LPI AP locations impacted by MFCN for different frequency offsets

Frequency offset from the last 20 MHz channel in the lower 6 GHz band (MHz)	WAS/RLAN centre frequency (MHz)	Percentage of WAS/RLAN locations for which no exceedance of I/N=−6 dB is permitted for any instance of time (0% of time), for a sensitivity of -82 dBm	Percentage of WAS/RLAN locations for which no exceedance of I/N=−6 dB is permitted for any instance of time (0% of time), for a sensitivity of -92 dBm
0	6415	90.32	97.04
-20	6395	83.18	91.71
-40	6375	74.24	75.16
-60	6355	72.59	73.25
-80	6335	71.92	72.35
-100	6315	12.73	24.40
-120	6295	9.27	14.12
-140	6275	8.68	9.01
-160	6255	8.68	9.01

A deep analysis of the interference exceedance ratio per topology based on the distance from the MFCN BS was carried out. It indicates that WAS/RLAN LPI APs operating on one of the last five 20 MHz channels of the lower 6 GHz band could experience some level of interference exceedance over time, especially when close to the MFCN BS

In one scenario (WAS/RLAN sensitivity of −92 dBm/20 MHz), 40% [14] of WAS/RLAN devices using the last 20 MHz channel of the lower 6 GHz band (0 MHz offset) experience interference where I/N exceeds −6 dB with probabilities of at least 18% and 32% over time when within 150 m and 75 m from the MFCN BS, respectively (see Figure 10). When using the fifth to last 20 MHz channel of the lower 6 GHz band (80 MHz offset), 20% [15] of WAS/RLAN devices will experience interference where I/N exceeds −6 dB with probabilities of at least 5% and 13% over time when they are within 150 m and 75 m from the MFCN BS, respectively.

[14] Note that these correspond to 40% of 23% (i.e. 9%) and 40% of 6% (i.e. 2.4%) of the total number of AP locations in the cell

[15] Note that these correspond to 20% of 23% (i.e. 5%) and 20% of 6% (i.e. 1.2%) of the total number of devices in the cell

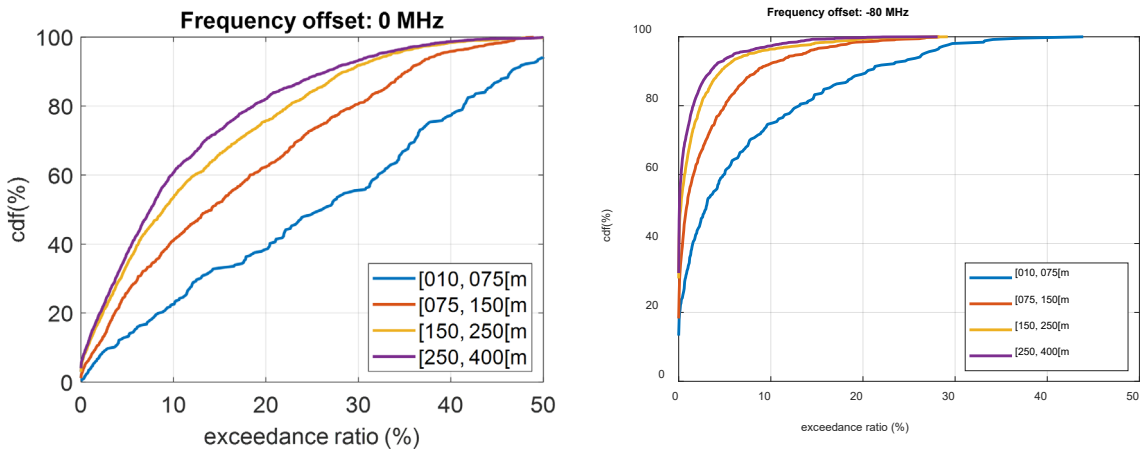


Figure 10:WAS/RLAN exceedance ratio statistics vs MFCN distance for various frequency offset (WAS/RLAN sensitivity of -92 dBm/20 MHz)

Using either the spectrum emission mask or ACLR to derive MFCN power entering the WAS/RLAN receiver did not lead to different conclusions than the ones presented here, especially regarding the location and time analysis.

6.20 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE - OUTDOOR VLP – STUDY 6

6.20.1 Introduction

This study analyses the impact of interference from MFCN deployment in the upper 6 GHz band on outdoor Very Low Power (VLP) WAS/RLAN operating in the lower 6 GHz band under ECC Decision (20)01 [8].

6.20.2 Scenario description

This study uses a Monte Carlo approach to derive the I/N statistics from adjacent operation of MFCN and WAS/RLAN deployments. The scenario consists of an MFCN cluster with 57 sectors, where each base station is connected to a single MFCN user equipment. The victim VLP devices move only within the central hexagonal cell. At each Monte Carlo iteration, the VLP device position changes, and the electrical steering of each sector is randomly adjusted according to the served UE position. Based on the dropped configuration at each snapshot, the aggregate interference from all the 57 MFCN sectors/active MFCN UEs is computed at the outdoor VLP device. No VLP devices are dropped within 12 m from the central MFCN BS, and no UEs are dropped closer than 1 m to any VLP device.

6.20.3 Technical parameters

6.20.3.1 Propagation model

Urban macro (UMa) pathloss and line-of-sight (LOS) probability modelling are based on ETSI TR 138 901, section 7 [39]. For the case of indoor UEs, the building entry loss from Recommendation ITU-R P.2109 [15] model is applied with 30% thermally efficient and 70% traditional buildings.

6.20.3.2 MFCN simulation parameters

The MFCN parameters are the ones from Table 5, Table 6 and Table 7. The BS load factor is fixed to 50% in all the simulations. The antenna configuration is Configuration 1. MFCN BS unwanted emission levels are based on the first and second approaches in section 3.1.1, and MFCN UE unwanted emission levels are based on the first and second approaches in section 3.1.2.

6.20.3.3 WAS/RLAN simulation parameters

The WAS/RLAN VLP antenna gain is simulated according to the distribution shown in Table 17 for VLP with body loss. The VLP antenna height is according to the outdoor distribution in Table 18. The bandwidths of (20, 40, 80, 160 and 320 MHz were studied. Finally, the WAS/RLAN rejection values are the ones computed in WAS/RLAN 1 (see section 6.15) as $A_1 = 29$ dB, and $A_2 = 45$ dB.

6.20.3.4 Net filter discrimination (NFD)

The study uses NFD to quantify the amount of transmitter energy falling into the receiver due to the combined filtering at both sides (transmitter and receiver). It is computed by integrating both TX and Rx filters on the overlapping spectrum portion. The method also includes a bandwidth adjustment factor which is applied when the interferer's assigned channel has greater bandwidth than the victim's receiver. As indicated in Recommendation ITU-R M.2101 [16]: "For scenarios involving IMT and non-IMT systems the co-channel and adjacent channel effects could be considered jointly as frequency dependent rejection (FDR) as described in Recommendation ITU-R SM.337".

6.20.4 Study results

Simulations were carried out for 100000 Monte Carlo runs.

The obtained CCDF for the case of no guard band and where the VLP victim receiver would operate under different channel bandwidth for both SEM and ACLR mask are plotted in Figure 11. With the SEM, for 20 MHz, the probability of exceedance is 9.58%, for 40 MHz it is 8.9%, for 80 MHz it is 8.09%, for 160 MHz it is 6.35% and finally for 320 MHz it is 4.61%. With the ACLR mask, these values drop to 6.57%, for both 20 MHz and 40 MHz, to 6.52% for the 80 MHz case, to 5.23% for 160 MHz and to 3.75% for the 320 MHz channel.

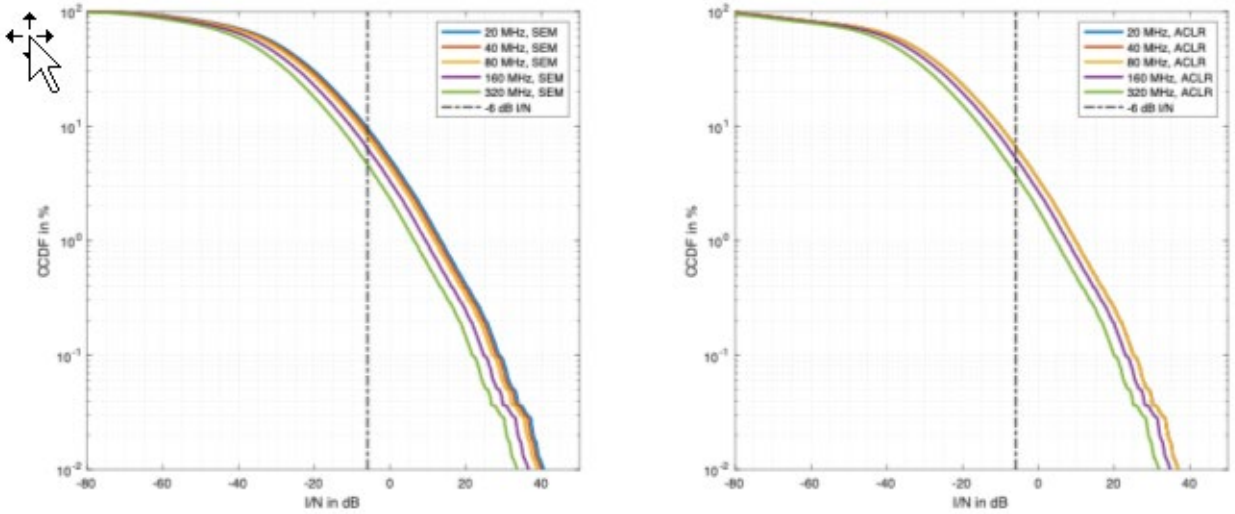


Figure 11: Results for no frequency offset between WAS/RLAN outdoor VLP and MFCN BS (antenna configuration 1). Left SEM and right ACLR mask

In Table 35, are studied cases of frequency offset between 0 and 100 MHz with an increment of 20 MHz. In Table 35, both scenarios with the SEM and ACLR mask are studied. Overall, the ACLR when applied as constant out-of-band emission exhibits lower exceedance probabilities when compared to the SEM. None of the studied scenarios achieve 0% exceedance probability of the protection criterion. Narrower to intermediate bandwidths (20, 40 and 80 MHz) are associated with higher interference when no frequency offset is applied, but interference decreases significantly with a 100 MHz offset, as most of MFCN interference originates from spurious emissions. Cases with large bandwidths (160 MHz and 320 MHz), although associated with lower probabilities of exceedance when no frequency offset is applied, do not see significant reductions even with a 100 MHz offset.

Table 35: Results for different WAS/RLAN outdoor VLP bandwidth and frequency offset: probability that I/N of −6 dB is exceeded

BW (MHz)	Frequency offset (MHz)											
	0	20	40	60	80	100	0	20	40	60	80	100
	Using SEM						Using ACLR					
20	9.6%	6.2%	4.7%	4.6%	4.5%	0.2%	6.6%	3.7%	3.6%	3.6%	3.6%	0.2%
40	8.9%	6.8%	4.7%	4.6%	3.2%	0.2%	6.6%	5.4%	3.7%	3.6%	2.5%	0.2%
80	8.1%	6.9%	5.6%	4.4%	2.5%	0.7%	6.5%	6.0%	5.1%	3.9%	2.0%	0.7%
160	6.4%	5.7%	5.3%	5.0%	4.4%	3.6%	5.2%	5.1%	5.0%	4.8%	4.3%	3.5%
320	4.6%	4.1%	3.8%	3.6%	3.4%	3.2%	3.8%	3.6%	3.6%	3.4%	3.3%	3.2%

6.21 MFCN AND WAS/RLAN ADJACENT CHANNEL COEXISTENCE - ACCESS POINTS – STUDY 7

6.21.1 Introduction

This study assesses the impact of potential MFCN deployment in the upper 6 GHz on the WAS/RLAN access points (APs) operating in the lower 6 GHz band. As APs are fixed in location, the study quantifies the percentage of AP location configurations that do not meet the WAS/RLAN I/N threshold of -6 dB using a separated location and time Monte Carlo methodology.

6.21.2 Scenario description

The MFCN consists of a cluster of 19 sites, each with 3 hexagonal sectors, leading to 57 BSs. In each Monte Carlo snapshot, one UE is randomly placed within each sector with a uniform distribution and a minimum ground distance of 35 m from the BS. The UE height distribution is the urban distribution from Table 18. At each snapshot, the BS is electrically steering to this UE.

4000 WAS/RLAN APs configurations are considered within the central MFCN cell to account for the aggregate interference from all BSs and UEs. For each AP, 4000 time-snapshots are evaluated to determine the received time-wise interference power at each AP. This approach allows for a detailed analysis of the power levels experienced by each AP across various locations and conditions, accounting for the MFCN BSs beamforming patterns variability. All APs are considered to be located indoors, and each AP has a constant building entry loss value for all time-snapshots. The following algorithm is used for the simulations

1 Deploy the 57 sector MFCN cluster considering the upper 6 GHz envisaged parameters

2 **Start the location loop**

a Deploy 4000 AP randomly situated in the central cell and attribute fixed 3D coordinates to it (x,y,z), no APs are deployed within the first 12 m from the BS

b Between each MFCN BS sector and each deployed AP decide if the propagation conditions are LOS or NLOS in accordance with TR 38.901 and compute the path loss between each WAS/RLAN and each BS and fix it

c Between each MFCN BS sector and each deployed AP attribute a probability that the building entry loss is not exceeded, to be used with Recommendation ITU-R P.2109 [15] and fix it to compute the BEL

d Start the time dependent loop

i) Based on the load factor decide statistically which are the active MFCN BS

ii) Steer electrically each MFCN BS sector to a random MFCN UE

iii) Compute the aggregate interference from all transmitting MFCN devices (BSs or UEs) into each deployed AP

iv) Gather the interference statistics over several time snapshots (4000) for each AP

e **End time dependent loop**

f Depending on the studied WAS/RLAN channel bandwidth, estimate if each AP's statistics can be above the I/N=-6 dB

3 **End location loop**, gather statistics on location iterations, e.g. 4000, that have exceeded the protection criteria for a given percentage of time from among all the tested location iterations.

The above methodology applies for the DL interference from MFCN BS to APs. For uplink interference (i.e. MFCN UE to AP), the joint location/time Monte Carlo approach is applied. In addition, a condition that no MFCN UE is closer than 1 m to an AP is set.

6.21.3 Technical parameters

6.21.3.1 Propagation model

Urban macro (Uma) pathloss and line-of-sight (LOS) probability modelling are based on ETSI TR 138 901, section 7 [39]. The building entry loss is calculated using Recommendation ITU-R P.2109 [15]. An additional 3 dB loss is considered to reflect the polarisation mismatch. The UEs are considered to be 70% indoor and 30% outdoor. The building type is considered to be 70% traditional and 30% thermally efficient, with this distribution applied to both MFCN UEs and WAS/RLAN APs. If both the MFCN UE and WAS/RLAN AP are indoors and if the ground distance (on x-y plan) is greater than 10 m, Recommendation ITU-R P.2109 is applied from both sides. If the ground distance (on x-y plan) is less than 10 m, the MFCN UE and the AP are considered to be in the same building, the TR 36.814 UE to HeNB Dual-stripe model (UE is inside the same house as HeNB) applies.

6.21.3.2 MFCN simulation parameters

The MFCN parameters are the ones from Table 5, Table 6 and Table 7. The BS load factor is fixed at 50% in all the simulations. The antenna configuration is Configuration 1. MFCN BS unwanted emission levels are based on the first and second approaches in section 3.1.1, and MFCN UE unwanted emission levels are based on the first and second approaches in section 3.1.2.

6.21.3.3 WAS/RLAN simulation parameters

The WAS/RLAN AP antenna gain is simulated in accordance with the distribution shown in Table 15. The AP antenna height is according to the urban distribution in Table 20. The bandwidths of 20, 40, 80, 160 and 320 MHz were studied. Finally, the WAS/RLAN rejection values are the ones computed in WAS/RLAN study 1 (see section 6.15) as $\boldsymbol{A_1} = 29$ dB, and $\boldsymbol{A_2} = 45$ dB.

6.21.3.4 Net filter discrimination (NFD)

The study uses the NFD to quantify the amount of transmitter energy falling into the receiver due to the combined filtering at both sides (transmitter and receiver). It is computed by integrating both TX and Rx filters on the overlapping spectrum portion. The method also includes a bandwidth adjustment factor which is applied when the interferer's assigned channel has greater bandwidth than the victim's receiver. As indicated on Recommendation ITU-R M.2101 [16]: "For scenarios involving IMT and non-IMT systems the co-channel and

adjacent channel effects could be considered jointly as frequency dependent rejection (FDR) as described in Recommendation ITU-R SM.337".

6.21.4 Study results

Simulations were carried out for 4000 WAS/RLAN AP topologies within the central MFCN sector. The impact on each WAS/RLAN AP, was assessed over 4000 "time" Monte Carlo runs. The simulations are assessed for the MFCN (BS and UE) masks in section 3.1.1 and in section 3.1.2 using both approaches of each section.

The results in Table 36 summarises percentage of WAS/RLAN AP locations for which no exceedance of I/N=−6 dB is permitted for any instance of time (0% of time), i.e. I/N is less than or equal to −6 dB all the time for all WAS/RLAN channel bandwidth and for different frequency offset set-up with an increment of 20 MHz up to 100 MHz. It can be observed that none of the studied scenarios allow a 0% probability of I/N exceeding -6 dB over time. In fact, only a 100 MHz frequency offset corresponding to the spurious emission levels allows to significantly reduce the % of locations where I/N exceeds -6 dB with a 0% probability over time for smaller WAS/RLAN BWs (below 80 MHz).

Recording the statistics of I/N=-6 being exceeded for each frequency offset, CCDF (complementary cumulative distribution function) of exceedance rate over the morphologies were generated for both SEM and ACLR approaches. For a 20 MHz WAS/RLAN channel bandwidth, it was observed that for SEM case, for example, if no frequency offset is applied, at 12% of locations, the I/N exceeds -6 dB with a probability of more than 10% over time, while at 3.5% of locations, the I/N exceeds -6 dB with a probability of more than 20% over time. For a 20 MHz channel, the 100 MHz frequency offset configuration is the only one offering very low percentages of locations where I/N exceeds -6 dB with low probabilities (< 2%) over time. The same exceedance values drop to 6.8% and 1.7% of the locations for the ACLR case.

Further investigation on which are the APs that are most impacted, indicated that the closest distance ring to the base station up to 75 m contains the highest percentage of morphologies (locations) exceeding the I/N with highest percentage of time.

Comparing the 0 MHz and the 100 MHz frequency offset cases for all possible WAS/RLAN bandwidths indicated that small bandwidths (i.e. 20, 40 and 80 MHz) benefit from the frequency offset. Larger bandwidths such as 160 MHz and 320 MHz experience less improvement as the overlapping is not only on the spurious emission part even after 100 MHz frequency offset.

Finally, the case of a population of WAS/RLAN APs operating with channel bandwidths according to distributions in Table 14 was investigated. As expected, increasing the frequency separation improves the results. However, compared to the 20 MHz case, where the percentage of morphologies (locations) decreases significantly with a frequency offset, the mixed-bandwidth population still indicates a higher percentage of impacted APs, due to the contribution of wider bandwidths (160 MHz and 320 MHz) to the overall results.

From the finding that the WAS/RLAN I/N limit of -6 dB is already exceeded even with a 100 MHz frequency separation between the WAS/RLAN upper band edge and the MFCN lower band edge, it follows that with no separation, multiple WAS/RLAN channels would be adversely affected.

It is to be noted that this study assesses the impact of aggregate interference from MFCN on WAS/RLAN APs.

Table 36: Percentage of WAS/RLAN LPI AP morphologies (locations) which exceed I/N=−6 dB for any instance of time (0% of time) for different frequency offsets

BW (MHz)	Frequency offset (MHz)											
	0	20	40	60	80	100	0	20	40	60	80	100
	Using SEM						Using ACLR					
20	88%	81%	77%	76%	76%	24%	76%	63%	62%	62%	62%	22%
40	86%	82%	77%	76%	66%	24%	76%	72%	63%	62%	54%	21%
80	85%	82%	79%	73%	58%	35%	76%	74%	71%	64%	49%	33%
160	80%	77%	75%	73%	69%	62%	71%	71%	70%	69%	66%	61%
320	72%	69%	66%	64%	62%	60%	63%	62%	62%	60%	59%	59%

6.22 ADJACENT CHANNEL INTERFERENCE FROM MFCN UES TO WI-FI AT 2400 MHZ AND 6425 MHZ – STUDY 8

6.22.1 Introduction

In some countries in Europe, MFCNs are permitted to operate in the 2300 MHz band (2300-2400 MHz) and in immediate frequency adjacent to Wi-Fi in the 2.4 GHz band (2400-2483.5 MHz). This is subject to ECC Decision (14)02 [41]. The MFCN block 2390-2400 MHz is assigned as a restricted block (for small cells), which effectively implies a 12 MHz edge-to-edge frequency separation (2390-2402 MHz) between the uppermost macro-cellular MFCN channel and the lowermost Wi-Fi channel.

This means that Wi-Fi equipment operating in the 2.4 GHz band would experience a certain level of interference from MFCN UEs operating in the 2300 MHz band. This could be used as a benchmark in assessing the potential for interference from MFCN UEs operating in the upper 6 GHz band (6425-7125 MHz) to Wi-Fi equipment operating in the lower 6 GHz band (5925-6425 MHz), and also in interpreting various other simulation results.

Accordingly, this study compares the I/N at Wi-Fi receivers due to interference from nearby MFCN UEs (23 dBm) across the 2400 MHz and 6425 MHz boundaries. It is assumed that a) MFCN and Wi-Fi both have channel bandwidths of 20 MHz in the 2300 MHz and 2.4 GHz bands, respectively, and b) MFCN has a channel bandwidth of 100 MHz in the upper 6 GHz and Wi-Fi has channel bandwidths of 80, 160 and 320 MHz in the lower 6 GHz band.

6.22.2 Scenario description

The scenario relates to a comparative minimum coupling loss (MCL) analysis of a) interference from MFCN UEs operating in the upper 6 GHz band to Wi-Fi equipment operating in the lower 6 GHz band across the 6425 MHz frequency boundary, and b) interference from MFCN UEs operating in the 2300 MHz band to Wi-Fi equipment operating in the 2.4 GHz band (accounting for the existing regulatory 12 MHz frequency separation) across the 2400 MHz frequency boundary. The interference is characterised in terms of the combination of a) the blocking of Wi-Fi receivers caused by the (carrier) emissions from the MFCN UEs and the finite frequency selectivity of the Wi-Fi receivers, and b) the unwanted out-of-block emissions from the MFCN UEs due to the finite frequency selectivity at their transmitters.

6.22.3 Technical parameters

6.22.3.1 Upper 6 GHz and lower 6 bands

An MFCN UE is modelled as transmitting in the upper 6 GHz band with a channel bandwidth of 100 MHz, an *e.i.r.p.* of 23 dBm, and bandwidth-adjusted ACLR values of 31, 29 and 27 dB for Wi-Fi bandwidths of 80, 160 and 320 MHz, respectively (derived from ETSI standards), assuming no edge-to-edge frequency separation with respect to Wi-Fi. MFCN UE unwanted emission levels are modelled according to the first approach described in section 3.1.2.

A Wi-Fi receiver is modelled as receiving in the lower 6 GHz band at a free-space line of sight distance of 1 metre from an MFCN UE transmitting in the upper 6 GHz band, with an antenna gain of -4 dBi, body loss of 4 dB, polarisation loss of 3 dB, noise figure of 9 dB, and ACS values of 30, 29 and 29 dB for Wi-Fi channel bandwidths of 80, 160 and 320 MHz, respectively (derived from IEEE standards), assuming no edge-to-edge frequency separation with respect to MFCN.

6.22.3.2 2300 MHz and 2.4 GHz bands

An MFCN UE is modelled as transmitting in the 2300 MHz band with a channel bandwidth of 20 MHz, an *e.i.r.p.* of 23 dBm, and a bandwidth-adjusted ACLR of 33 dB for a Wi-Fi bandwidth of 20 MHz (derived from ETSI standards), assuming a 12 MHz edge-to-edge frequency separation with respect to Wi-Fi as specified in ECC Decision (14)02 [39].

A Wi-Fi receiver is modelled as operating in the 2.4 GHz band at a free-space line of sight distance of 1 metre from an MFCN UE operating in the 2300 MHz band, with an antenna gain of -4 dBi, body loss of 4 dB, polarisation loss of 3 dB, noise figure of 9 dB, and an ACS value of 33 dB for a Wi-Fi channel bandwidth of 20 MHz (derived from IEEE standards), assuming a 12 MHz edge-to-edge frequency separation with respect to MFCN as specified in ECC Decision (14)02 [39].

6.22.4 Study methodology

The I/N at the Wi-Fi receiver is calculated via a minimum coupling loss (MCL) analysis corresponding to a free-space line of sight separation of 1 metre.

6.22.5 Study results

The analysis indicates that:

- The total coupling gain is 8.5 dB lower at 6425 MHz than at 2400 MHz;
- The Wi-Fi AP/client noise floor is 6-12 dB greater in the upper 6 GHz band than in the 2300 MHz band;
- The ACIR is 2.5-5.1 dB lower at 6425 MHz than at 2400 MHz (given a 0 MHz frequency separation at 6425 MHz and the regulatory 12 MHz frequency separation at 2400 MHz);
- As a result, the I/N is around 12 to 15 dB lower in the lower 6 GHz band than in the 2.4 GHz band.

The MCL analysis indicates that for similar geometries with an MFCN UE transmitter in free-space line of sight of a Wi-Fi receiver, the I/N at the receiver would be around 12 to 15 dB lower in the lower 6 GHz band (with a 0 MHz frequency separation) than in the 2.4 GHz band (with the regulatory 12 MHz frequency separation).

6.23 NON-GSO FSS DOWNLINK – STUDY 1

6.23.1 Introduction

This site-general study evaluates the co-channel aggregate received power levels from MFCN base stations (BSs) with full power to a non-geostationary earth station (non-GSO ES) of the fixed satellite service (FSS) operating in the downlink direction (space-to-Earth).

6.23.2 Scenario description

In order to derive the earth station azimuth and elevation statistics and to use the propagation model, this study considered latitude and longitude coordinates corresponding to Aussaguel, France (43.42° N, 1.49° E). This FSS ES is a gateway station that operates as a downlink non-GSO feeder link. The MFCN network consists of a 19-site cluster, each with 3 hexagonal sectors, totalling 57 BSs. In each Monte Carlo snapshot, 3 UEs are randomly and uniformly distributed within each sector, maintaining a minimum ground distance of 35 m from the BS.

6.23.3 Technical parameters

The MFCN BS parameters are based on the Macro Urban as detailed in Table 5. The UE parameters are provided in Table 6. The FSS parameters are detailed in section 4.2. In this study the HIBLEO-X satellite constellation is considered.

6.23.4 Study methodology

Monte Carlo simulations are performed to assess the aggregate interference from multiple MFCN BSs to a non-GSO FSS ES at a fixed distance. The MFCN network modelling is based on Recommendation ITU-R M.2101 [16]. The simulations are structured as follows:

- Simulation setup:
  - The propagation model in Recommendation ITU-R P.2001-4 [35] is used for links between stations on the Earth's surface. In Monte Carlo simulations, a smooth terrain profile and a random time percentage (Tpc) from 0.001 to 100% are assumed;
  - The clutter losses for terrestrial paths are calculated according to Recommendation ITU-R P.2108-3 [33] using a uniformly distributed random percentage of locations and are applied only on the MFCN side. The clutter loss model with random percentages is applied to all BSs;
  - A 3 dB polarisation loss is considered.
- For each snapshot, the following steps are carried out:
  - A hexagonal cell macro network with 19 sites is generated. Each site has 3 sectors, and 3 UEs randomly located within each sector (uniformly distributed);
  - The active MFCN BSs are determined based on the MFCN network loading factor;
  - The coupling loss between the MFCN BSs and the FSS ES is calculated. This value includes path loss, clutter loss, and the antenna gains of both the MFCN BSs and the FSS ES;
  - The aggregate interference from all MFCN BSs at the FSS ES receiver is calculated, considering the TDD activity factor. The aggregate interference is calculated as follows:

$$I_{External} = \sum_j \sum_k I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) \quad (10)$$

where:

- $I_{External}(TX_{BS_j}^{UE_k}, RX^{victim})$ is inter-system interference from BS_j (when its k-th UE is served) / UEk (served by BS_j) to the interfered receiver.

The interference per BS is calculated as follows:

$$I_{External}(TX_{BS_j}^{UE_k}, RX^{victim}) = PD_{tx} + G_{tx}(\theta_{tx}, \varphi_{tx}) - PL + G_{rx}(\theta_{rx}, \varphi_{rx}) \quad (11)$$

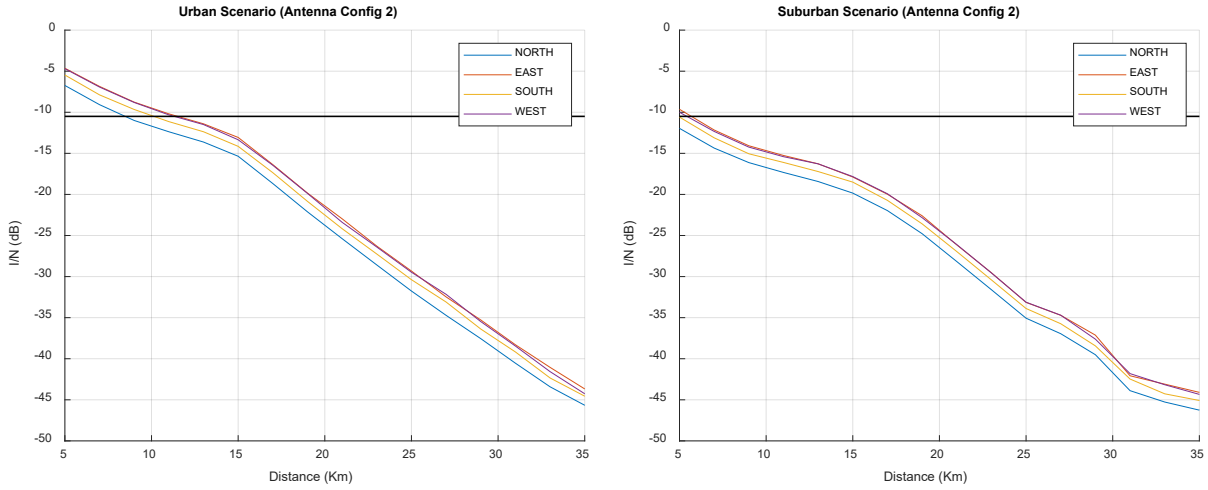
where:

- PD_{tx} is transmit station signal power density (dBm/MHz);
- $G_{tx}(\theta_{tx}, \varphi_{tx})$ is transmit station antenna gain in the direction of the receiver station (dBi);
- PL is path loss including clutter, polarisation, building entry, and body losses (when applicable) (dB);
- $G_{rx}(\theta_{rx}, \varphi_{rx})$ is receiver station antenna gain in the direction of the transmit station (dBi).

6.23.5 Study results

For both MFCN BS antenna configurations and assuming 50% network loading factor, simulation results indicate that, in both urban macro and suburban scenarios, aggregate interference from MFCN BSs to a non-GSO FSS feeder link (gateway) remains within acceptable long-term protection limits with reasonable separation distances. The FSS feeder link was modelled to the extent possible to accurately reflect realistic operation.

Figure 12 shows the relationship between the 80th percentile (long-term statistics) of the I/N cumulative distribution function (CDF) of the aggregate interference and the separation distance for the antenna Configuration 2, noting that slight longer distances are required for this configuration. Separation distances are provided assuming that the MFCN network is located to the north, east, south, and west of the FSS ES. The analysis indicates that separation distances of up to 12 km are sufficient to ensure the I/N criterion is met. These results confirm that, with appropriate coordination, MFCN BSs can coexist with non-GSO FSS ESs without undue interference.



(b)

Figure 12: Antenna Configuration 2 - 80th percentile of the I/N CDF vs separation distance: (a) urban scenario and (b) suburban scenario

6.24 NON-GSO FSS DOWNLINK – STUDY 2

6.24.1 Introduction

This study assesses the impact of MFCN in the upper 6 GHz on FSS DL operation.

6.24.2 Scenario description

The MFCN network consists of a 19-site cluster where each site comprises 3 hexagonal sectors leading to 57 BS in total. The victim ground station is located in the centre of the reference area, and the MFCN cluster is moved to different distances and azimuths. For each distance/azimuth, the CDF of the stored aggregate I/N values is generated. Monte Carlo simulations are run for 100000 snapshots for each distance/azimuth.

The aggregate interference is computed from the contribution of both BS and UE with an apportionment of 75% and 25% of the samples respectively. The total number of active MFCN BS or UE, is simulated taking into account a load factor of 50%. The load factor is modelled by a Bernouilli distribution with a probability of 0.5.

6.24.3 Technical parameters

6.24.3.1 MFCN base station and user equipment parameters

The MFCN base station parameters are based on the Macro Urban case, Configuration 1, as depicted in Table 7. The UE parameters are the ones in Table 6. UE heights follow ECC Report 364 [18], however, only UEs within the 90-100° elevation range are retained. Outdoor UEs are assigned a height of 1.5 m.

6.24.3.2 FSS DL ground station parameters

This study assessed HIBLEO-X constellation corresponding to carrier 7 in Table 10. HIBLEO-X was simulated for a sufficient period of time with a time step of 10 seconds, and the elevation and azimuths of each satellite were stored as seen from an earth station that would have geographical coordinates corresponding to Aussaguel (France).

6.24.3.3 Propagation parameters

The studied scenario is urban. Recommendation ITU-R P.452-17 [32] was used for path loss computation with a percentage of time randomly picked between 0 and 100% but caped at 50%. For clutter loss Recommendation ITU-R P.2108 [33] was used with a random percentage of location spanning all the possible range. Indoor UEs are subject to BEL in accordance with Recommendation ITU-R P.2109 [15], with a random percentage.

6.24.4 Study methodology

The aggregate interference from the MFCN system towards the FSS ground station is due to the BS contribution or to the UE contribution. Given the TDD factor, any Monte Carlo simulation is made of 75% samples due to the BS interference and 25% due to the UE interference. In all cases, the aggregate interference is computed as follows:

$$I_{aggregate} = 10 \times log_{10}\left(\sum_{i=1}^{N} 10^{\frac{I_i}{10}}\right) \quad (12)$$

where Ii is the interference created by the interferer number i:

$$I_i = P_{tx} + Gt_i\left(\theta_{t_i}, \phi_{t_i}\right) + Gr_i\left(\theta_{r_i}, \phi_{r_i}\right) - PL_i \quad (13)$$

where:

- N is the total number of active MFCN BS or UE, considering a load factor of 50%. The load factor is modelled by a Bernouilli distribution with a probability of 0.5;
- P_{tx} is the MFCN BS/UE conducted power;
- Gt is the MFCN BS/UE antenna gain towards the FSS earth station in the directions θ_{t_i}, ϕ_{t_i}, bearing towards the ground station;
- Gr is the FSS ground station antenna gain towards the MFCN BS/BS in the direction θ_{r_i}, ϕ_{r_i}, bearing towards each MFCN BS. In the case of the Recommendation ITU-R S.465 [24], the gain depends on one direction only which is the 3D angle ψ_i;
- PL_i is the loss from the propagation model based on Recommendation ITU-R P.452-17 [32] and clutter loss Recommendation ITU-R P.2108. A polarisation mismatch of 3 dB is taken into account in the propagation loss. Indoor UEs are subject to BEL in accordance with Recommendation ITU-R P.2109, with a random percentage.

6.24.5 Study results

Simulation were carried out taking into consideration the above parameters and scenarios. The earth station is centred at the position (0,0), the position of the MFCN network is varied and Monte Carlo simulations are run for 100000 snapshots. Distance in the Figure 13 represent the separation between the earth station and the centre of the MFCN network. At each snapshot the position of the UE inside each cell is varied, the earth station azimuths and elevations are also varied according to the tracked satellites positions.

These simulations were carried out for several distances and azimuth around the earth station. The aggregate I/N is stored to generate the CCDF for each distance.

In Figure 13, simulations results for the HIBLEO-X constellation (communication mode, elevation > 10°) versus the Urban Configuration 1 are plotted. The load factor is fixed at 50%, the number of BS on which the clutter loss is applied is fixed to 65% of the total BS (below rooftops percentage), and no clutter loss is applied on the earth station side. It is assumed that for all studied distances, the MFCN cluster is situated within an urban environment in order to be able to apply Recommendation ITU-R P.2108 [33]. In Figure 13, results, where the clutter loss is applied to all BS, are also plotted.

The results indicate that, in the configurations described above, to meet the long-term protection criterion, in the case where the clutter applied to 65% of BS, a protection distance ranging between 27.5 km and 30.5 km is necessary. In the case where clutter loss applies to all BS, the distances ranges between 7.6 km and 14.8 km. In both scenarios, the north direction is showing the minimum distance, the maximum ranges are south and +/-60° azimuth. This can be explained by the fact that for the north direction, the earth station is always pointing above a 50° elevation, leading to a minimum earth station gain towards the horizon. For the south direction, the heading of all sectors aligned with the x-axis is directly pointing to the earth station with 0° azimuth offset. For the +/- 60°, the range is maximum due to the fact that the earth station gain towards the horizon is maximum given the number of occurrences of satellites at low elevations.

However, to meet the short-term protection criterion, protection distances vary between 97 km and 200 km for the case of clutter applied to 65% of the stations, and from 20 km to 38 km in the case where all BS are under clutter. The results with 65% of stations under clutter appear to be rare and may be mitigated through site specific studies.

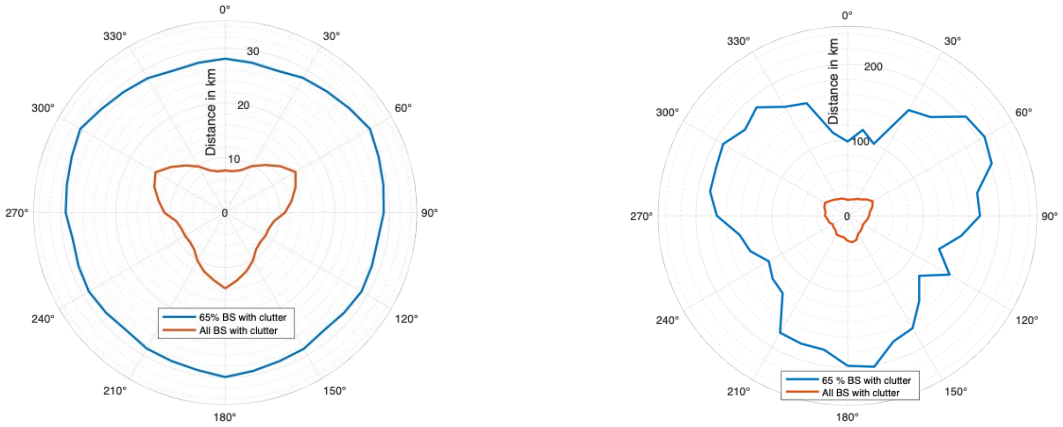


Figure 13: Results for the long-term (left) and short-term criteria (right) versus the distance

6.25 MFCN INTERFERENCE INTO UWB – STUDY 1

6.25.1 Introduction

This study of MFCN interference into UWB (Ultra-Wide Band) at 6 GHz indicates the impact from three MFCN macro-cell urban networks to an outdoor UWB when operated co-channel.

6.25.2 Scenario description

This study focused on UWB uses such as building access (door locks) or vehicle access (digital keyless entry) used for unlocking, locking after exit, engine start. It is assumed that the UWB device is located outdoor and is interfered by three MFCN macro-cell urban networks of 57 sectors each. The UWB devices were deployed uniformly over a simulation cell range (hexagonal shape area) of 400 m (same area as an MFCN sector).

6.25.3 Technical parameters

The UWB system is characterised by parameters set in section 4.4 where maximum allowable interference level is not based on I/N but measured as −78 dBm/500 MHz as in ECC Report 302 [30]. However, it is about the same level as an I/N of 0 dB.

The MFCN BS and UE parameters used are those defined in section 3.2.3 (Configuration 1).

The propagation models have been used according to section 5.1. For scenarios where the victim system is located within the MFCN network the pathloss (including clutter) and line-of-sight (LOS) probability modelling based on ETSI TR 138 901 with LoS probability, section 7.4 [37] were used for distances below 5 km.

6.25.4 Study methodology

The study was made using SEAMCAT. A Monte Carlo simulation was performed under the assumption of a three MNO configurations because of the spectrum overlap of 3 MNOs with UWB channel 5 at 6 GHz (see Figure 14). The UWB device is positioned separately from the UE, within the centre reference cell, ensuring their positions remain decorrelated. This assumption does not account for real-world cases where the UWB device may be in the proximity of a UE, like for instance a passenger holding a UE connected to the BS that interferes with the vehicle.

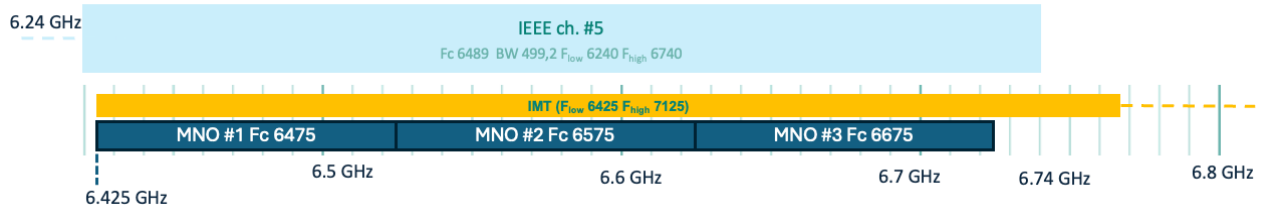


Figure 14: MFCN spectrum overlap of 3 MNOs with UWB channel 5

6.25.5 Study results

Results indicate the level of interference caused by three MNOs in the same area to an outdoor UWB device under the stated assumptions. Results include effects of both DL and UL, presented as a post-processed combination of DL and UL.

Result indicate that in 75% of Monte Carlo events (space and time), the interfering signal exceeds −78 dBm, which is equivalent to a Rx sensitivity degradation of 3 dB. Results also indicate that in an uncorrelated case (UE statistically distant from the UWB), the predominant interference originates from DL.

6.26 ANALYSIS ON MFCN BS ANTENNA HEIGHT ASSUMPTIONS

6.26.1 Introduction

This analysis investigates the placement of existing MFCN base station antennas in the 3.5 GHz (n78) band in Paris with respect to surrounding buildings. The analysis was carried out to provide empirical evidence on whether current CEPT assumptions regarding the percentage of deployed antennas below rooftops used in

coexistence studies are representative of real deployments. The findings are intended for future consideration, as it has often been assumed that the percentage of base station antenna deployment below rooftop is 65%.

6.26.2 Scenario description

The analysis focused on the municipality of Paris, selected as a representative dense European urban environment. The analysis combined official datasets on licensed base stations, building footprints and heights, and the municipal boundary. Terrain information was also included through a high-resolution national Digital Terrain Model. The assessment considered antennas located strictly within the administrative boundary of Paris and classified them as above or below rooftops depending on their relative height compared to surrounding buildings within analysis areas of 100 m, 400 m, and 600 m radius. The 400 m radius was used as the main reference, consistent with the cell size assumption in Table 5.

6.26.3 Technical parameters

The analysis relied on three main datasets. The first was the ANFR base station database[16], which provides details of all licensed transmitting antennas in France with an *e.i.r.p.* of at least 5 W. From this dataset, antenna coordinates were extracted, and antenna heights were normalised using the SUP_NM_HAUT field, expressed in metres above ground level (AGL), and above mean sea level (AMSL) – the latter calculated using a 5 m-resolution Digital Terrain Model[17]. The second dataset was the official national building database[18], which provides building footprints together with a generalised rooftop value derived from the national elevation models. Finally, the Paris administrative boundary dataset was used to ensure that only antennas physically located within the municipal boundary were retained for analysis.

To ensure robustness of the results, several quality filters were applied. Antennas with implausibly low heights (below 1 m AGL) were excluded to remove underground or anomalous records. Duplicate entries were removed by collapsing records that referred to the same physical installation, defined by location, height, azimuth, beamwidth and frequency band. This ensured that the analysis considered unique antenna deployments while preserving the diversity of frequency bands in use.

6.26.4 Study methodology

For each antenna, the surrounding environment was characterised within analysis areas of 400 m radius (100 m and 600 m were used for sensitivity analysis). Where information on antenna orientation was available, the analysis area took the form of a sector, with a default beamwidth of 120°, otherwise, a circular area was applied. All buildings intersecting the area were considered, with the exception of the building hosting the antenna itself, in order to avoid self-bias. The analysis did not consider other obstructions, such as vegetation.

The rooftop height reference was determined using three statistical measures - the mean building height within the selected area, the median building height, and the 90th percentile (P90) building height. As part of a sensitivity analysis, the maximum building height within the selected area was also considered. An antenna was classified as above rooftops if its height exceeded the chosen rooftop height reference (either AGL or AMSL).

6.26.5 Study results

As indicated in Figure 15, the results depend on the statistic used to define the rooftop height reference. Using the mean or median rooftop height, approximately 99% of n78 antennas in the municipality of Paris are located above the reference level within a 400 m sector, whereas using the P90 reduces this proportion to 84%. The

[16] Données sur les installations radioélectriques de plus de 5 watts – https://www.data.gouv.fr/datasets/donnees-sur-les-installations-radioelectriques-de-plus-de-5-watts-1/

[17] IGN RGE ALTI® – https://geoservices.ign.fr/rgealti

[18] "Base Nationale des Bâtiments" millesime 2024-10.a (26 February 2025) – https://www.data.gouv.fr/datasets/base-de-donnees-nationale-des-batiments/

sensitivity analysis further indicates that 16% of antennas are above the maximum rooftop elevation within the sector.

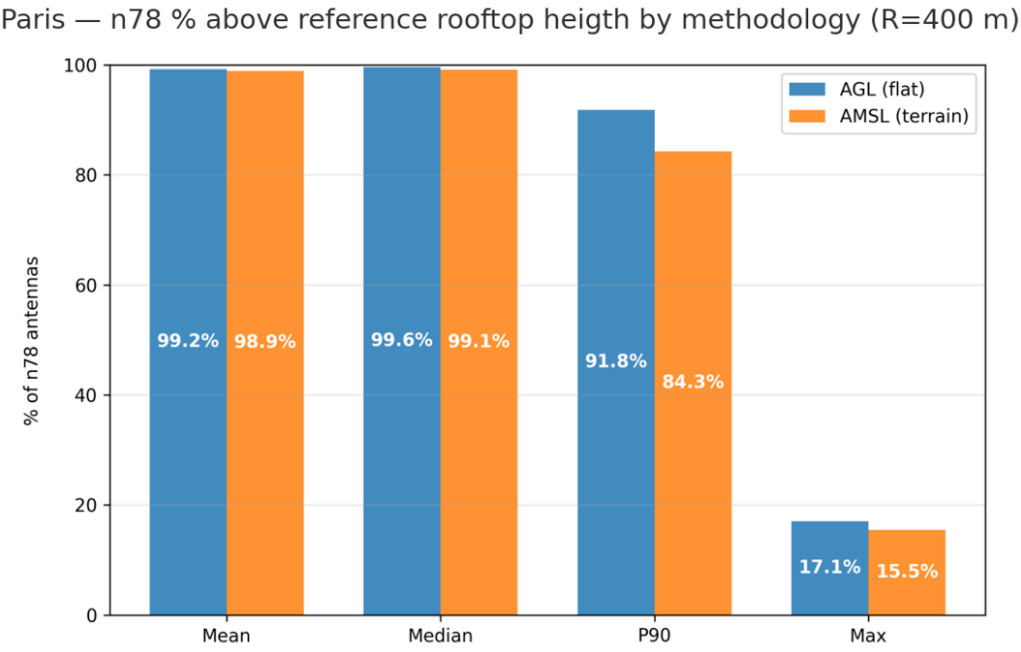


Figure 15: Percentage of n78 antennas in Paris above rooftops within a 400 m sector/radius under different rooftop height reference definitions (mean, median, 90th percentile, maximum building rooftop height), AMSL

7 CONCLUSIONS

This section summarises the overall conclusions of the studies in this Report grouped by incumbent services.

Studies were conducted in accordance with MFCN deployment parameters and scenarios as defined in section 3. This includes full power and reduced power base stations, operating with a maximum channel bandwidth of 100 MHz. In addition to that, when considering the UE contribution to the interference, only UE power class 3 with a maximum 23 dBm *e.i.r.p.* was considered.

7.1 SHARING BETWEEN MFCN AND FS

In-band/co-channel sharing between MFCN and FS was studied in this Report. These studies used Minimum Coupling Loss (MCL) and Monte Carlo analyses and compared the results against the long-term and the Fractional Degradation in Performance (FDP) protection criteria for the FS. The studies estimated the minimum geographical separation between a MFCN base station and a FS receiver at which the interference at the input of the FS receiver would not exceed the protection criteria.

Studies assessed urban and suburban scenarios as it has been assumed that contiguous coverage by the MFCN BSs is not expected in rural areas in the 6425-7125 MHz band. Study 1, additionally, assessed the coexistence conditions considering rural MFCN base stations.

Studies in this report indicate that the separation distance for co-channel sharing depends on multiple factors, e.g. the protection criteria used (i.e. I/N or FDP), the extent to which radio clutter (e.g. vegetation and buildings) is assumed to impact interference paths and the application of the propagation models (e.g. time percentages, percentage of locations). For example studies assuming clutter applied to a higher proportion of interference paths (up to 100%) and/or applying the long-term protection criterion and/or using propagation models with higher attenuation reported shorter separation distances.

In summary, studies have indicated separation distances ranging from 42 km to 321 km in the main beam of the FS receiver, and from 2 km to 56 km outside of the main beam of the FS receiver, specifically:

- A Monte Carlo study (Study 2) applied clutter loss to all interference paths. Based on the long-term criterion, it indicated separation distances of 42 to 56 km within the FS receiver main lobe, and 2 to 4 km for the side lobes. Based on the FDP criterion, it evaluated separation distances up to 68 km within the FS receiver main lobe;
- Two Monte Carlo studies (Studies 3 and 7) applied clutter loss to 65% of the interference paths. These studies have indicated separation distances of 67 to 105 km within the FS main lobe for the long-term criterion and 244 to 310 km when the FDP criterion was considered. If clutter loss is applied to 100% of interference paths, separation distances are in the range between 51 to 72 km within FS main lobe for the long-term protection criterion, and between 59 to 124 km if the FDP criterion is used. Outside the FS receiver main lobe, separation distances ranged from 33 km to 53 km for the long-term and the FDP criteria. A Monte Carlo study (Study 5) found that the required separation distance in the main lobe ranges from 52 km to 87 km depending on the MFCN deployment configuration using the long-term criterion, assuming no clutter loss applied to any interference path and with an antenna steering range limited to 3 degrees below the horizon;
- A Monte Carlo study (Study 6) used the Recommendation ITU-R P.452-18 [32] propagation loss model which accounts for MFCN BS, UE, FS and representative clutter heights and yields lower clutter loss estimates. These estimates were applied to all interference paths. Under the long-term protection criterion, the study found separation distances of 165 km within the FS receiver main lobe for the long-term criterion, increasing to 314 km when using the FDP criterion. Outside the FS receiver main lobe, distances remained below 10 km but could go up to 29 km for higher MFCN base stations at a height of 22.5 m;
- An MCL study (Study 1) considers the actual FS deployment in the band in a CEPT country and the actual terrain elevation. In addition to assuming MFCN BS peak gain and *e.i.r.p.* in the direction of victim FS receiver, it includes a scenario where the MFCN BS emission above the horizon is reduced by up to 36 dB to comply with the expected *e.i.r.p.* mask from Resolution 220 (WRC-23). Clutter loss was applied to all interference paths, with different location probabilities depending on the simulated environment. For full power MFCN base stations, the study reports median separation distances ranging from 53 km to 129 km within the FS receiver main lobe depending on the clutter environment for the long-term criterion. This

study also considered a reduced MFCN BS *e.i.r.p.* of 57 dBm/100 MHz) which resulted in shorter separation distances in the range of 31 to 61 km again for the long-term criterion.

For Monte Carlo studies, the use of joint or separated time and location statistics [19] impacts the results. Study 7 indicated that even when applying the separation distances computed using joint location/time Monte Carlo, not all location morphologies using separated location/time Monte Carlo would comply with the protection criteria.

Some studies assessed interference using FS data from administrations (operating in the upper 6 GHz band), and in some cases (Study 4 and 8) also using real MFCN deployment sites in the 2.6 GHz and/or 3.6 GHz band:

- An MCL study (Study 1) assuming MFCN BS peak gain and *e.i.r.p.* in the direction of victim FS receiver, evaluated interference against the long-term protection criterion. This study also examined a case where the MFCN BS emissions above the horizon were reduced by up to 36 dB to comply with the expected *e.i.r.p.* mask from the Resolution 220 (WRC-23). The results indicated that 58% of the national territory under study would be excluded from MFCN deployment when the expected *e.i.r.p.* mask was applied and 86.6% without the expected *e.i.r.p.* mask. When assuming reduced MFCN *e.i.r.p.* of 57 dBm/100 MHz, the impacted areas dropped to 34.9% with the expected *e.i.r.p.* mask applied and 54.5% without that expected *e.i.r.p.* mask;
- An MCL study (Study 4) applied the long-term protection criterion, including both full power MFCN BSs and up to a 36 dB power reduction to comply with the expected *e.i.r.p.* mask. Clutter loss was applied to all interference paths, with different location probabilities depending on the simulated environment. At full *e.i.r.p.* level, 10% of MFCN BSs (expected *e.i.r.p.* mask not applied) up to 40% of MFCN BSs (with the expected *e.i.r.p.* mask applied) in urban areas, could operate without impacting FS. These increased to 55% and 85% respectively for a reduced MFCN BS *e.i.r.p.* level of 57 dBm/100 MHz;
- A site-specific separated time and location Monte Carlo study (Study 8) was used to evaluate interference against the long-term and FDP protection criteria. The study found that about 30% of the studied FS receivers had the long-term protection criterion met, while only 20% met the FDP criterion.

The calculated separation distances give an indication of the size of the geographic areas within which coordination between MFCN and the existing services might be required, although in practice these will vary depending on location-specific conditions such as terrain and clutter.

The main method to enable coexistence between MFCN and FS receivers is to apply a sufficient separation distance between MFCN base station transmitters and FS receivers, and to limit MFCN base stations to not transmit in FS main beam directions. Some studies considered the following mitigation techniques to improve coexistence between MFCN base station transmitters and FS receivers:

- Limiting the MFCN BS beam steering to reduce the interference towards the relevant receiver, including limiting the beam directions so that they point at 3 degrees or more below the horizon (Study 5);
- Adjusting the MFCN antennas' mechanical downtilt (Study 5) and azimuth (considered in all studies) to avoid coupling with the FS main lobe;
- Downlink subcarrier blanking in the MFCN signals to avoid the use of specific parts of the band during downlink transmissions (Study 5);
- Operating MFCN base stations at a lower *e.i.r.p.* level (Studies 1 and 4).

According to Study 5, combining the first three techniques reduced the required separation distance in the FS side lobe to around 1 km when considering the long-term protection criterion for the FS link.

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[19] The studies used two different Monte Carlo approaches:

- Joint location/time Monte Carlo: Location- and time-dependent parameters are randomly sampled together during each Monte Carlo event. The results are expressed as the percentage of events (i.e. joint location and time instances) where interference exceeds a given threshold;
- Separated location/time Monte Carlo: Location-dependent parameters are sampled in one loop (the morphology loop), and time-dependent parameters in a separate loop (the time loop). The results are expressed as the percentage of locations (morphologies) where interference exceeds a threshold with a certain probability over time.

The time variation is due to beamforming activity at the base station.

7.2 SHARING AND COMPATIBILITY BETWEEN MFCN AND RAS

Sharing and compatibility between MFCN and RAS was studied through MCL and Monte Carlo simulations. The estimated separation distances provided below, indicate the areas in which coordination (e.g. interference mitigation measures) might be needed. Key modelling parameters affecting the separation distance are:

- the assumption made about the propagation changes with respect to atmospheric conditions, in particular temporal variability;
- the extent to which clutter is assumed to impact interference paths.

In studies, which assume that not all interference paths are impacted by clutter, for the in-band case, the resulting separation distances range from 130 km to 380 km depending on the assumptions used, specifically:

- Studies assuming annual-average atmospheric conditions (time percentage = 50%) estimated separation distances of 150 to 170 km (Studies 3 and 4), noting that RAS is usually afforded protection for larger proportion of time;
- Studies that considered variable atmospheric conditions (time percentage between 0% and 100% as appropriate, see section 5.1) found larger separation distances of 370 to 380 km (Studies 2 and 5). Study 1 used terrain and clutter along the path, and included an additional assumption about the tropospheric propagation, leading to a separation distance of 130 km. Study 1 also examined separation distances for a network of local VLBI RAS stations with 29 dB less stringent protection criterion than a single dish, resulting in separation distances of 70 km to 85 km.

In studies, which assume that all interference paths are impacted by radio clutter, for the in-band case, the resulting separation distances range from 60 km to 220 km, depending on the assumptions used, specifically:

- Studies assuming annual-average atmospheric conditions estimated separation distance of 60 km (Studies 3 and 4);
- Studies that considered variable atmospheric conditions found longer separation distances of 90-220 km (Studies 2, 5 and 6).

For the adjacent channel and spurious domain cases, the resulting separation distances were 100 km and 25 km respectively (Study 2).

The calculated separation distances give an indication of the size of the geographic areas within which coordination between MFCN and the existing services might be required, although in practice these will vary depending on location-specific conditions such as terrain and clutter.

In addition, some studies considered the following mitigation techniques to improve coexistence between MFCN and RAS receivers, i.e.:

- Avoiding MFCN antenna beam pointing toward RAS receivers (Study 2);
- Adjusting the MFCN antennas' azimuth (Studies 2 and 6) to avoid pointing towards the RAS receivers;
- Operating MFCN base stations at a lower *e.i.r.p.* level (Study 1);
- Applying frequency separation (Study 2);
- Ensuring that clutter is present between MFCN BS and RAS sites (Studies 2 and 6).

7.3 ADJACENT BAND COEXISTENCE BETWEEN MFCN AND WAS/RLAN

Adjacent band coexistence between MFCN in the upper 6 GHz band and WAS/RLAN in the lower 6 GHz band, was evaluated through a number of Monte Carlo studies and a Minimum Coupling Loss analysis. Most of the studies focused on two types of WAS/RLAN deployments: low power indoor (LPI) APs and very low power (VLP) outdoor equipment, but some studies also considered client devices indoor and outdoor (with and without body loss) as well as VLP equipment indoor. All of the studies analysed the impact on the individual WAS/RLAN receiver.

In the Monte Carlo studies, the locations of MFCN UEs and WAS/RLAN equipment were modelled as independent random variables and without any correlation.

The simulations considered scenarios with no edge-to-edge frequency separation (0 MHz) as well as cases with frequency separation of more than 0 MHz between the two systems. Interference statistics were presented in two formats: one where location and time statistics are combined; and another where location and time statistics are presented separately.

The calculated level of interference at WAS/RLAN receivers from MFCN BSs depends on several key assumptions:

- The amount of out-of-band emission of MFCN transmitters;
- The adjacent channel selectivity of WAS/RLAN receivers, depending on whether ETSI or IEEE specifications are used;
- The sensitivity of WAS/RLAN receivers;
- Whether joint (combined) or separated location and time statistics are considered in the case of WAS/RLAN LPI APs (joint location and time statistics only are considered for VLPs);
- Distances and the minimum distance between WAS/RLAN equipment and MFCN BSs as assumed in the simulations;
- Location of MFCN UEs, particularly whether indoor users are assumed to be positioned at a range of heights over a number of building floors and accordingly draw the MFCN BS beams towards them.

The probabilities of interference-to-noise ratio (I/N) at the WAS/RLAN receivers exceeding nominal values of 0 dB and −6 dB are assessed in the studies and reported below.

Studies based on the ETSI specified absolute basic limits on MFCN BS ACLR equivalent to −6 dBm/MHz and modelled as +7 dBm over a measurement bandwidth of 20 MHz provide the following results:

- Studies 1 and 2 examined interference from MFCN BSs to WAS/RLAN LPI APs, with BS beams directed towards UEs positioned 1.5 m above ground. A minimum BS-UE and BS-AP separation of 35 m was assumed, along with IEEE-compliant WAS/RLAN receiver selectivity. Analysing joint location and time statistics and assuming 0 MHz frequency separation, the studies indicate that LPI APs experience an I/N which exceeds 0 dB and −6 dB with probabilities of 0.8% and 1.5% (Study 1) and 0.9% and 1.8% (Study 2), respectively. The above results correspond to the distribution of WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz as specified in ECC Report 364 [18];
- Studies 1, 3 and 4 also examined interference from MFCN BSs to WAS/RLAN LPI APs with similar assumptions as above, but with MFCN UEs positioned at a range of heights consistent with WAS/RLAN equipment distribution from ECC Report 364 [18]. Analysing joint location and time statistics, and assuming a 0 MHz frequency separation, the studies indicate that LPI APs experience an I/N which exceeds 0 dB and −6 dB with probabilities of less than 1.5% and 3% in Study 1, 1% and 2% in Study 3, 0.5% and 1.2% in Study 4, respectively. Study 1 also combined the results for different WAS/RLAN receiver types, based on the distribution of LPI APs, and STAs/VLPs indoor and outdoor (both with and without body loss) specified in ECC Report 364. This showed that mixed population of WAS/RLANs experience an I/N which exceeds 0 dB and −6 dB with probabilities of 1.2% and 2.4%, respectively;
- Studies 5 and 7 examined interference from MFCN BSs to WAS/RLAN LPI APs, assuming UEs at a range of heights consistent with ECC Report 364 [18]. A minimum BS-UE separation of 35 m and a minimum BS-AP separation of about 10 m was assumed, and in the case of Study 7, a minimum UE-AP separation of 1 m. ETSI-specified WAS/RLAN receiver selectivity was assumed for Study 5, whereas IEEE-specified WAS/RLAN receiver selectivity was assumed for Studies 5 and 7. Referring to separated location and time statistics for WAS/RLAN with a channel bandwidth of 20 MHz and assuming a 0 MHz frequency separation, Study 7 shows that 7% of LPI APs experienced an I/N which exceeds −6 dB with a probability of more than 10% over time using MFCN BS ACLR and IEEE WAS/RLAN ACS. This percentage of affected LPI APs could rise to around 30% (Study 7, using MFCN BS SEM and IEEE WAS/RLAN ACS) or 47% (Study 5, using MFCN BS ACLR and ETSI WAS/RLAN ACS) when considering only LPI AP locations within 75 m of an MFCN BS (this area captures up to 6% of the total number of locations simulated). Study 5 shows that if LPI APs in this area were more sensitive (−92 dBm/20MHz) then 50% of them would experience an I/N which exceeds −6 dB more than 26% of the time. Both studies indicate that a 100 MHz frequency offset can reduce the proportion of impacted LPI APs experiencing interference exceeding the I/N of −6 dB. Larger bandwidths (above 160 MHz) did not benefit significantly more from the 100 MHz offset compared to the smaller bandwidth channels (20 MHz, 40 MHz and 80 MHz).

As a sensitivity analysis, Studies 5 and 7 also provided results assuming MFCN BS emissions limits at the level of the ETSI-specified operating band unwanted emissions (see Table 2). Results can be found in section 6.

Regarding the outdoor VLP use case (with body loss), the level of interference observed for a 0 MHz frequency separation was examined by Studies 1 and 6 based on joint location and time Monte Carlo analysis, IEEE-specified WAS/RLAN ACS values. These studies found that 1.5% (Study 1) and 4-7% (Study 6 depending on the bandwidth) of VLP links would experience an I/N which exceeds −6 dB. The percentages reduce to 0.7% (Study 1) and 2-4% (Study 6 depending on the bandwidth) for an I/N of 0 dB. Study 6 also indicated that if using the SEM on the MFCN side, those exceedance rates can range between 4 to 9% depending on the bandwidth.

The above results for Study 1 correspond to the distribution of WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz as specified in ECC Report 364 [18], whereas the results for Study 6 correspond to a range of WAS/RLAN channel bandwidths from 20 MHz to 320 MHz.

In addition to the above studies, further assessments were made:

- Study 4 also looked at the impact on WAS/RLAN throughput. Using joint location/time statistics and a 0 MHz frequency separation, it estimated that interference from MFCN could lead to a throughput degradation of less than 0.65%;
- Study 8 analysed potential interference levels from MFCN UEs in upper 6 GHz band to WAS/RLAN equipment in the lower 6 GHz band and compared these to interference from MFCN UEs in 2300 MHz band to WAS/RLAN in the 2.4 GHz band. A minimum coupling loss (MCL) analysis indicated that for similar geometries with an MFCN UE transmitter in free-space line-of-sight of a WAS/RLAN receiver, the I/N at the receiver would be around 12 dB to 15 dB lower in the lower 6 GHz band (with a 0 MHz frequency separation) than in the 2.4 GHz band (with MFCN operating at the high-frequency end of its band, just below 2390 MHz implying a 12 MHz frequency separation).

7.4 SHARING BETWEEN MFCN AND NON-GSO FSS DOWNLINK

Two site-generic studies explored in-band sharing between MFCN and non-GSO FSS downlink. They investigated separation distances in order to protect the operation of non-GSO FSS earth stations for communication mode (Satellite elevations above 10°). The separation distances range from 12 km to 30 km, based on long-term protection criteria. These protection distances are site specific and depend on several elements such as the propagation parameters, local terrain topography, clutter surrounding the earth station, orbital parameters of the non-GSO system, satellite selection strategy and MFCN BS orientation towards the earth station.

7.5 SHARING BETWEEN MFCN AND UWB

A Monte Carlo study considered sharing between MFCN and UWB (channel 5). It assessed interference to a handheld UWB device from a 19-site MFCN cluster operating at full power at varied network load levels.

The findings indicated that, an interference threshold of −78 dBm/500 MHz (as measured and reported in ECC Report 302, and approximately corresponding to an I/N of 0 dB) is exceeded in 75% of simulated events. The time domain aspect of MFCN and UWB operation has not been investigated in this Report. An analysis of some technical documentations and measurements suggest that this threshold may be relaxed depending on the UWB use case.

7.6 OBSERVATIONS ON MFCN BS ANTENNA LOCATION

In addition to the coexistence studies, an analysis of actual base stations in the 3400-3800 MHz band in Paris (see section 6.26) was performed. FS study 4 also performed an analysis of the actual MFCN BS deployment in a CEPT country in the 3.6 GHz band.

ANNEX 1: EXTRACT OF THE EUROPEAN COMMON ALLOCATION TABLE FOR THE FREQUENCY BAND 5925-7250 MHZ [43]

Frequency range (MHz)	RR Region 1 Allocation and RR footnotes applicable to CEPT	European Common Allocation and ECA footnotes	Applications	Notes
5925-6700 MHz	FIXED(5.457), FIXED-SATELLITE (EARTH-TO-SPACE)(5.457A, 5.457B), MOBILE(5.457C, 5.457E) 5.149 5.440 5.458	FIXED , FIXED-SATELLITE (EARTH-TO-SPACE) (5.457A), MOBILE (5.457E), Earth Exploration-Satellite (passive) 5.149 5.440 5.458	ESV	Within the band 5925-6425 MHz
			FSS Earth stations	
			Fixed	Point-to-point
			ITS	Urban rail systems only 5925–5935 MHz. Safety related applications within the band 5875-5935 MHz
			LPR	
			Passive sensors (satellite)	For sea surface temperature, sea surface wind speed and soil moisture measurements
			RLAN	Within the band 5945-6425 MHz
			Radio astronomy	Spectral line observations (e.g. methanol line), VLBI.
			TLPR	
			UWB applications	Generic UWB as well as UWB on-board aircraft regulation within the band 6.0-8.5 GHz
			VSAT	
6700-7075 MHz	FIXED, FIXED-SATELLITE (EARTH-TO-SPACE) (SPACE-TO-EARTH)(5.441), MOBILE(5.457E) 5.458 5.458A 5.458B	FIXED, FIXED-SATELLITE (EARTH-TO-SPACE) (SPACE-TO-EARTH)(5.441), MOBILE (5.457E), Earth Exploration-Satellite (passive) 5.458 5.458A 5.458B	Feeder links	
			Fixed	Point-to-point
			LPR	
			Passive sensors (satellite)	For sea surface temperature, sea surface wind speed and soil moisture measurements
			TLPR	
			UWB applications	Generic UWB as well as on-board aircraft regulation

Frequency range (MHz)	RR Region 1 Allocation and RR footnotes applicable to CEPT	European Common Allocation and ECA footnotes	Applications	Notes
				within the band 6.0-8.5 GHz
			VSAT	
			Video PMSE	Cordless Cameras; Portable video links; Mobile video links; Temporary point-to-point video link within 7-8.5 GHz.
7075-7145 MHz	FIXED, MOBILE(5.457E) 5.458	FIXED, MOBILE (5.457E), Earth Exploration-Satellite (passive) 5.458	Fixed	Point-to-point
			LPR	
			Passive sensors (satellite)	For sea surface temperature, sea surface wind speed and soil moisture measurements
			UWB applications	Generic UWB as well as on-board aircraft regulation within the band 6.0-8.5 GHz
			Video PMSE	Cordless Cameras; Portable video links; Mobile video links; Temporary point-to-point video link.
7145-7190 MHz	FIXED, MOBILE, SPACE RESEARCH (DEEP SPACE) (EARTH-TO-SPACE) 5.458	FIXED, MOBILE, SPACE RESEARCH (DEEP SPACE) (EARTH-TO-SPACE), Space Operation (Earth-to-space) 5.458	Fixed	Point-to-point
			LPR	
			UWB applications	Generic UWB. On-board aircraft regulation within the band 6.0-8.5 GHz
			Video PMSE	Cordless Cameras; Portable video links; Mobile video links; Temporary point-to-point video link.
7190-7235 MHz	EARTH EXPLORATION-SATELLITE (EARTH-TO-SPACE)(5.460A, 5.460B), FIXED, MOBILE, SPACE RESEARCH (EARTH-TO-SPACE)(5.460)	EARTH EXPLORATION-SATELLITE (EARTH-TO-SPACE) (5.460A, 5.460B), FIXED, MOBILE, SPACE RESEARCH (EARTH-TO-SPACE)(5.460)	Fixed	Point-to-point
			LPR	
			Passive sensors (satellite)	For sea surface temperature, sea surface wind speed and soil moisture measurements
			UWB applications	Generic UWB. On-board aircraft

Frequency range (MHz)	RR Region 1 Allocation and RR footnotes applicable to CEPT	European Common Allocation and ECA footnotes	Applications	Notes
	5.458	5.458		regulation within the band 6.0-8.5 GHz
			Video PMSE	Cordless Cameras; Portable video links; Mobile video links; Temporary point-to-point video link.

5.149: In making assignments to stations of other services to which the bands:

13 360-13 410 kHz,	4 950-4 990 MHz,	102-109.5 GHz,
25 550-25 670 kHz,	4 990-5 000 MHz,	111.8-114.25 GHz,
37.5-38.25 MHz,	6 650-6 675.2 MHz,	128.33-128.59 GHz,
73-74.6 MHz in Regions 1 and 3,	10.6-10.68 GHz,	129.23-129.49 GHz,
150.05-153 MHz in Region 1,	14.47-14.5 GHz,	130-134 GHz,
322-328.6 MHz,	22.01-22.21 GHz,	136-148.5 GHz,
406.1-410 MHz,	22.21-22.5 GHz,	151.5-158.5 GHz,
608-614 MHz in Regions 1 and 3,	22.81-22.86 GHz,	168.59-168.93 GHz,
1 330-1 400 MHz,	23.07-23.12 GHz,	171.11-171.45 GHz,
1 610.6-1 613.8 MHz,	31.2-31.3 GHz,	172.31-172.65 GHz,
1 660-1 670 MHz,	31.5-31.8 GHz in Regions 1 and 3,	173.52-173.85 GHz,
1 718.8-1 722.2 MHz,	36.43-36.5 GHz,	195.75-196.15 GHz,
2 655-2 690 MHz,	42.5-43.5 GHz,	209-226 GHz,
3 260-3 267 MHz,	48.94-49.04 GHz,	241-250 GHz,
3 332-3 339 MHz,	76-86 GHz,	252-275 GHz
3 345.8-3 352.5 MHz,	92-94 GHz,	
4 825-4 835 MHz,	94.1-100 GHz,	

are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 4.5 and 4.6 and Article 29). (WRC-07)

5.440: The standard frequency and time signal-satellite service may be authorized to use the frequency 4 202 MHz for space-to-Earth transmissions and the frequency 6 427 MHz for Earth-to-space transmissions. Such transmissions shall be confined within the limits of ± 2 MHz of these frequencies, subject to agreement obtained under No. 9.21.

5.441: The use of the bands 4 500-4 800 MHz (space-to-Earth), 6 725-7 025 MHz (Earth-to-space) by the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by geostationary-satellite systems in the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by a non-geostationary-satellite system in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed-satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated. (WRC-2000)

5.457 In Australia, Burkina Faso, Cote d'Ivoire, Mali and Nigeria, the allocation to the fixed service in the bands 6 440-6 520 MHz (HAPS-to-ground direction) and 6 560-6 640 MHz (ground-to-HAPS direction) may also be used by gateway links for high-altitude platform stations (HAPS) within the territory of these countries. Such use is limited to operation in HAPS gateway links and shall not cause harmful interference to, and shall not claim protection from, existing services, and shall be in compliance with Resolution 150 (WRC 12). Existing services shall not be constrained in future development by HAPS gateway links. The use of HAPS gateway links in these bands requires explicit agreement with other administrations whose territories are located within 1 000 kilometres from the border of an administration intending to use the HAPS gateway links. (WRC 12)

5.457A: In the frequency bands 5 925-6 425 MHz and 14-14.5 GHz, earth stations located on board vessels may communicate with space stations of the fixed-satellite service. Such use shall be in accordance with Resolution 902 (Rev.WRC-23). In the frequency band 5 925-6 425 MHz, earth stations located on board vessels and communicating with space stations of the fixed-satellite service may employ transmit antennas with minimum diameter of 1.2 m and operate without prior agreement of any administration if located at least 330 km away from the low-water mark as officially recognized by the coastal State. All other provisions of Resolution 902 (Rev.WRC-23) shall apply. (WRC-23)

5.457E: The frequency bands 6 425-7 125 MHz in Region 1 and 7 025-7 125 MHz in Region 3 are identified for use by administrations wishing to implement the terrestrial component of International Mobile Telecommunications (IMT). This identification does not preclude the use of these frequency bands by any application of the services to which they are allocated and does not establish priority in the Radio Regulations. Resolution 220 (WRC-23) applies.
The frequency bands are also used for the implementation of wireless access systems (WAS), including radio local area networks (RLANs). (WRC-23)

Frequency range (MHz)	RR Region 1 Allocation and RR footnotes applicable to CEPT	European Common Allocation and ECA footnotes	Applications	Notes

5.457B: In the frequency bands 5 925-6 425 MHz and 14-14.5 GHz, earth stations located on board vessels may operate with the characteristics and under the conditions contained in Resolution 902 (Rev.WRC-23) in Algeria, Saudi Arabia, Bahrain, Comoros, Djibouti, Egypt, United Arab Emirates, Jordan, Kuwait, Libya, Morocco, Mauritania, Oman, Qatar, the Syrian Arab Republic, Sudan, Tunisia and Yemen, in the maritime mobile-satellite service on a secondary basis. Such use shall be in accordance with Resolution 902 (Rev.WRC-23). (WRC-23)

5.457C: In Region 2 (except Brazil, Cuba, French overseas departments and communities, Guatemala, Mexico, Paraguay, Uruguay and Venezuela), the frequency band 5 925-6 700 MHz may be used for aeronautical mobile telemetry for flight testing by aircraft stations (see No. 1.83). Such use shall be in accordance with Resolution 416 (WRC-07) and shall not cause harmful interference to, or claim protection from, the fixed-satellite and fixed services. Any such use does not preclude the use of this frequency band by other mobile service applications or by other services to which this frequency band is allocated on a co-primary basis and does not establish priority in the Radio Regulations. (WRC-15)

5.458: In the band 6 425-7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075-7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the Earth exploration-satellite (passive) and space research (passive) services in their future planning of the bands 6 425-7 075 MHz and 7 075-7 250 MHz.

5.458A: In making assignments in the band 6 700-7 075 MHz to space stations of the fixed-satellite service, administrations are urged to take all practicable steps to protect spectral line observations of the radio astronomy service in the band 6 650-6 675.2 MHz from harmful interference from unwanted emissions.

5.458B: The space-to-Earth allocation to the fixed-satellite service in the band 6 700-7 075 MHz is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service and is subject to coordination under No. 9.11A. The use of the band 6 700-7 075 MHz (space-to-Earth) by feeder links for non-geostationary satellite systems in the mobile-satellite service is not subject to No. 22.2.

5.460: No emissions from space research service (Earth-to-space) systems intended for deep space shall be effected in the frequency band 7 190-7 235 MHz. Geostationary satellites in the space research service operating in the frequency band 7 190-7 235 MHz shall not claim protection from existing and future stations of the fixed and mobile services and No. 5.43A does not apply. (WRC-15)

5.460A: The use of the frequency band 7 190-7 250 MHz (Earth-to-space) by the Earth exploration-satellite service shall be limited to tracking, telemetry and command for the operation of spacecraft. Space stations operating in the Earth exploration-satellite service (Earth-to-space) in the frequency band 7 190-7 250 MHz shall not claim protection from existing and future stations in the fixed and mobile services, and No. 5.43A does not apply. No. 9.17 applies. Additionally, to ensure protection of the existing and future deployment of fixed and mobile services, the location of earth stations supporting spacecraft in the Earth exploration-satellite service in non-geostationary orbits or geostationary orbit shall maintain a separation distance of at least 10 km and 50 km, respectively, from the respective border(s) of neighbouring countries, unless a shorter distance is otherwise agreed between the corresponding administrations. (WRC-15)

5.460B: Space stations on the geostationary orbit operating in the Earth exploration-satellite service (Earth-to-space) in the frequency band 7 190-7 235 MHz shall not claim protection from existing and future stations of the space research service, and No. 5.43A does not apply. (WRC-15)

ANNEX 2: CALCULATION OF MFCN BS AND UE ACLR

This annex describes the approach for the calculation of adjacent channel leakage power ratio (ACLR) for MFCN base stations (BSs) and user equipment (UE) in the context of studies of interference from MFCNs to WAS/RLANs. In each case, the emission limits of the MFCN equipment are first presented based on ETSI specifications. Next, the ACLRs are calculated from the emission limits as the ratios of the MFCN BS or UE in-block powers to the respective out-of-block/band powers over the bandwidth of a WAS/RLAN receiver.

Note that both MFCN UE and BSs must meet the ACLR minimum requirements and the spectrum emission mask specifications, according to ETSI standards. The ACLRs and emission masks serve different purposes. The emission mask is a broad specification to ensure that high spectral peaks are avoided at frequencies outside the channel bandwidth, as might be caused by non-linear RF components and local oscillator leakage, among others. ACLR, on the other hand, is a specific requirement to ensure that signals in adjacent radio channels can coexist side-by-side without mutual interference. ETSI specifications spell out the exact ACLR limits, making them a mandatory requirement for all compliant devices.

In the context of interference to WAS/RLAN, the bandwidth-adjusted ACLR of an MFCN BS or UE is defined as

$$ACLR = \frac{P_{IB}}{P_{OOB}} \tag{14}$$

where:

- P_{IB} is the equipment's in-block emission power in mW/(B_{MFCN} Hz);
- P_{OOB} is the equipment's out-of-block/band emission power in mW/(B_{RLAN} Hz);
- B_{MFCN} and B_{RLAN} are the channel bandwidths of MFCN and WAS/RLAN, respectively.

The overall interference P_I in mW/(B_{RLAN} Hz) at a WAS/RLAN receiver as a result of spectral leakage from the transmitter and receiver blocking is then given as

$$P_I = P_{OOB,Rx} + \frac{P_{IB,Rx}}{ACS} = \frac{P_{IB,Rx}}{ACLR} + \frac{P_{IB,Rx}}{ACS} = \left(\frac{1}{ACLR} + \frac{1}{ACS}\right) P_{IB,Rx} = \frac{P_{IB,Rx}}{ACIR} \tag{15}$$

where:

- ACS is the receiver's adjacent channel selectivity and $ACIR$ is the adjacent channel interference ratio.

A2.1 CALCULATION OF MFCN BS ACLR WITH RESPECT TO WAS/RLAN

ETSI TS 138.104 specifies the over-the-air ACLR in terms of an absolute out-of-band TRP limit of -15 + 9 = -6 dBm/MHz for Type 1-O Category B wide area BSs (see Section 9.7.3.2. in conjunction with Table 6.6.3.2-2 of the specifications). Section 9.7.3.2 states that the less stringent of the absolute limit in Table 6.6.3.2-2 + X (where X = 9 dB) and the basic limit in Table 6.6.3.2-1 shall apply. In the cases under study in this Report, the absolute limit is the less stringent, and therefore applies. Furthermore, this limit applies for a frequency offset of up to 100 MHz from the MFCN band edge. For larger frequency offsets, a TRP spurious emission limit of -30 dBm/MHz applies in Europe (see ERC Recommendation 74-01 [14]). The above limits are summarised in Table 37 as averaged over 20 MHz bandwidths below the band edge.

Table 37: BS TRP limits averaged over 20 MHz bandwidths at different band edge offsets (from ETSI limits on ACLR and spurious emissions)

Offset from band edge (MHz)	Average MFCN BS out-of-band TRP (dBm/20 MHz)
0-20	+7.0
20-40	

Offset from band edge (MHz)	Average MFCN BS out-of-band TRP (dBm/20 MHz)
40-60	
60-80	
80-100	
> 100	−17.0

Accordingly, depending on whether the WAS/RLAN channel bandwidth is greater or less than 100 MHz, the MFCN BS out-of-band emission limit over an immediately adjacent WAS/RLAN channel bandwidth may have one or two values. Table 38 shows the average BS TRP limits over the various WAS/RLAN channel bandwidths.

Table 38: MFCN BS TRP limits over immediately adjacent WAS/RLAN channel bandwidths (from ETSI limits on ACLR and spurious emissions).

WAS/RLAN channel bandwidth B_{RLAN} (MHz)	Average MFCN BS out-of-band TRP in a WAS/RLAN channel (dBm/20 MHz)
20	7.0
40	
80	
160	$10\ log_{10}\left((100/160)\ 10^{+7/10} + (60/160)\ 10^{-17/10}\right) = 5.0$
320	$10\ log_{10}\left((100/320)\ 10^{+7/10} + (220/320)\ 10^{-17/10}\right) = 2.0$

AAS Configuration 1

The MFCN BS AAS configuration delivers a maximum BS *e.i.r.p.* of 82.6 dBm/(100 MHz), which along with its antenna gain of 35.3 dBi (Configuration 1) (which includes 2 dB ohmic loss), implies a total conducted power of 47.3 dBm/(100 MHz), or a total radiated power of 45.3 dBm/(100 MHz).

Accordingly, based on Equation (14), the MFCN BS ACLR for different WAS/RLAN channel bandwidths can be calculated as shown in Table 39.

Table 39: MFCN BS bandwidth adjusted ACLR values (AAS Configuration 1)

WAS/RLAN bandwidth B_{RLAN} (MHz)	MFCN BS out-of-band TRP P_{OOB}		MFCN BS in-block TRP P_{IB} (dBm/100 MHz)	Bandwidth adjusted ACLR (dB)
	(dBm/20 MHz)	(dBm/B_{RLAN} MHz)		
20	7.0	7.0	45.3	38.3
40		10.0		35.3
80		13.0		32.3
160	5.0	14.0		31.3
320	2.0	14.0		31.3

Rounding to the nearest integer, it has been proposed to use MFCN BS ACLR values of 38, 35, 32, 31 and 31 dB for WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz.

AAS Configuration 2

The MFCN BS AAS configuration delivers a maximum BS *e.i.r.p.* of 82.6 dBm/(100 MHz), which along with its antenna gain of 33.5 dBi (Configuration 2) (which includes 2 dB ohmic loss), implies a total conducted power of 49.1 dBm/(100 MHz), or a total radiated power of 47.1 dBm/(100 MHz).

Accordingly, based on Equation (14), the MFCN BS ACLR for different WAS/RLAN channel bandwidths can be calculated as shown in Table 40.

Table 40: MFCN BS bandwidth adjusted ACLR values (AAS Configuration 2)

WAS/RLAN bandwidth B_{RLAN} (MHz)	MFCN BS out-of-band TRP P_{OOB}		MFCN BS in-block TRP P_{IB} (dBm/100 MHz)	Bandwidth adjusted ACLR (dB)
	(dBm/20 MHz)	(dBm/B_{RLAN} MHz)		
20	7.0	7.0	47.1	40.1
40		10.0		37.1
80		13.0		34.1
160	5.0	14.0		33.1
320	2.0	14.0		33.1

Rounding to the nearest integer, the bandwidth adjusted MFCN BS ACLRs are 40, 37, 34, 33 and 33 dB for WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz, respectively.

A2.2 CALCULATION OF MFCN UE ACLR WITH RESPECT TO WAS/RLAN

ETSI TS 138 101-1, table 6.5.2.4.1-2 [13] specifies a 5G NR UE ACLR of 30 dB (UE power class 3). Furthermore, according to ETSI TS 138 101-1, table 6.5.2.2-1, the spectrum emission mask of a 100 MHz 5G NR UE is given as -25 dBm/MHz for an offset of 100-105 MHz from the channel or band edge. Finally, for greater frequency separations the spurious emission limit of -30 dBm/MHz applies (see ETSI TS 138 101-1, table 6.5.3.1-2).

Accordingly, using a common measurement bandwidth of 1 MHz, and assuming a UE in-block transmit power of 23 dBm/(100 MHz), the emission limits of a 100 MHz 5G NR UE are then as shown in Table 41.

Table 41: Emission limits of an MFCN UE.
(from ETSI limit on ACLR, spectrum emission mask, and limit on spurious emissions)

	UE channel bandwidth: 100 MHz	
Offset from band edge	Spectrum emission limit (dBm)	Measurement bandwidth
Co-channel	3.0	1 MHz
0-100 MHz	3.0 – 30 = −27.0	1 MHz
100-105 MHz	−25.0	1 MHz
> 105 MHz	−30.0	1 MHz

The limits in Table 41 indicate that the emissions within WAS/RLAN receiver bandwidths of 20, 40, 80, 160, and 320 MHz immediately below the band are as follows:

- With WAS/RLAN bandwidths of 20, 40, 80 MHz, and for 0-20 MHz, 0-40 MHz, and 0-80 MHz from the channel or band edge, respectively, the emission limit is -27 dBm/MHz;
- With a WAS/RLAN bandwidth of 160 MHz, for 0-100 MHz from the channel edge the an emission limit is -27 dBm/MHz, for 100-105 MHz we have -25 dBm/MHz, and for 105-160 MHz we have -30 dBm/MHz. The average is then

$$10\,log_{10}\left((100/160).10^{-27/10} + (5/160).10^{-25/10} + (55/160).10^{-30/10}\right) = -27.7 \text{ dBm/MHz},$$

- With a WAS/RLAN bandwidth of 320 MHz, for 0-100 MHz from the channel edge the emission limit is -27 dBm/MHz, for 100-105 MHz -25 dBm/MHz, and for 105-320 MHz -30 dBm/MHz. The average is then

$$10\,log_{10}\left((100/320).10^{-27/10} + (5/320).10^{-25/10} + (215/320).10^{-30/10}\right) = -28.7 \text{ dBm/MHz},$$

The bandwidth-adjusted UE ACLR values can then be calculated as indicated in Table 42.

Table 42: MFCN UE bandwidth adjusted ACLR

WAS/RLAN bandwidth B_{RLAN} (MHz)	MFCN UE out-of-band emission P_{OOB}		MFCN UE in-block emission P_{IB} (dBm/100 MHz)	Bandwidth adjusted ACLR (dB)
	(dBm/MHz)	(dBm/B_{RLAN} MHz)		
20	−27.0	−14.0	23	37.0
40		−11.0		34.0
80		−8.0		31.0
160	−27.7	−5.7		28.7
320	−28.7	−3.7		26.7

Rounding to the nearest integer, the bandwidth adjusted MFCN UE ACLRs are 37, 34, 31, 29 and 27 dB for WAS/RLAN channel bandwidths of 20, 40, 80, 160 and 320 MHz, respectively.

ANNEX 3: LIST OF REFERENCES

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