International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R F.2326-0

(11/2014)

Sharing and compatibility study between indoor International Mobile Telecommunication small cells and fixed service stations in the 5 925-6 425 MHz frequency band

F Series

Fixed service

150

1865 - 2015

International
Telecommunication
Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from http://www.itu.int/ITU-R/go/patents/en where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at http://www.itu.int/publ/R-REP/en)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	**Fixed service**
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management

***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2015

REPORT ITU-R F.2326-0

Sharing and compatibility study between indoor International Mobile Telecommunication small cells and fixed service stations in the 5 925-6 425 MHz frequency band

(2014)

1 Introduction

The frequency band 5 925-6 425 MHz has been proposed as a possible candidate band for International Mobile Telecommunication (IMT) identification.

However this band is heavily used for point-to-point fixed service (FS) links. The objective is to study the sharing and compatibility between indoor IMT small cells and FS stations. The study considers only the impact of interference from IMT indoor small cells into point-to-point FS station receivers.

2 Background

The frequency band 5 925-6 425 MHz is already allocated to the mobile service (MS) on a primary basis worldwide. However identification of this frequency band for IMT will significantly change the usage of the band which requires the coexistence studies with other incumbent services. The main services deployed in this band are FS and fixed-satellite service (FSS) (Earth-to-space).

Point-to-point FS links in this frequency band are heavily used for cellular network backhaul in many countries. The use of point-to-point FS links in the 5 925-6 425 MHz band is relevant for rural areas as well as for urban environment, which requires consideration of different sharing scenarios. It is assumed in the study that IMT systems are to be deployed only as indoor small cells, which is required to ensure coexistence with FSS space stations, receiving in the band 5 925-6 425 MHz.

Deliverables describing typical deployment of FS stations in the 5 925-6 425 MHz band and relevant for the assessment of interference are:

- Report ITU-R F.2240 – Interference analysis modelling for sharing between HAPS gateway links in the fixed service and other systems/services in the range 5 850-7 075 MHz.
- Recommendation ITU-R F.758 – System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference.

3 Technical characteristics

3.1 IMT systems characteristics and assumptions

Considering the rather high frequency of the frequency band 5 925-6 425 MHz, it was assumed that the IMT systems would most likely be deployed in dense urban areas and mainly indoor as pico and femto cells with wideband channels and high data rate. It was also assumed that the frequency band 5 925-6 425 MHz would be used as a separate level of coverage without macro cells, making the time division duplex more advantageous for such IMT systems. Taking this into account the calculations consider only small base stations emitting up to 100% of time. Subscriber stations, which are generally low power and power controlled, were not considered. Parameters for small base stations used in the calculations are given in Table 1 below.

TABLE 1

Deployment-related parameters

Base station characteristics/Cell structure	**Small cell indoor**
Cell radius/Deployment density	Depending on indoor coverage/capacity demand
Antenna height	3 m
Sectorization	Single sector
Downtilt	n.a.
Frequency reuse	1
Antenna pattern	Recommendation ITU-R F.1336 omni (Figs 1, 2)
Antenna polarization	Linear
Indoor base station deployment	100%
Indoor base station penetration loss	20 dB (Note 1)
Below rooftop base station antenna deployment	n.a.
Feeder loss	n.a
Maximum base station output power (20 MHz)	24 dBm and 30 dBm (Note 2)
Channel bandwith	20 MHz
Transmitter spectrum mask	Table 2, Fig. 3
Base station characteristics/Cell structure	**Small cell indoor**
Maximum base station antenna gain	0 dBi
Maximum base station output power (e.i.r.p.)	24 dBm and 30 dBm
Average base station activity	50%
Average base station power/sector (to be used in sharing studies)	21 dBm and 27 dBm

NOTE 1 – Typical value for indoor base station penetration loss is described as 25 dB for the horizontal direction in the band 5-6 GHz, however 20 dB is used for interference assessment.

NOTE 2 – 30 dBm value is added as an alternative value. Due to assumed 100 MHz channel higher power might be necessary to provide similar power spectrum density as within 20 MHz channel.

FIGURE 1

Antenna radiation pattern IMT base station system for azimuth angles

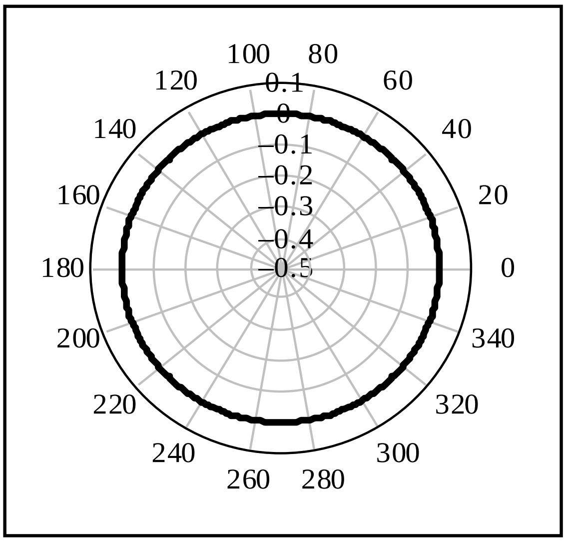


FIGURE 2

Antenna radiation pattern IMT base station system for elevation angles

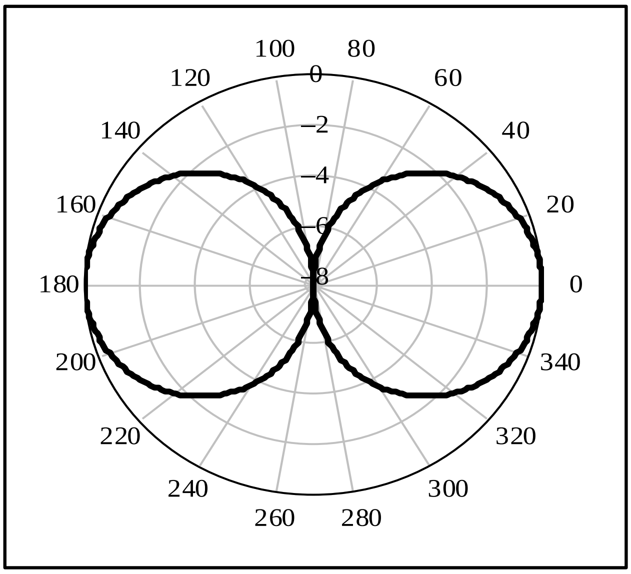


TABLE 2

Transmitter spectrum mask IMT Systems[1]

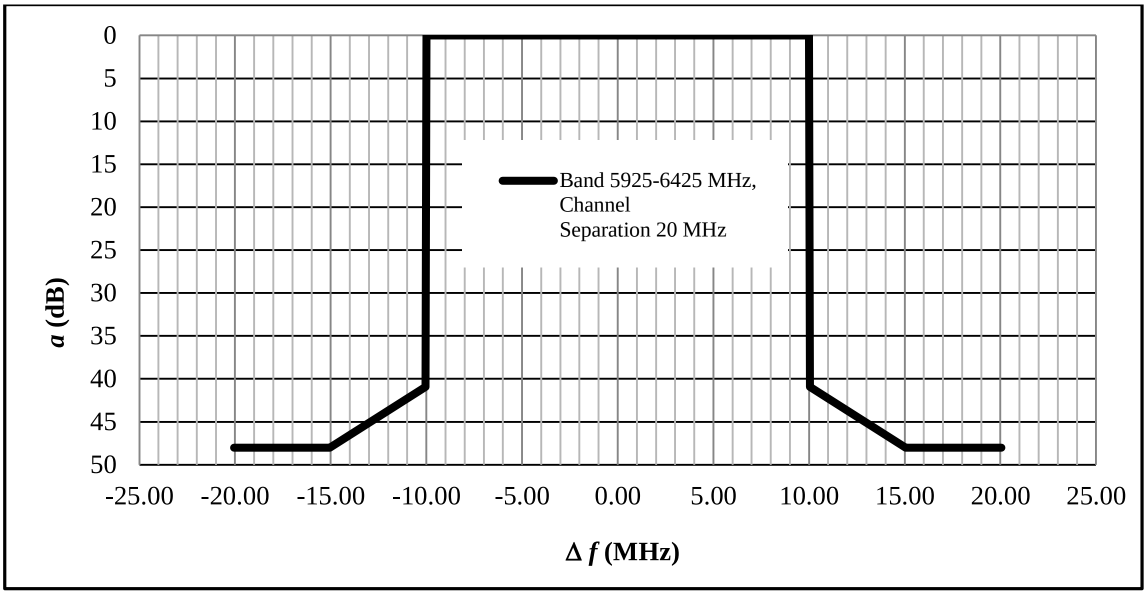
Band	**Channel separation**	**Transmitter spectrum mask IMT Systems**								
MHz	**MHz**									
5 925-6 425	20.0 …	Δf_i (MHz)	−20.05	−15.05	−10.05	−10.00	10.00	10.05	15.05	20.05
		a_i (dB)	48.00	48.00	40.93	0.00	0.00	40.93	48.00	48.00

---

[1] The data are taken from Table 6.6.3.2A-3 3GPP TS 36.104 V12.2.0 (2013-12).

FIGURE 3

Transmitter spectrum masks IMT systems



3.2 FS stations characteristics and assumptions

The technical characteristics of the point-to-point FS links were derived from Recommendation ITU-R F.758-5 and Report ITU-R F.2240 and are summarized in Table 3.

TABLE 3

System parameters for PP FS systems

Frequency range (GHz)	**5.925-6.425**	
	Type 1	**Type 2**
Reference	Rec. ITU-R F.383 (Figs 6, 5)	
Modulation	64-QAM	128-QAM
Channel spacing and receiver noise bandwidth (MHz)	40	29.65
Tx output power range (dBW)	−8…2.0 (Mode −4)	−11…2 (Mode −3)
Tx output power density range (dBW/MHz)	−24... −14.0	−25.7…−9.7
Feeder/multiplexer loss range (dB)	2.5…5.6 (Mode 3.4)	1.1…3 (Mode 1.3)
Antenna gain range (dBi)	38.1…45.0 (Mode 38)	38.7…46.6 (Mode 45)
Antenna pattern	Rec. ITU-R F.1245 (Fig. 4)	Rec. ITU-R F.1245 (Fig. 4)
Antenna height (m)	15…110 (Mode 55)	15…110 (Mode 55)
e.i.r.p. range (dBW)	20.6...37.5 (Mode 30.6)	25.7…45.9 (Mode 40.7)

TABLE 3 (*end*)

Frequency range (GHz)	**5.925-6.425**	
	Type 1	**Type 2**
e.i.r.p. density range (dBW/MHz)	4.6...21.5 (Mode 14.3)	10.9…31.1 (Mode 26.9)
Receiver noise figure typical (dB)	5	4
Receiver selectivity masks	Table 4, Fig. 6	Table 4, Fig. 5
Receiver noise power density typical (=N_{RX}) (dBW/MHz)	−139	−140
Normalized Rx input level for 1×10^{-6} BER (dBW/MHz)	−112.5	−110.5
Nominal long-term interference power density (dBW/MHz)	$-139 + I/N$	$-140 + I/N$
Protection criteria	$I/N = -10$	$I/N = -10$
Link Length (km)	10...80 (Mode 40)	10...80 (Mode 40)

FIGURE 4

Antenna radiation pattern point-to-point FS system

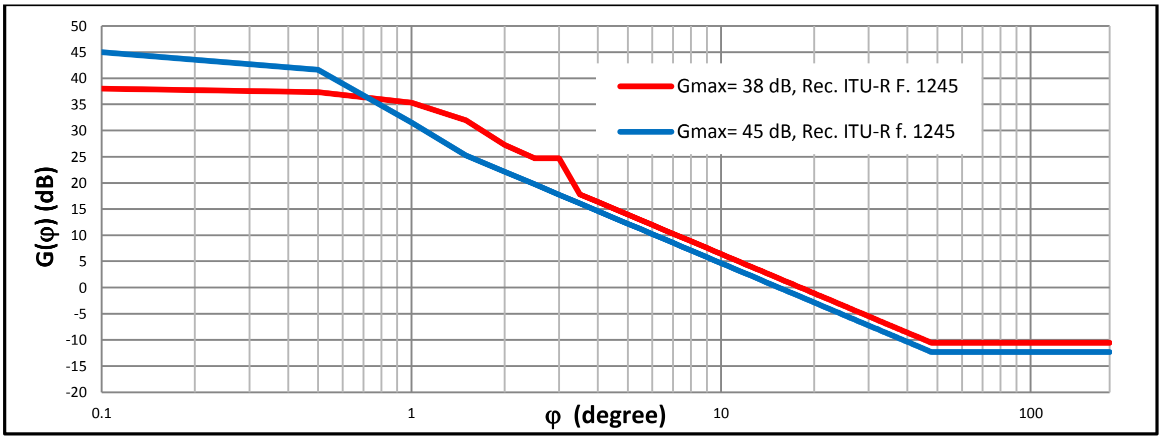


TABLE 4

Receiver selectivity masks PP FS systems[2]

Band	**Net to-Bit rate**	**Channel separation**	**Receiver selectivity masks PP FS system**												
MHz	**Mbit/s**	**MHz**													
5 925-6 425	155	28.0 ... 30.0	Δf_i (MHz)	−26.45833	−14.76264	−14.632	−14.10943	−13.06429	−11.36593	11.36593	13.06429	14.10943	14.632	14.76264	26.45833
			a_i (dB)	67	47	23.4	10.5	2	0	0	2	10.5	23.4	47	67
		40.0	Δf_i (MHz)	−31.31818	−21.85500	−20.925	−19.22000	−15.50000	−9.14500	9.14500	15.50000	19.22000	20.925	21.85500	31.31818
			a_i (dB)	63	46	17.8	9.9	2	0	0	2	9.9	17.8	46	63

---

[2] All values are calculated according to the method in ETSI TR 101 854 Annex F.

The data are taken from ETSI EN 302 217-2-2 V1.4.1 and Appendix 12 to Annex 2B HCM Agreement 2013.

FIGURE 5

Receiver selectivity masks PP FS systems (Channel separation 29.65 MHz)

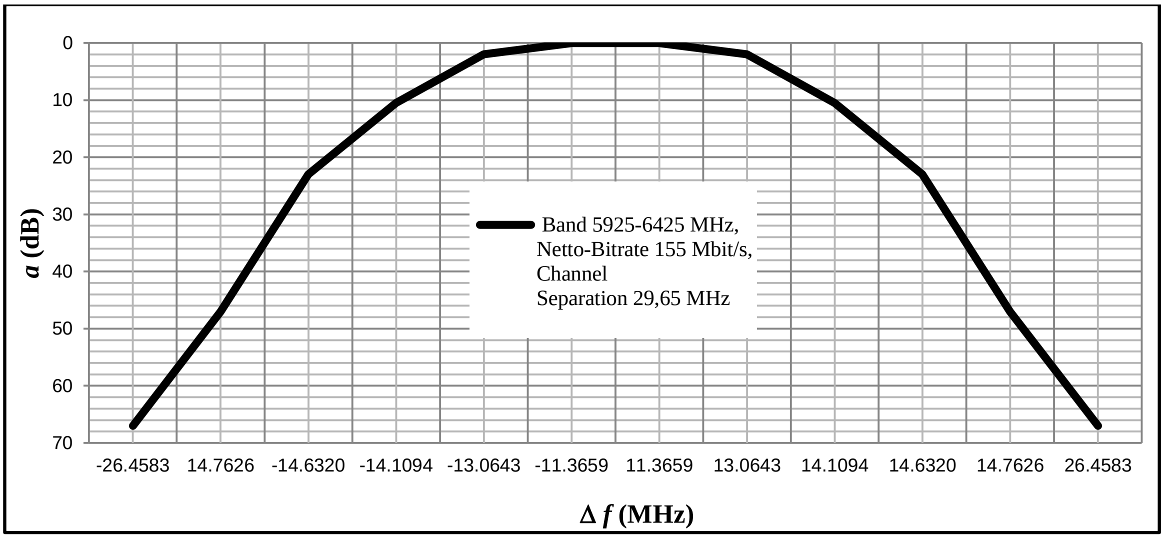
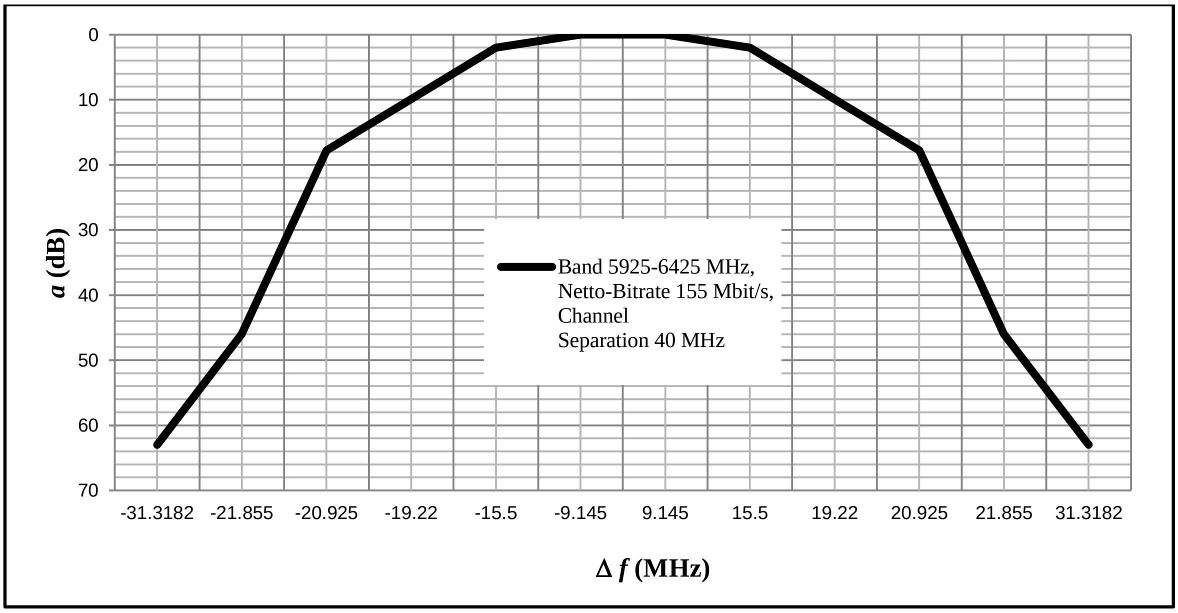


FIGURE 6

Receiver selectivity masks PP FS systems (Channel separation 40 MHz)



For a 29.65 MHz radio-frequency co-channel arrangement for fixed wireless systems operating in the 6 GHz band[3]:

Let:

f_0: be the frequency (MHz) of the centre of the band of frequencies occupied, $f_0 = 6\,175$

f_n: be the centre frequency (MHz) of one RF channel in the lower half of the band

f'_n: be the centre frequency (MHz) of one RF channel in the upper half of the band;

---

[3] Recommendation ITU-R F.383.

then the frequencies of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 259.45 + 29.65\,n$ MHz

upper half of the band: $f'_n = f_0 - 7.41 + 29.65\,n$ MHz

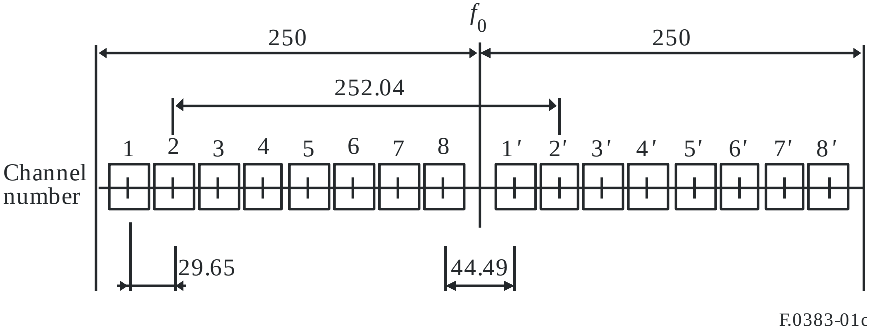
where:

$n =$ 1, 2, 3, 4, 5, 6, 7 or 8;

FIGURE 7

29.65 MHz radio-frequency co-channel arrangement for fixed wireless systems operating in the 6 GHz band for use in international connections

(All frequencies in MHz)



For a 40 MHz radio-frequency channel arrangement for radio-relay systems operating in the lower 6 GHz band[4].

Let:

f_0: be the frequency (MHz) of the centre of the band of frequencies occupied, $f_0 = 6\,175$

f_n: be the centre frequency (MHz) of one RF channel in the lower half of the band

f'_n: be the centre frequency (MHz) of one RF channel in the upper half of the band;

then the frequencies of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 260 + 40\,n$ MHz

upper half of the band: $f'_n = f_0 - 20 + 40\,n$ MHz

where:

$n =$ 1, 2, 3, 4, 5, or 6.

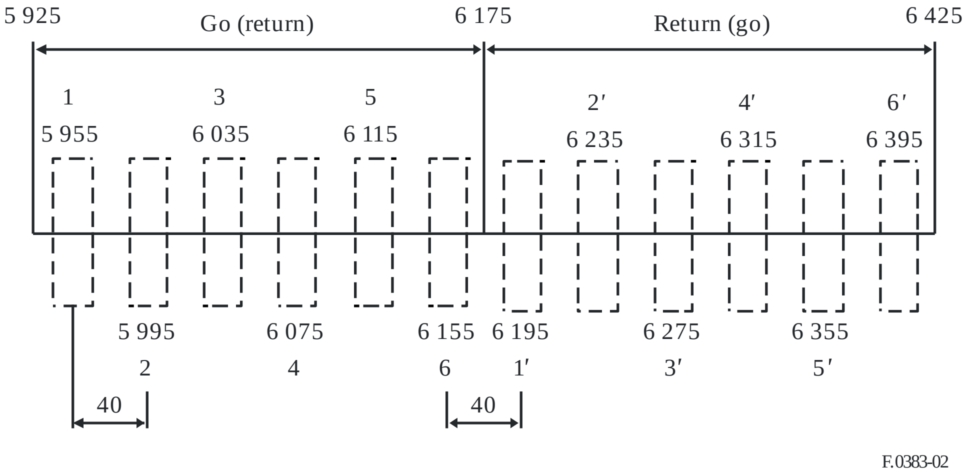
---

[4] Recommendation ITU-R F.383.

FIGURE 8

40 MHz radio-frequency channel arrangement for radio-relay systems operating in the lower 6 GHz band

(All frequencies in MHz)



4 Analysis

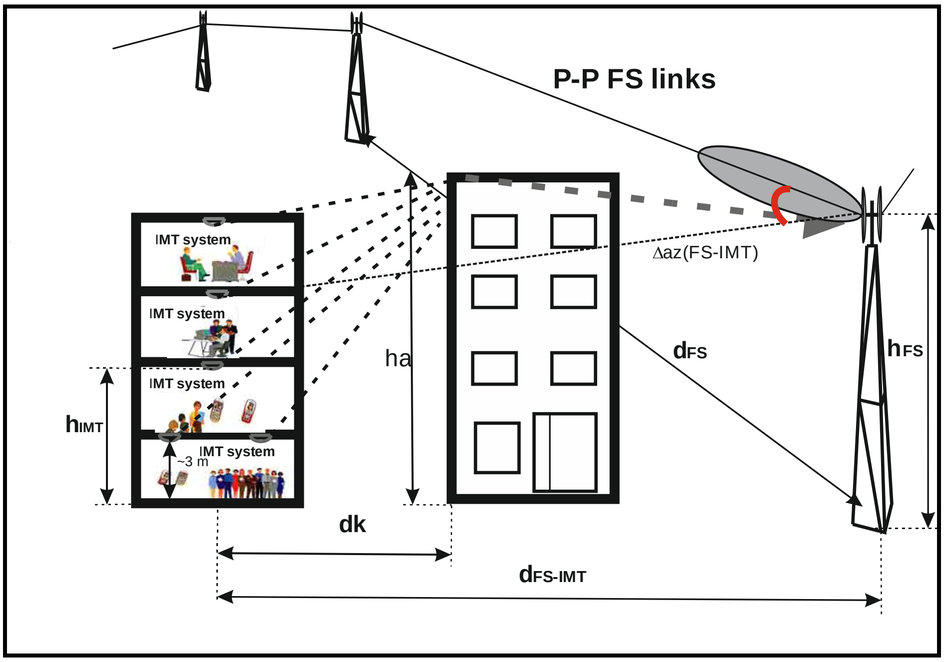
4.1 Assumptions

The studies and calculations are proposed to be performed for IMT urban environment scenario. However the IMT base stations may be deployed only indoor and located at different building floors. point-to-point FS antennas are generally mounted on the masts with heights exceeding the level of surrounding urban area. For this scenario, alongside with indoor-to-outdoor penetration losses of interference from IMT base station transmitters to point-to-point FS receivers and main lobe orientation of point-to-point FS station antenna in respect to IMT base station locations, additional diffraction interference losses are possible due to clutter from local obstacles surrounding IMT base station transmitters.

The option of deployment for point-to-point FS stations and IMT stations under the above scenario is shown in Fig. 9.

FIGURE 9

Urban interference scenario



4.2 Methodology

4.2.1 Propagation models

The propagation model is from Recommendation ITU-R P.452-14.

Basic transmission loss is from Recommendation ITU-R P.452-14 as follows:

$$L_{prop}(d) = 92.5 + 20\log f + 20\log d + L_{d50} + A_{hTx} + A_{hRx} \qquad \text{dB}$$

where:

f: frequency (GHz)

d: path length (km)

L_{d50}: the median diffraction loss (dB):

$$L_{d50} = L_{m50} + \left(1 - e^{-\frac{L_{m50}}{6}}\right)\left(L_{t50} + L_{r50} + 10 + 0.04d\right) \qquad \text{for } \nu_{m50} > -0.78$$

$$= 0 \qquad \text{otherwise}$$

where:

L_{m50}: median knife-edge diffraction loss for the main edge (dB)

L_{t50}: median knife-edge diffraction loss for the transmitter-side secondary edge (dB)

L_{r50}: median knife-edge diffraction loss for the receiver-side secondary edge (dB)

ν_{m50}: diffraction parameter of the main edge (dB)

A_{hTx}: additional losses to account for clutter shielding the transmitter (dB)

A_{hRx}: additional losses to account for clutter shielding the receiver (dB).

The additional loss due to protection from local clutter is given by the expression:

$$A_{hTx(hRx)} = 10.25\, F_{fc} \cdot \mathrm{e}^{-d_k} \left(1 - \tanh\left[6 \left(\frac{h_{IMT}}{h_a} - 0.625 \right) \right] \right) - 0.33 \qquad \text{dB}$$

where:

$$F_{fc} = 0.25 + 0.375\{1 + \tanh[7.5(f - 0.5)]\}$$

and:

d_k: distance (km) from nominal clutter point to the antenna

h_{IMT}: antenna height (m) above local ground level

h_a: nominal clutter height (m) above local ground level.

Additional losses due to shielding by clutter (ground cover) should not be claimed for categories not appearing in Table 5.

TABLE 5

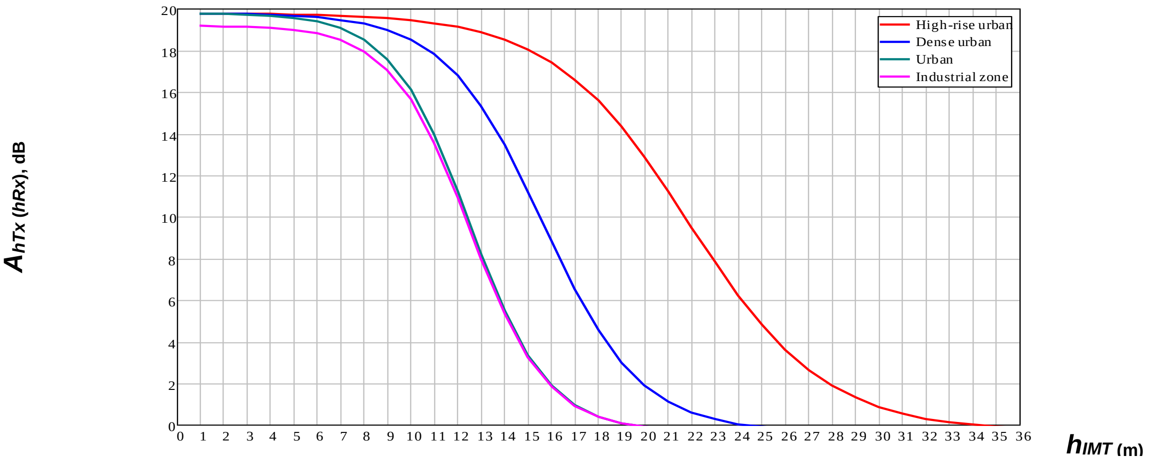
Nominal clutter heights and distances

Clutter (ground-cover) category	**Nominal height, h_a (m)**	**Nominal distance, d_k (km)**
Urban	20	0.02
Dense urban	25	0.02
High-rise urban	35	0.02
Industrial zone	20	0.05

The additional loss due to protection from local clutter is given in Fig. 10.

FIGURE 10

The additional loss due to protection from local clutter



4.2.2 Methodology of calculations

4.2.2.1 Baseline criteria *I*/*N*

The methodology envisages several protection criteria for point-to-point FS stations from interfering IMT base station stations.

I/*N* criterion is reasonable during protection assessment of FS stations operating under conditions of wanted signal reception with the level close to normal input signal, considering the required fading margin. Such conditions are characteristic for FS networks with long hops, and also when using FS stations with the basic parameters reduced: e.i.r.p. of station, antenna gain, receiver noise figure and antenna-feeder loss.

The interferer level *I*(dBW) is calculated by assessing the level of emissions from the interferer falling within the interfered receiver point-to-point FS systems bandwidth:

$$I = P_{Tx} - a_{Tx} + G_{Tx} - L_{prop}(d_{IMT\text{-}FS}) + G_{Rx} - a_{Rx} - a_{ant}(\Delta_{az}) - (MD + NFD(\Delta f)) - a_{indoor} \qquad \text{dBW}$$

where:

I (dBW) : the interfering power level the input of the interfered receiver point-to-point FS system

P_{Tx} (dBW) : transmitter power level interfering transmitter base station IMT system

G_T (dB) : transmitter antenna gain interfering transmitter base station IMT system

a_{Tx} (dB) : all losses between the antenna flange and the output of the interfering transmitter base station IMT system

G_R (dB) : receiver antenna gain interfered receiver point-to-point FS system

a_{Rx} (dB) : all losses between the antenna flange and the input of the interfered receiver point-to-point FS system

MD (dB) : Masks Discrimination[5]

$NFD(\Delta f)$ (dB) : Net Filter Discrimination[6]

where:

$\Delta f = f_{Tx} - f_{Rx}$

f_{Tx} : interferer timed frequency

f_{Rx} : receiver tuned frequency.

$$MD = 10 \log \frac{\int_0^\infty P(f)\mathrm{d}f}{\int_0^\infty P(f)\left|H(f)\right|^2 \ \mathrm{d}f}$$

$$NFD(\Delta f) = 10 \log \frac{\int_0^\infty P(f)\left|H(f)\right|^2 \mathrm{d}f}{\int_0^\infty P(f)\left|H(f+\Delta f)\right|^2 \mathrm{d}f},$$

---

[5] Recommendation ITU-R SM.337-6.

[6] Recommendation ITU-R SM.337-6.

where:

$P(f)$: transmitter spectrum mask base station IMT system

$H(f)$: receiver selectivity mask point-to-point FS system

$L_{prop}(d_{FS\text{-}IMT})$ (dB) : propagation attenuation between antennas interfered receiver point-to-point FS system and interfering transmitter base station IMT system (Recommendation ITU-R P.452-14)

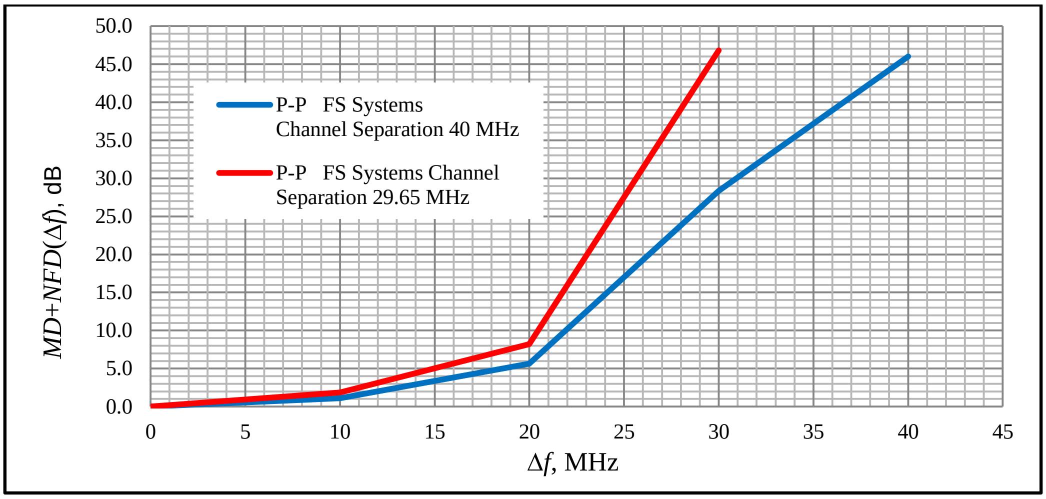
$d_{FS\text{-}IMT}$: distance between the interfering transmitter base station IMT system and the interfered receiver point-to-point FS system

$a_{ant}(\Delta_{az\ FS\text{-}IMT})$ (dB) : attenuation which is a function of angle between the main axis of the point-to-point FS system and the axis between the base station IMT system and the point-to-point FS system $\Delta_{az\ FS\text{-}IMT}$

a_{indoor} (dB) : indoor-to-outdoor penetration loss (Fig. 10, Rec. ITU-R P.1238).

FIGURE 11

Attenuation (MD+NFD)



According to Recommendation ITU-R V.573, noise level of the interfered receiver point-to-point FS system N can be determined by:

$$N = 10\log(kT_0B) + NF \qquad \text{dBW}$$

where:

k : Boltzmann's constant ($1.3806488 \times 10^{-23}$ J K^{-1})

T_0 : Reference temperature (290 K)

B : noise equivalent bandwidth of receiver (Hz)

NF : receiver noise figure (dB).

4.2.2.2 Additional consideration based on *C*/*I* ratio

When detailed information on point-to-point links deployment is available more careful planning of IMT systems could be performed to provide coexistence in same geographical area which could reduce separation distances. In this case *C*/*I* ratio could increase the potential for sharing between indoor IMT small cells and fixed stations.

The power of the point-to-point FS system carrier can be calculated by using the following equation:

$$C = P_{point\text{-}to\text{-}point\ FS\ Tx} - a_{point\text{-}to\text{-}point\ FS\ Tx} + G_{max\ point\text{-}to\text{-}point\ FS\ Rx} - L_{prop}(\text{Link Length}) + G_{max\ point\text{-}to\text{-}point\ FS\ Rx} - a_{point\text{-}to\text{-}point\ FS\ Rx} \qquad \text{dBW}$$

where:

C: power of the point-to-point FS system carrier;

$P_{point\text{-}to\text{-}point\ FS\ Tx}$ (dBW) : transmitter power level point-to-point FS system;

$G_{max\ point\text{-}to\text{-}point\ FS\ Tx}$ (dB) : transmitter maximum antenna gain point-to-point FS system;

$a_{point\text{-}to\text{-}point\ FS\ Tx}$ (dB) : all losses between the antenna flange and the output of the transmitter point-to-point FS system;

$G_{max\ point\text{-}to\text{-}point\ FS\ Rx}$ (dB) : receiver maximum antenna gain point-to-point FS system;

$a_{point\text{-}to\text{-}point\ FS\ Rx}$ (dB) : all losses between the antenna flange and the input of the receiver point-to-point FS system;

L_{prop}(Link Length): propagation attenuation between antennas transmitter and receiver point-to-point FS system (Rec. ITU-R P.525, Rec. ITU-R P.530);

Link Length (km): link length point-to-point FS system;

L_{prop}(Link Length) = 92.5 + 20 log f + 20 log(Link Length);

where:

f : frequency (GHz).

4.2.2.3 Baseline case #1 ((I/N)$_{required}$)

The method consists in calculating the resulting (I/N) and then comparing it with the required $(I/N)_{required}$ at the interfered receiver point-to-point FS systems ($(I/N)_{required}$ = –10 dB).

$$(I/N)_{required} = [\ P_{Tx} - a_{Tx} + G_{Tx} - L_{prop}(d_{IMT\text{-}FS}) + G_{Rx} - a_{Rx} - a_{ant}(\Delta_{az}) - (MD + NFD(\Delta f)) - a_{indoor}] - [10\log(kT_0B) + NF].$$

4.2.2.4 Additional case #2 ((C/I)$_{required}$)

The method consists in calculating the resulting (C/I) and then comparing it with the required $(C/I)_{required}$ at the interfered receiver point-to-point FS systems ($(C/I)_{required}$ = –55 dB and $(C/I)_{required}$ = –40 dB).

$$(C/I)_{required} = [\ P_{point\text{-}to\text{-}point\ FS\ Tx} - a_{point\text{-}to\text{-}point\ FS\ Tx} + G_{max\ point\text{-}to\text{-}point\ FS\ Rx} - L_{prop}(\text{Link Length}) + G_{max\ point\text{-}to\text{-}point\ FS\ Rx} - a_{\ point\text{-}to\text{-}point\ FS\ Rx}\ ] - [\ P_{Tx} - a_{Tx} + G_{Tx} - L_{prop}(d_{IMT\text{-}FS}) + G_{Rx} - a_{Rx} - a_{ant}(\Delta_{az}) - (MD + NFD(\Delta f)) - a_{indoor}\ ]$$

4.3 Calculations

4.3.1 Case #1 ($(I/N)_{required}$ = –10 dB)

The results of the required distance between the interfering transmitter base station IMT systems and the interfered receiver point-to-point FS systems d $_{\text{FS-IMT}}$ which is a function of angle between the main axis of the point-to-point FS system and the axis between the base station IMT system and the point-to-point FS system $\Delta_{az\ FS\text{-}IMT}$ are provided in Figs 12 to 15. (A_{hTx} = 0, 10, 19 dB; Co-channel ($MD + NFD(\Delta f)$ = 0 dB, First adjacent channel ($MD + NFD(\Delta f)$ = 45 dB).

FIGURE 12

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

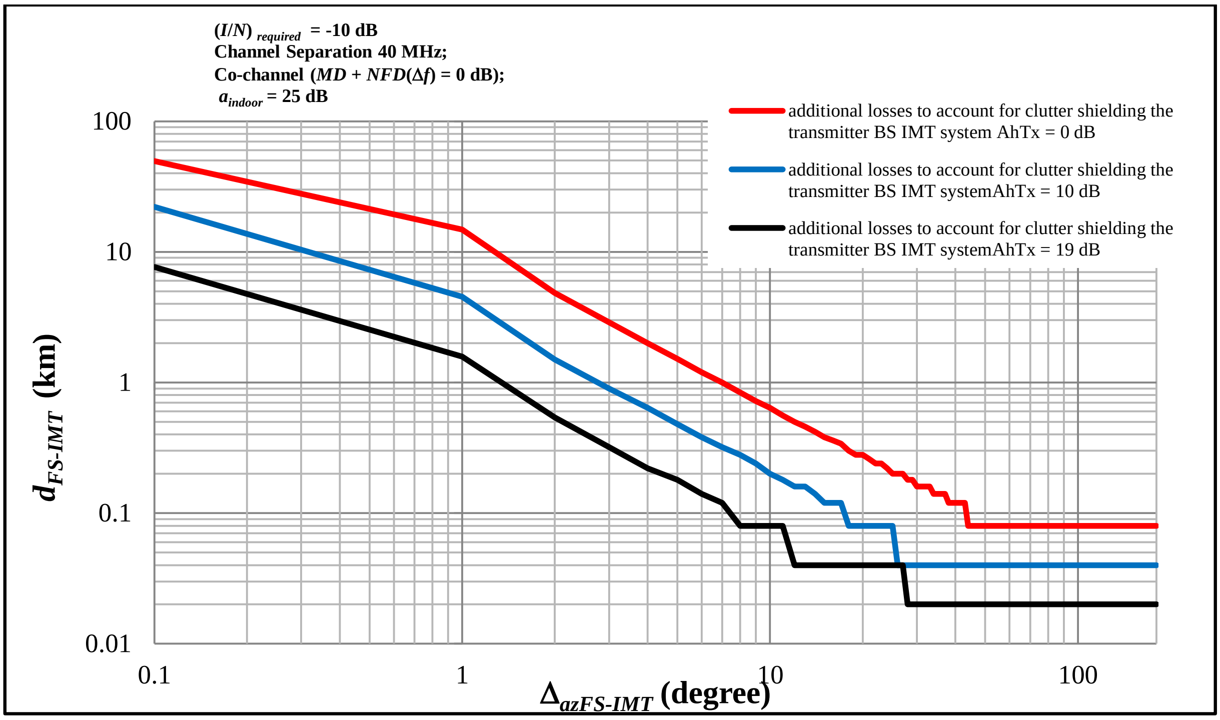


FIGURE 13

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

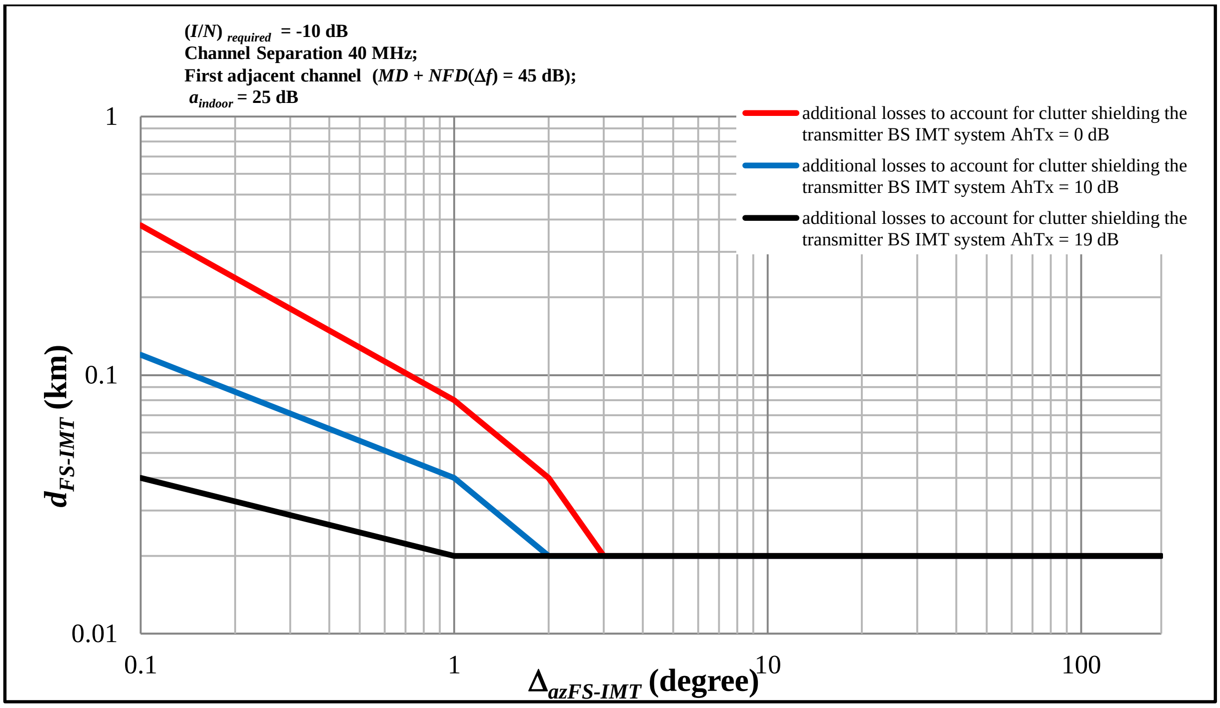


FIGURE 14

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

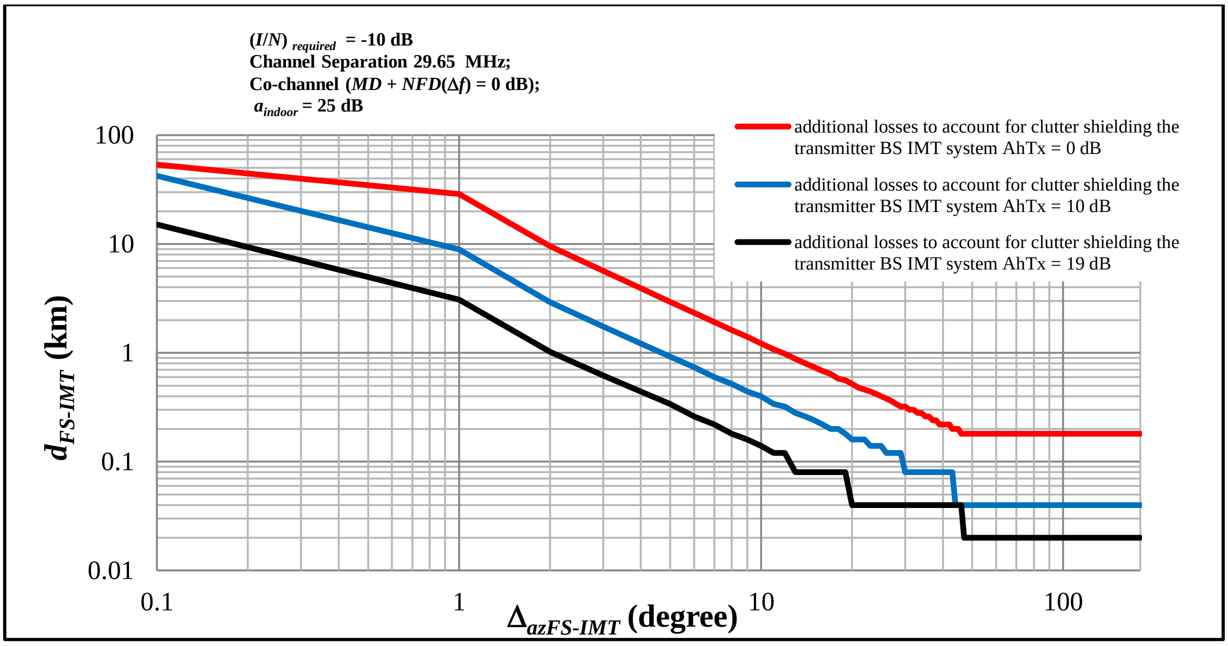
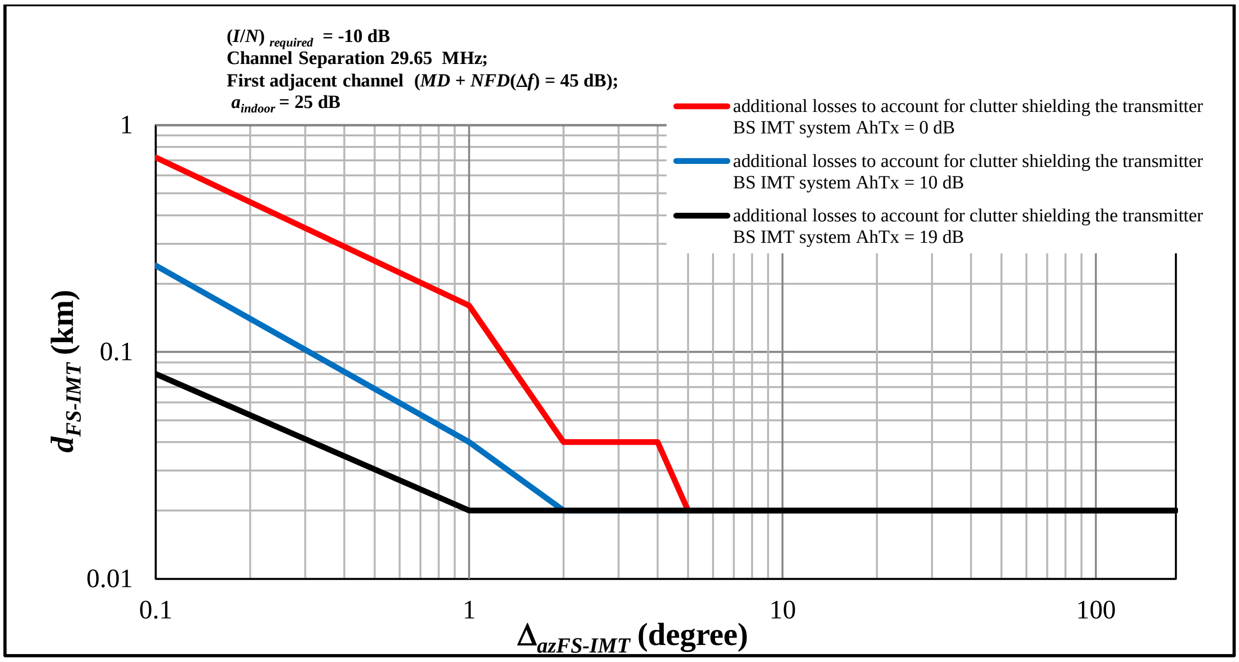


FIGURE 15

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)



4.3.1.1 Case #2.1 ($(C/I)_{required}$ = 55 dB)

The results of the required distance between the interfering transmitter base station IMT systems and the interfered receiver point-to-point FS systems d $_{FS\text{-}IMT}$ which is a function of angle between the main axis of the point-to-point FS system and the axis between the base station IMT system and the point-to-point FS system $\Delta_{az\ FS\text{-}IMT}$ are provided in Figs 16 to 27. (Link Length = 10, 30, 50, 70 km; A_{hTx} = 0, 10, 19 dB; Co-channel ($MD + NFD(\Delta f)$ = 0 dB, First adjacent channel ($MD + NFD(\Delta f)$ = 45 dB).

FIGURE 16

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

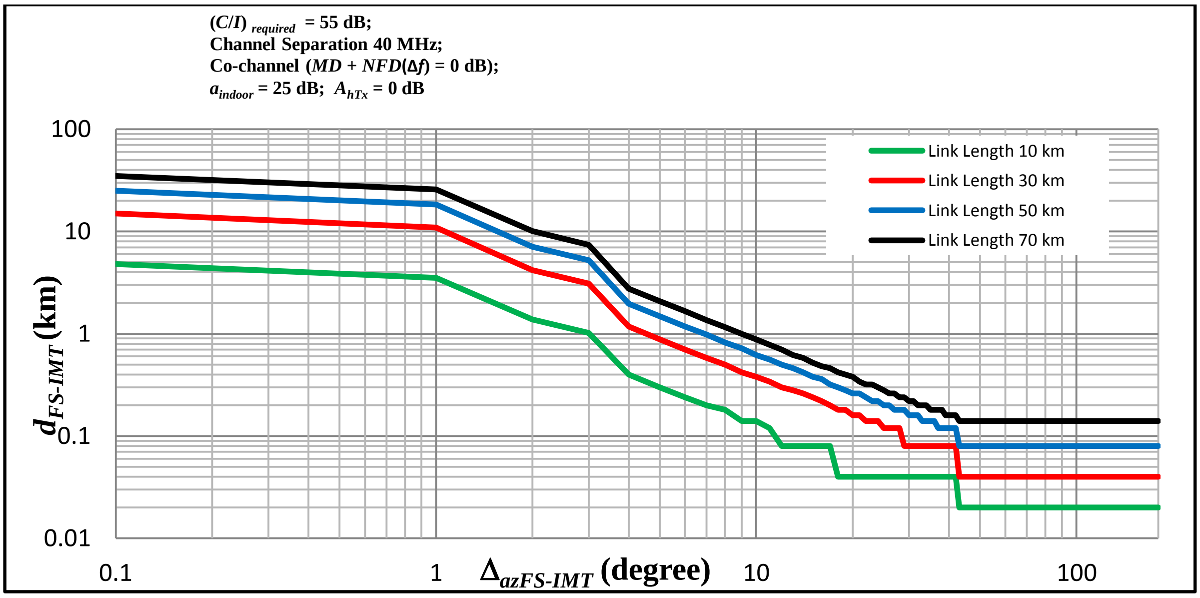


FIGURE 17

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

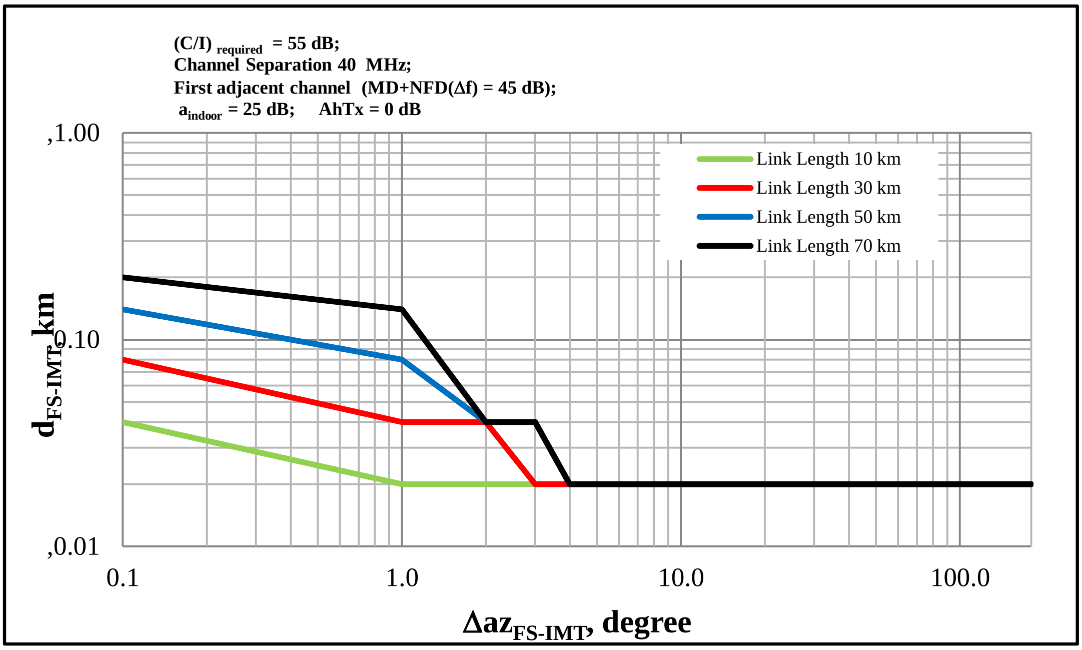


FIGURE 18

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

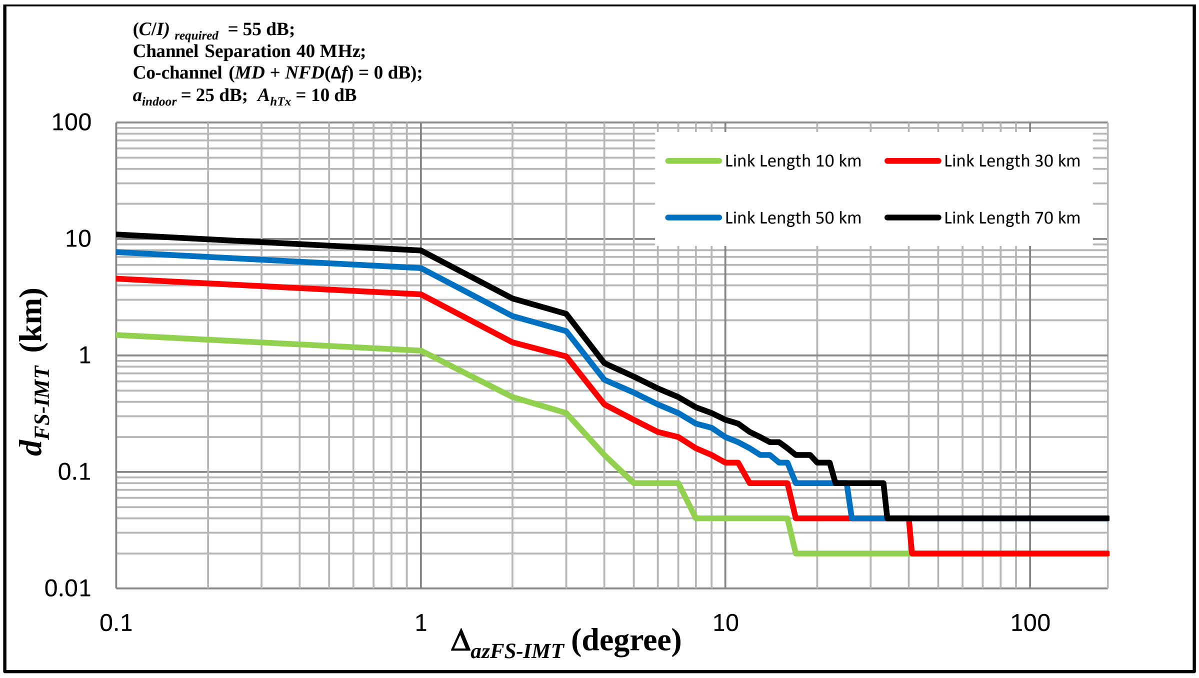


FIGURE 19

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

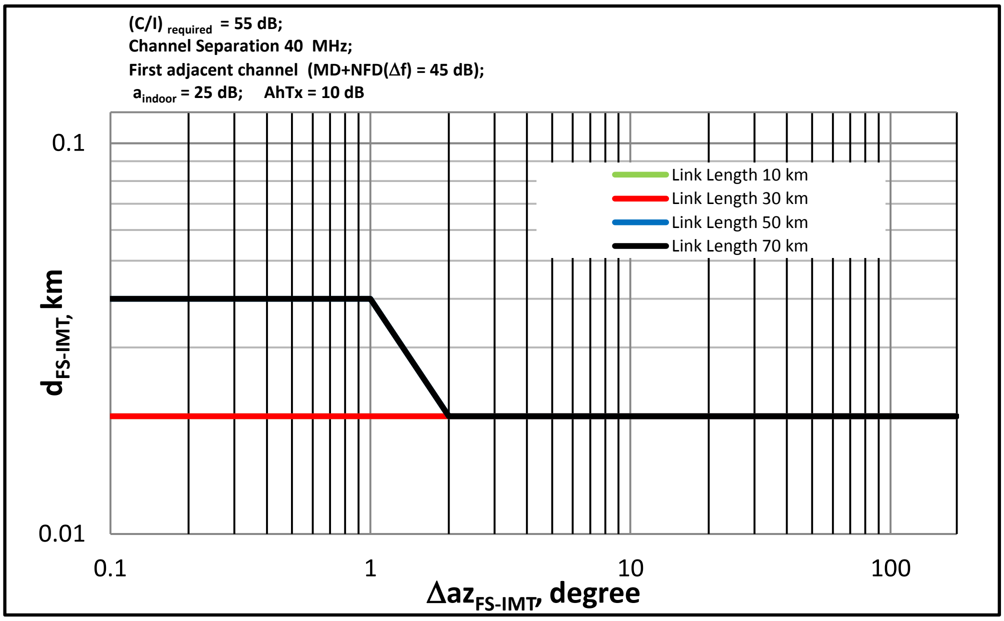


FIGURE 20

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

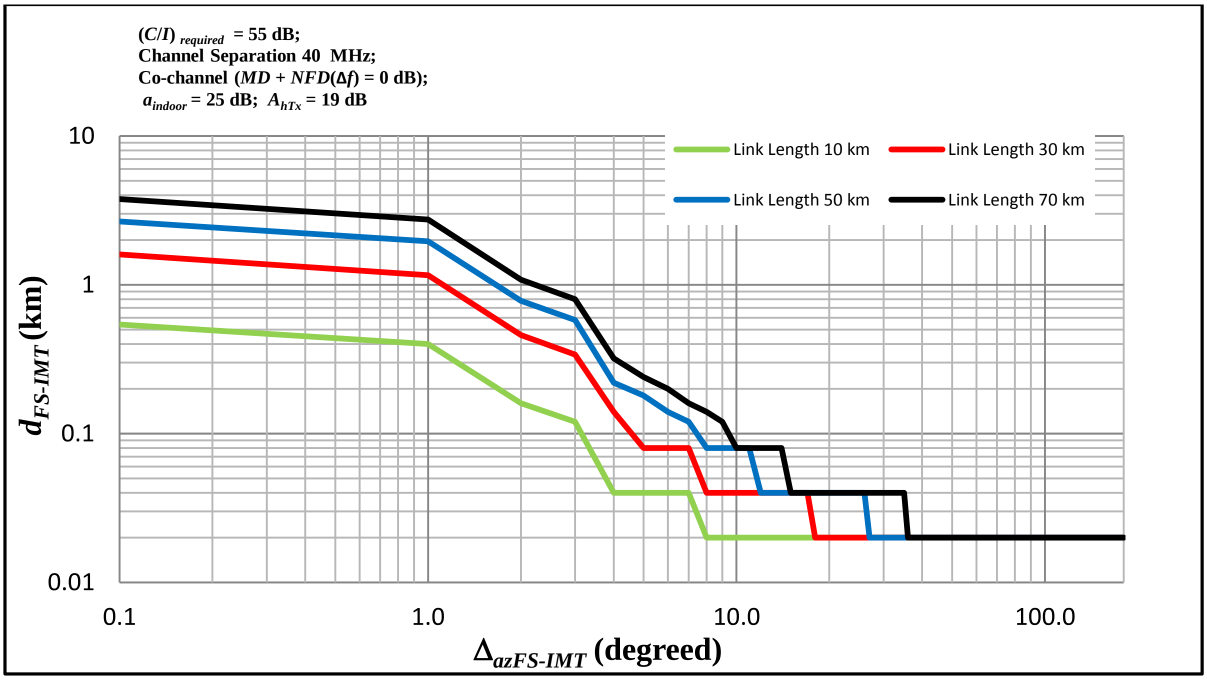


FIGURE 21

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

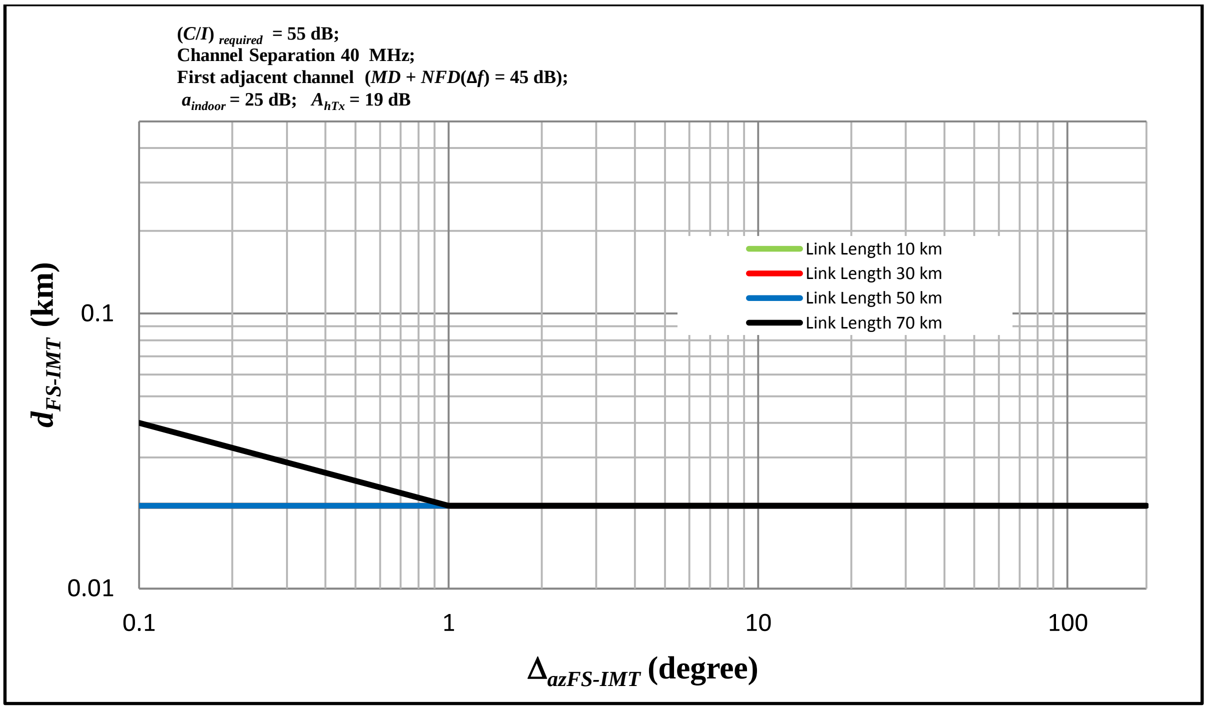


FIGURE 22

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

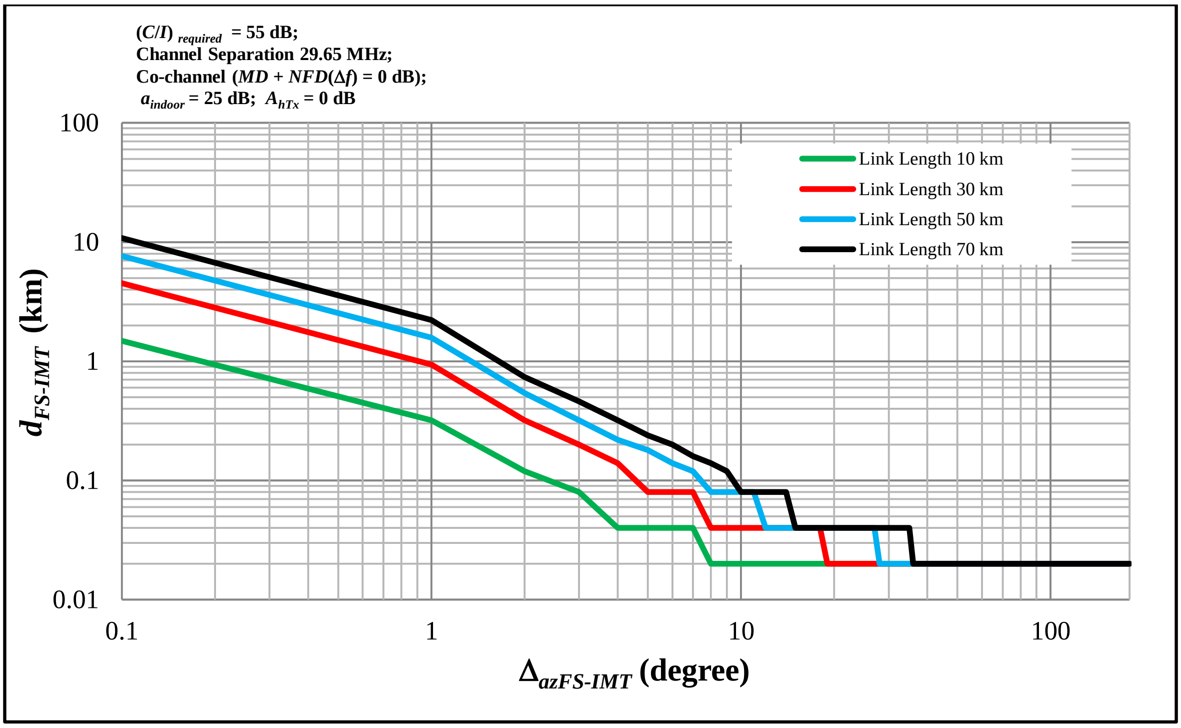


FIGURE 23

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

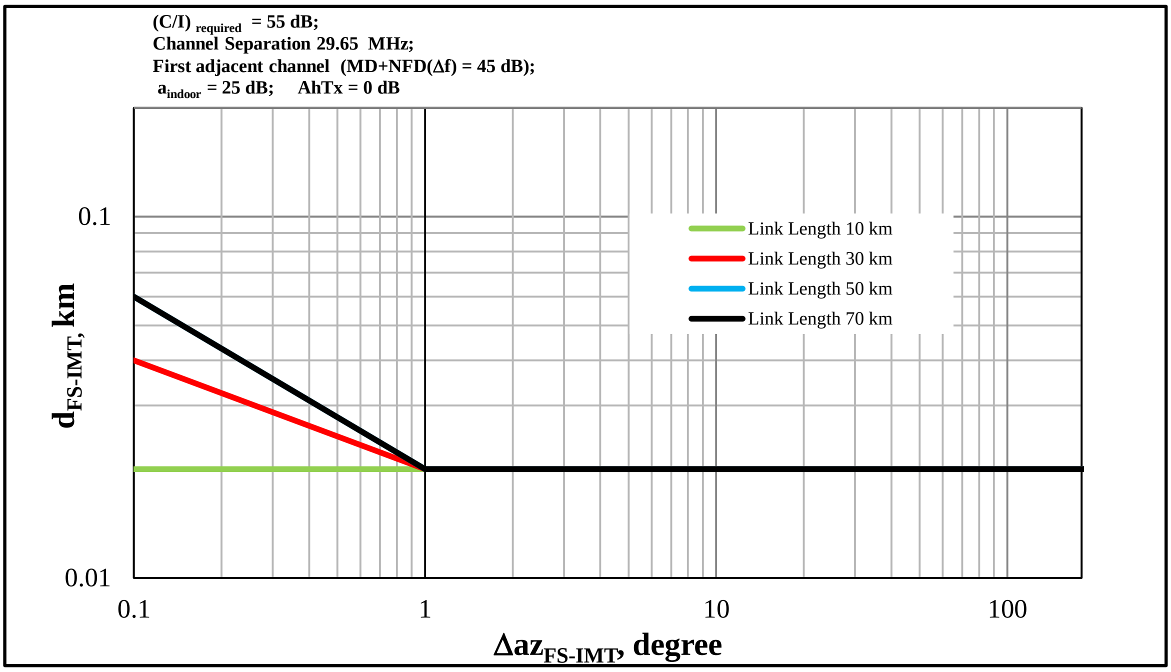


FIGURE 24

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

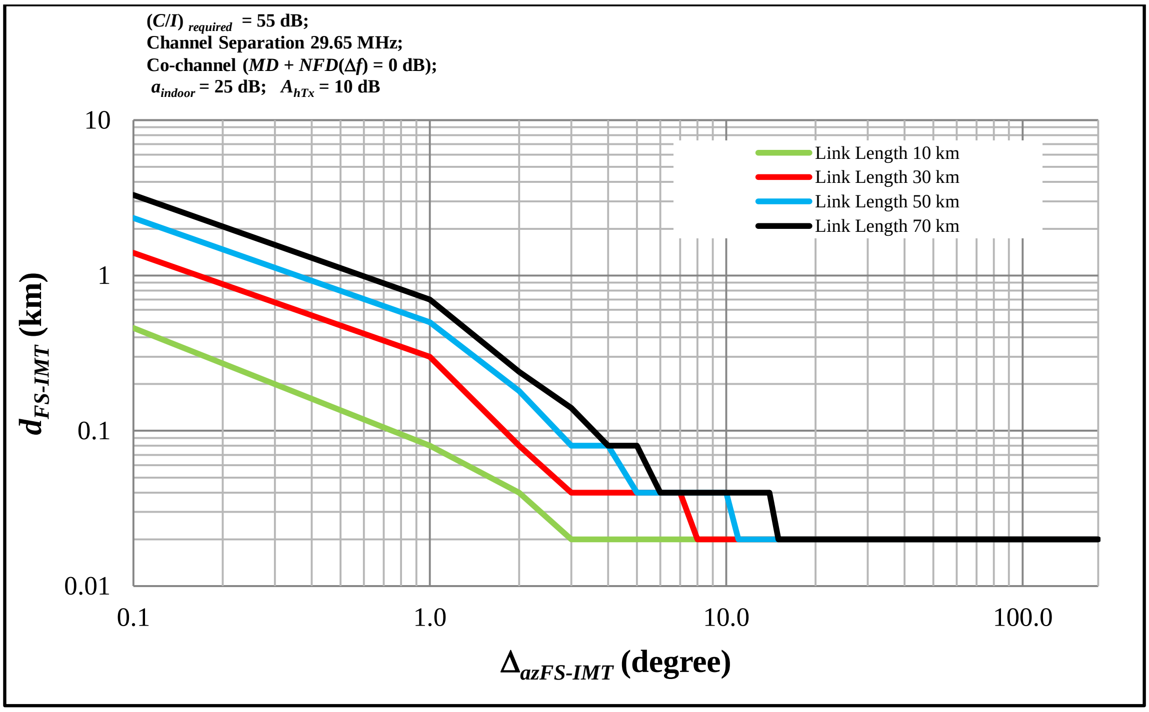


FIGURE 25

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

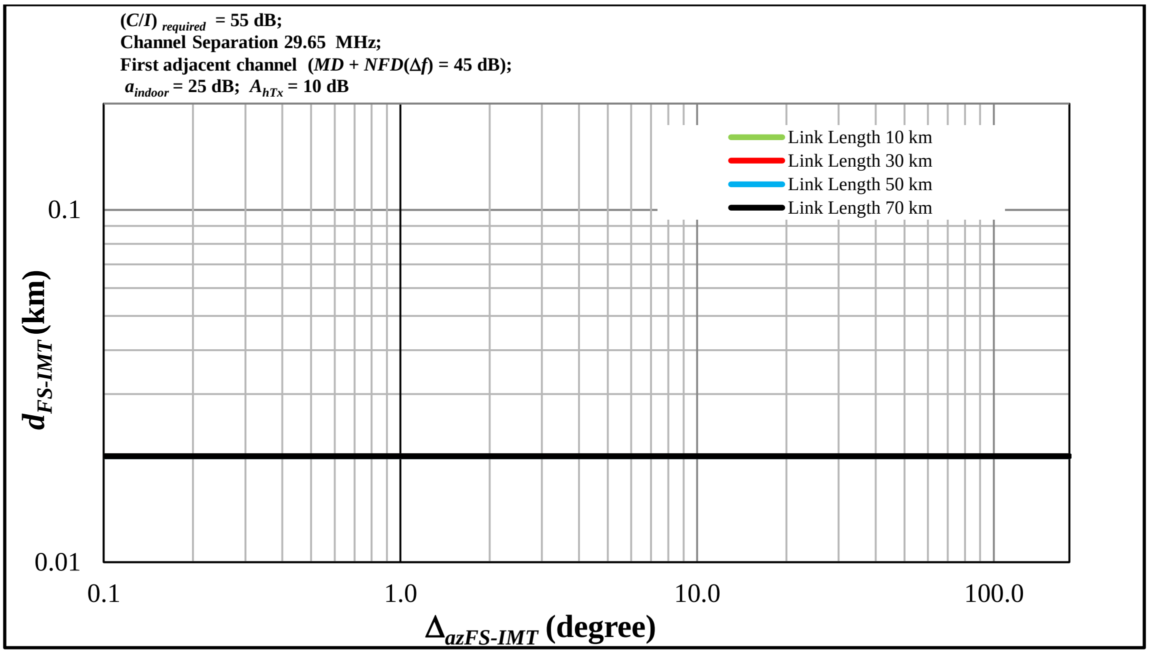


FIGURE 26

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

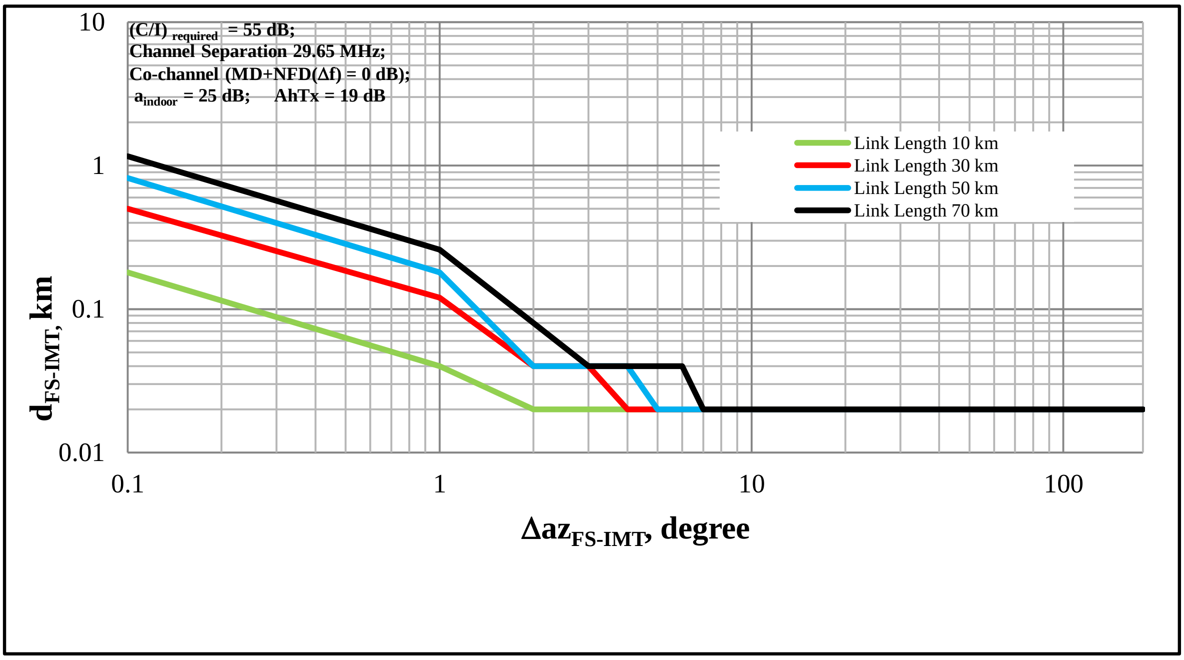
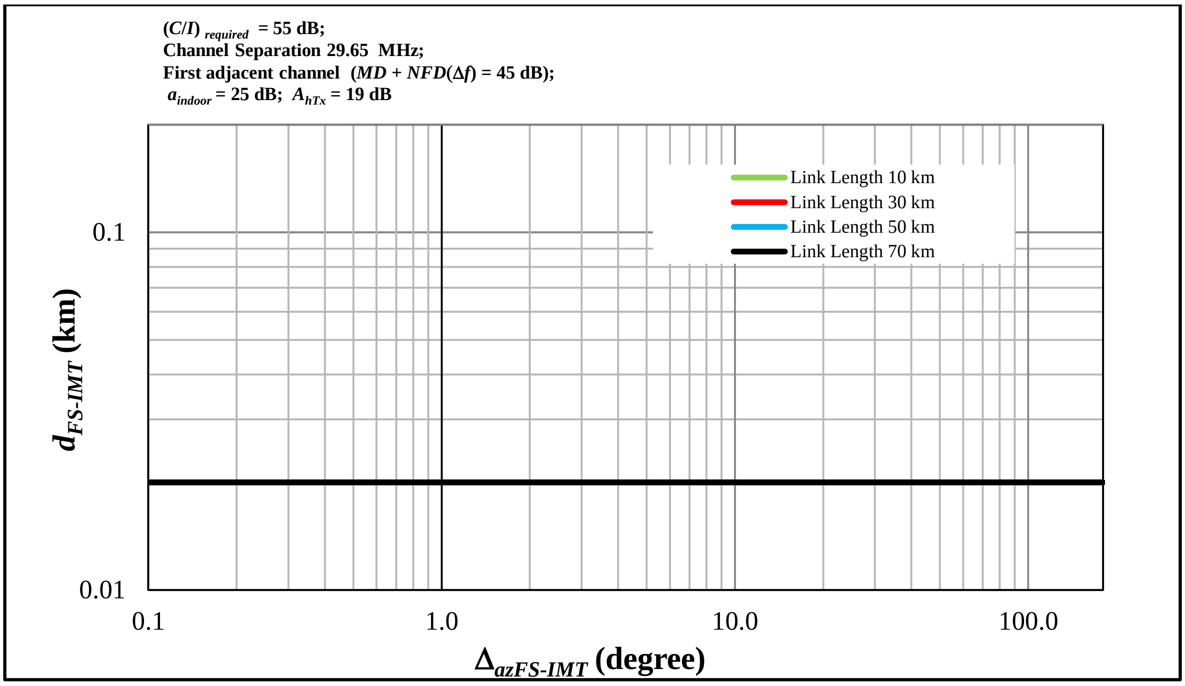


FIGURE 27

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)



4.3.1.2 Case #2.2 ($(C/I)_{required}$ = 40 dB)

The results of the required distance between the interfering transmitter base station IMT systems and the interfered receiver point-to-point FS systems $d_{FS\text{-}IMT}$ which is a function of angle between the main axis of the point-to-point FS system and the axis between the base station IMT system and the point-to-point FS system $\Delta_{az\ FS\text{-}IMT}$ are provided in Figs 28 to 39. (Link Length = 10, 30, 50, 70 km; A_{hTx} = 0, 10, 19 dB; Co-channel (*MD* + *NFD*(Δ*D* + *NFD*(l ((First adjacent channel (*MD* + *NFD*(Δ*D* + *NFD*(djac).

FIGURE 28

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

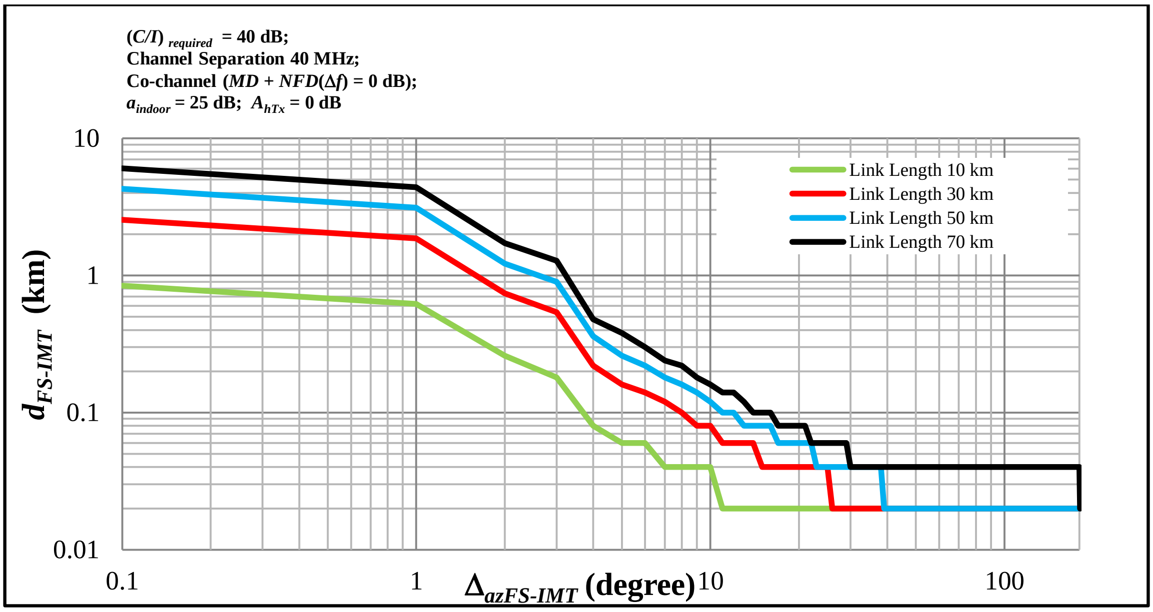


FIGURE 29

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

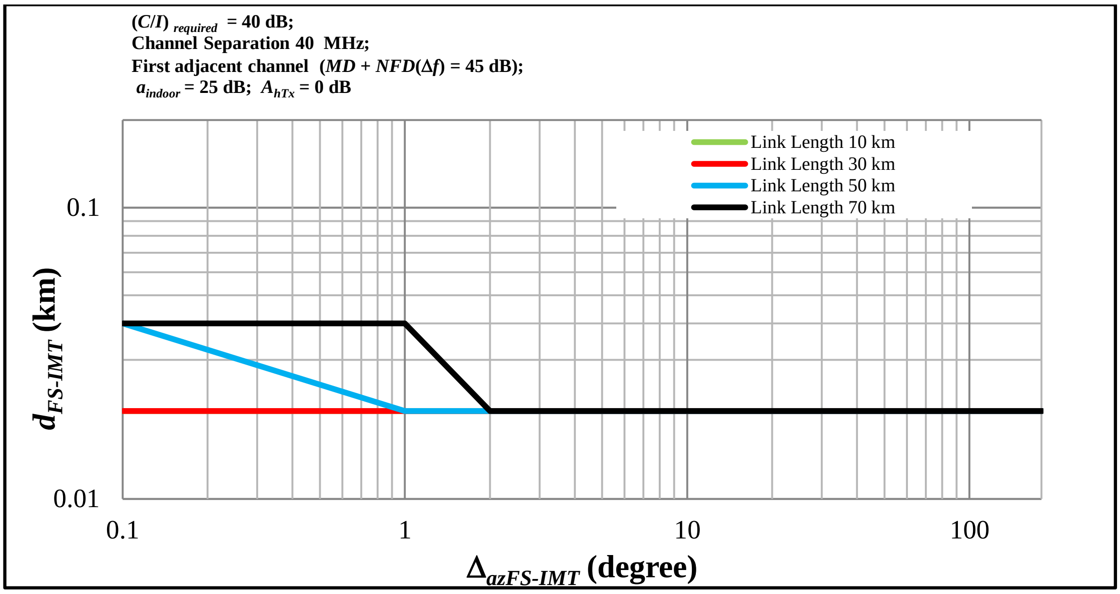


FIGURE 30

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

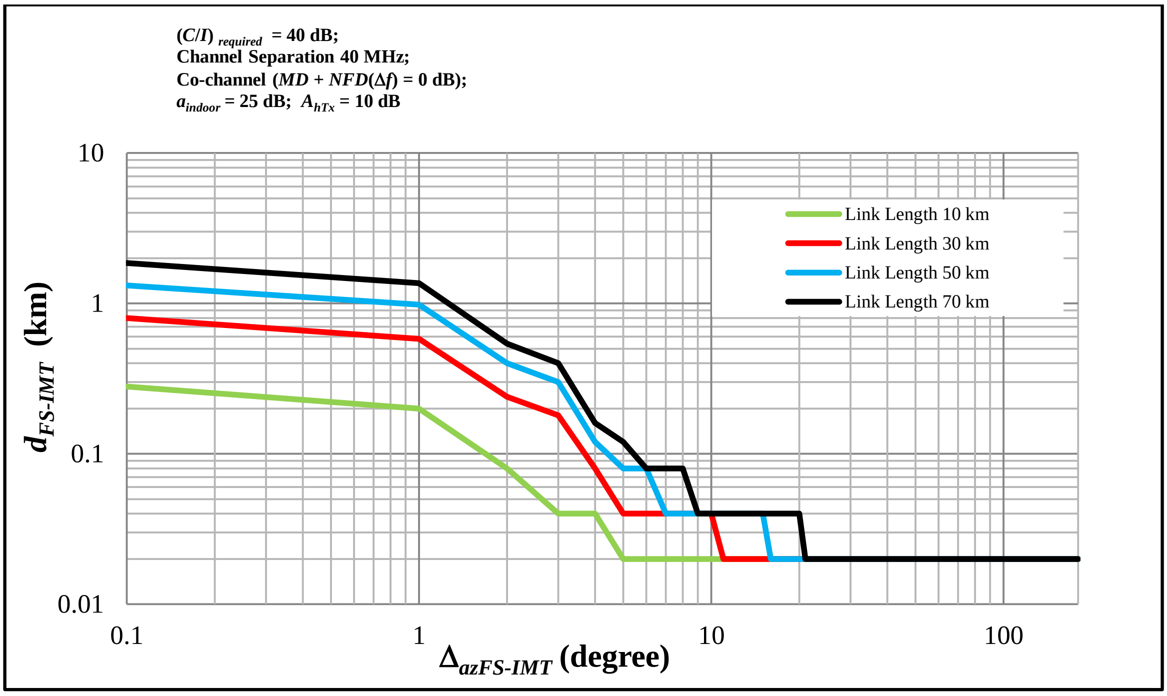


FIGURE 31

Required d$_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

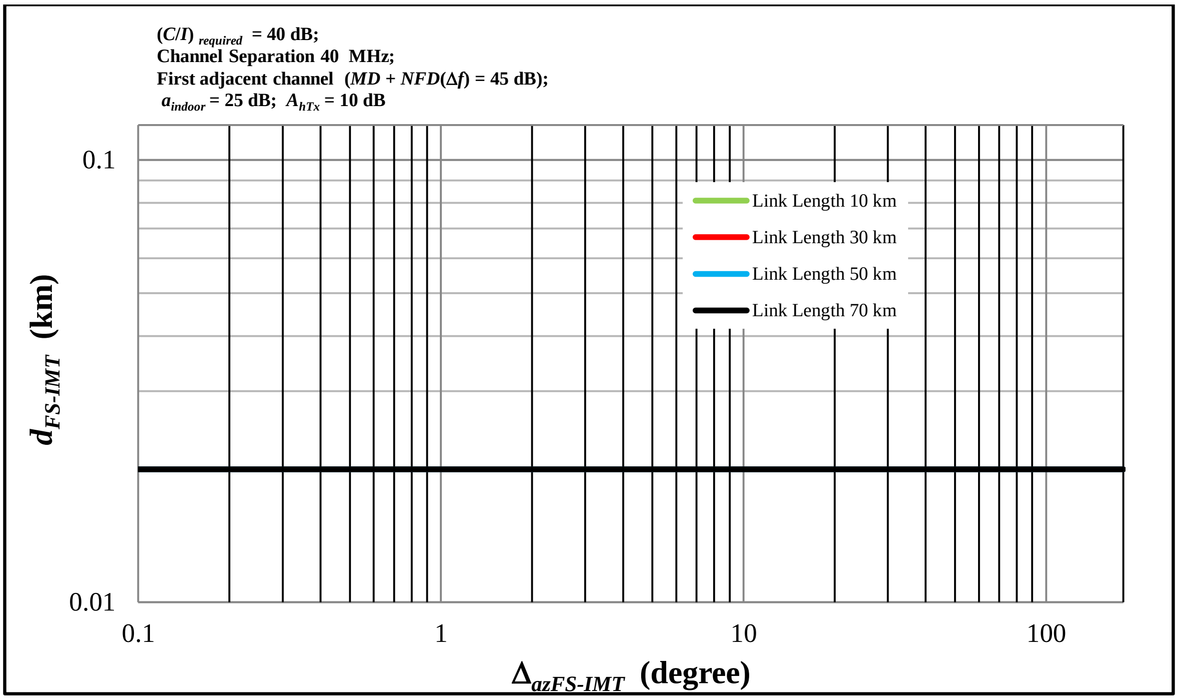


FIGURE 32

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

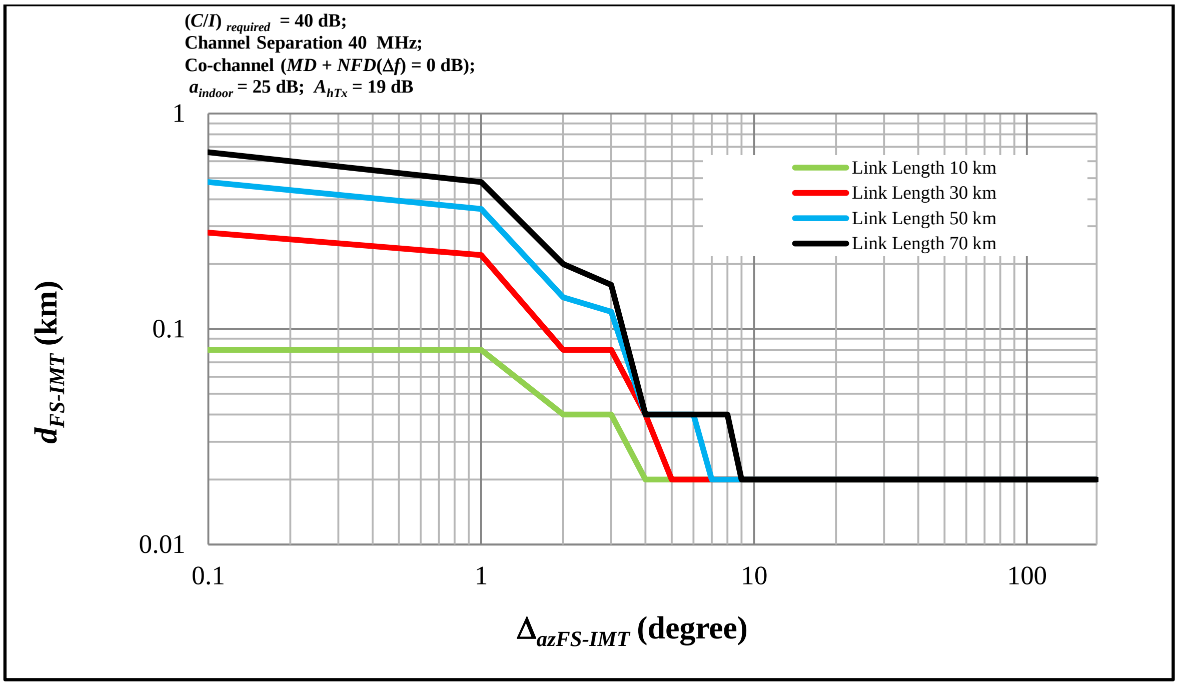


FIGURE 33

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 1)

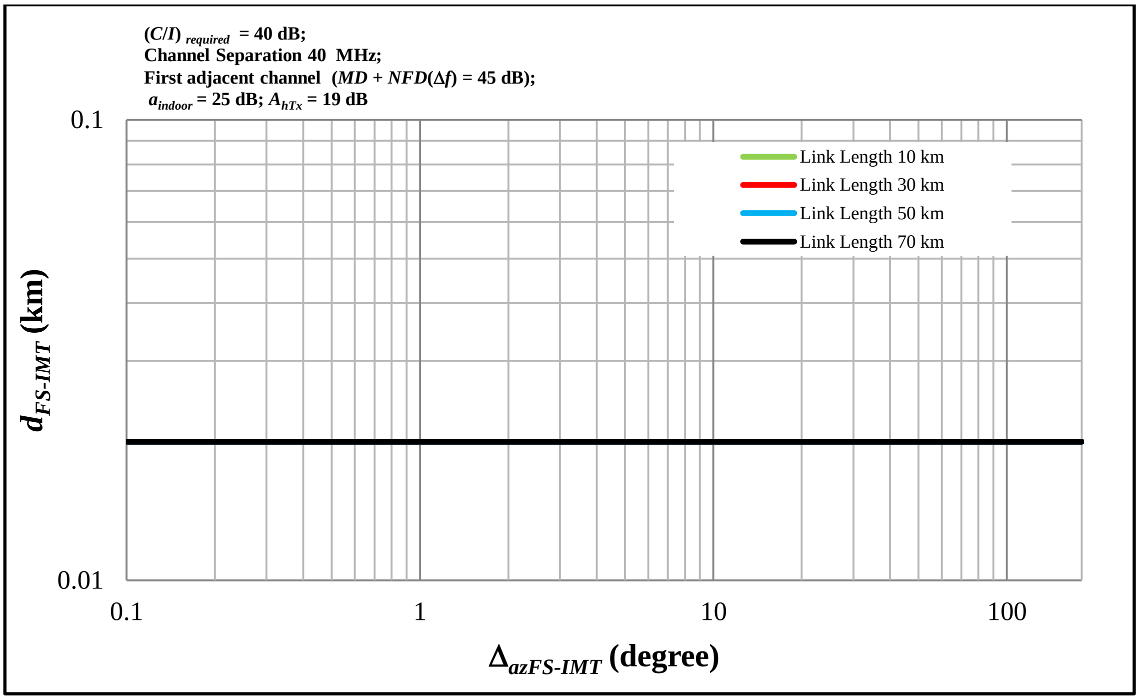


FIGURE 34

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

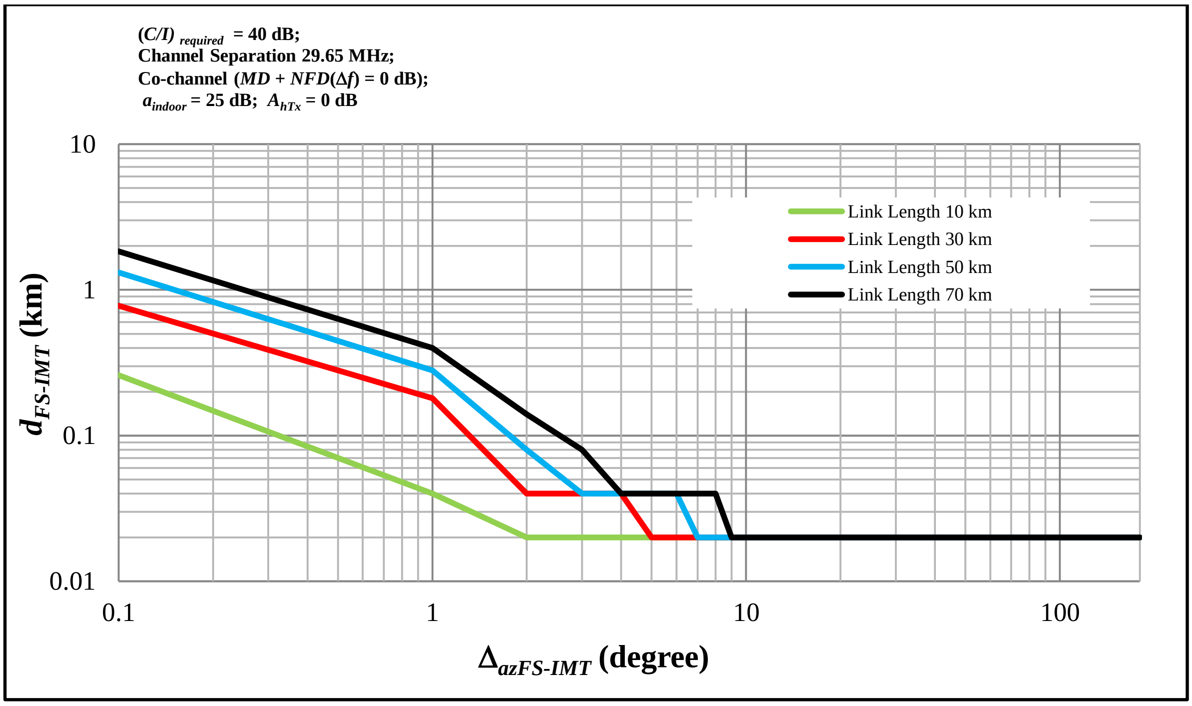


FIGURE 35

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

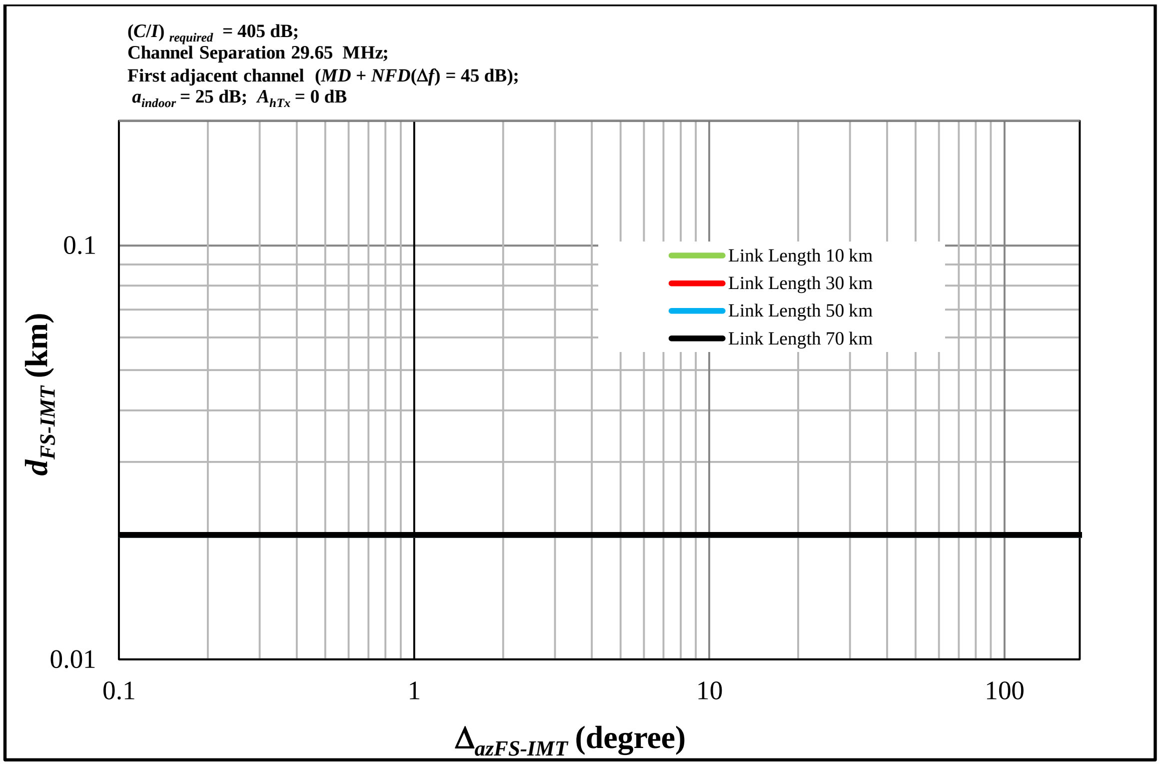


FIGURE 36

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

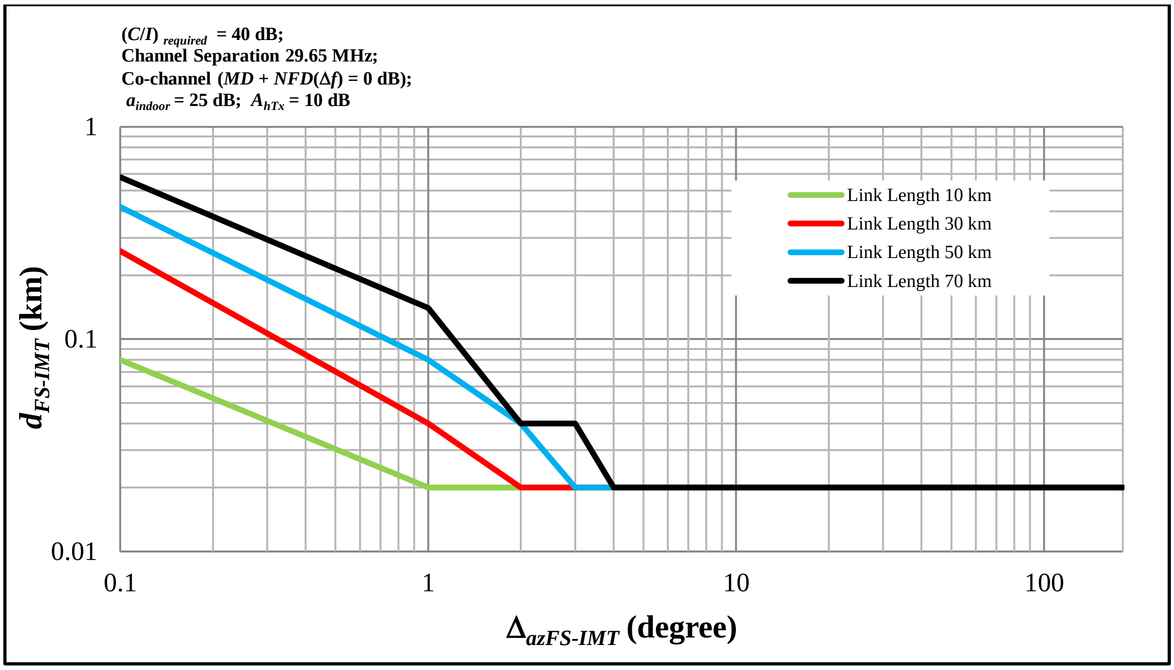


FIGURE 37

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

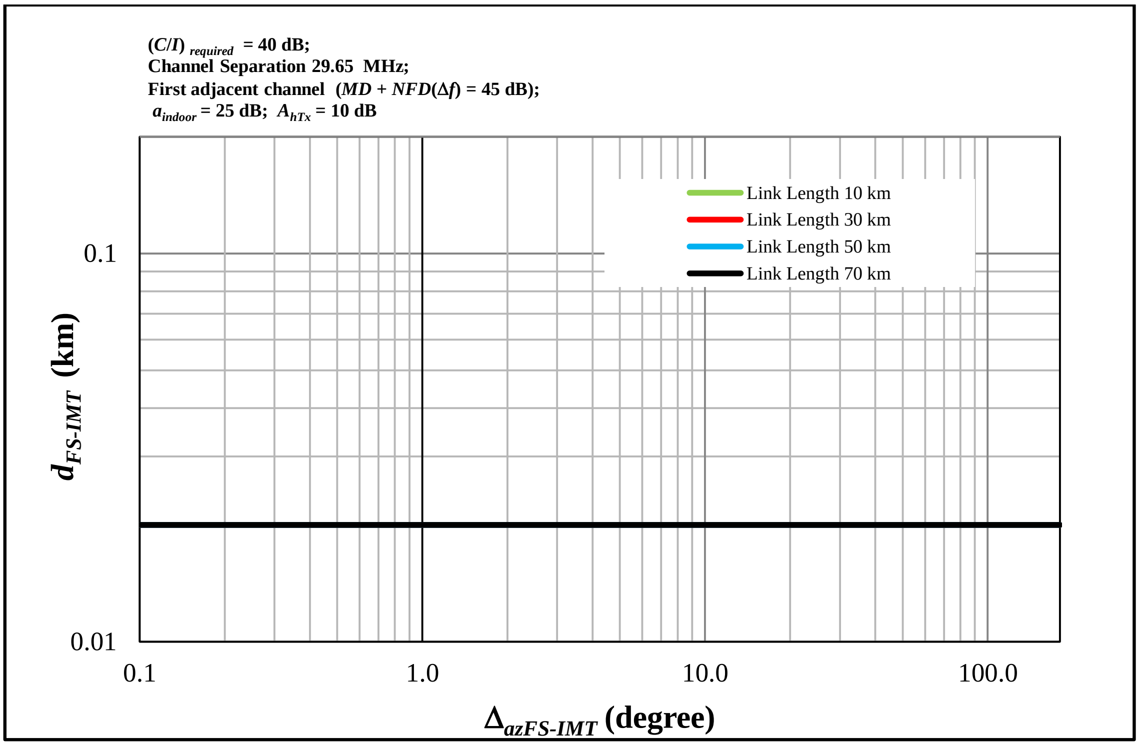


FIGURE 38

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)

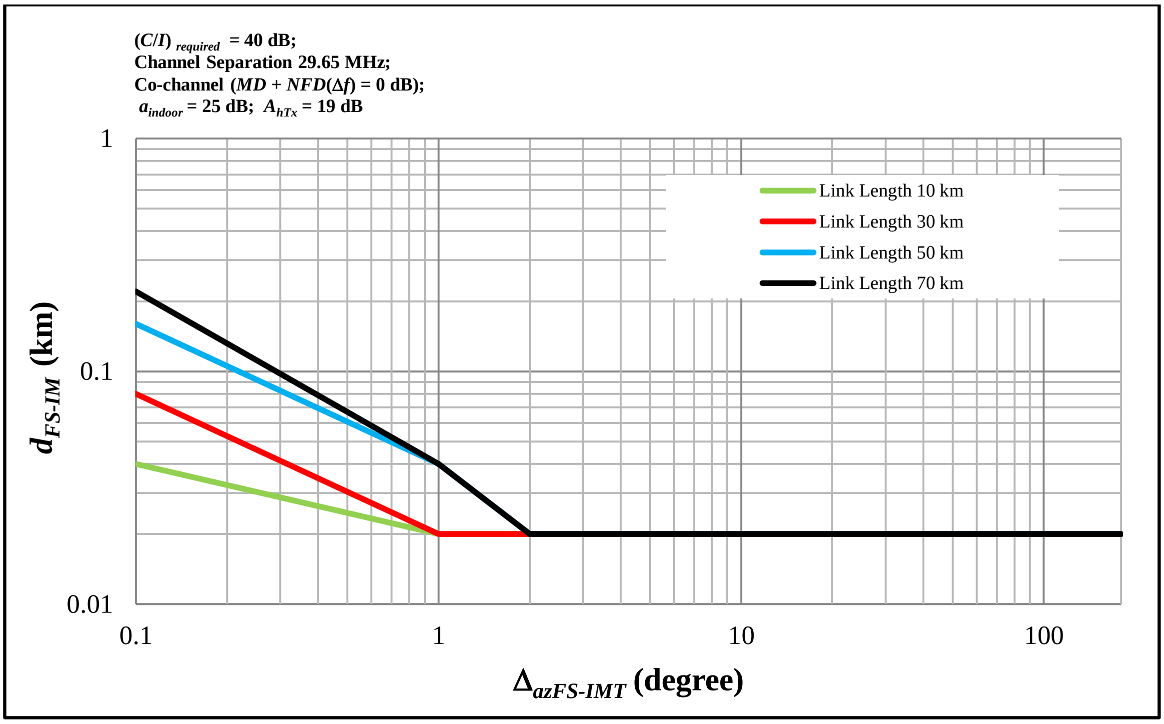
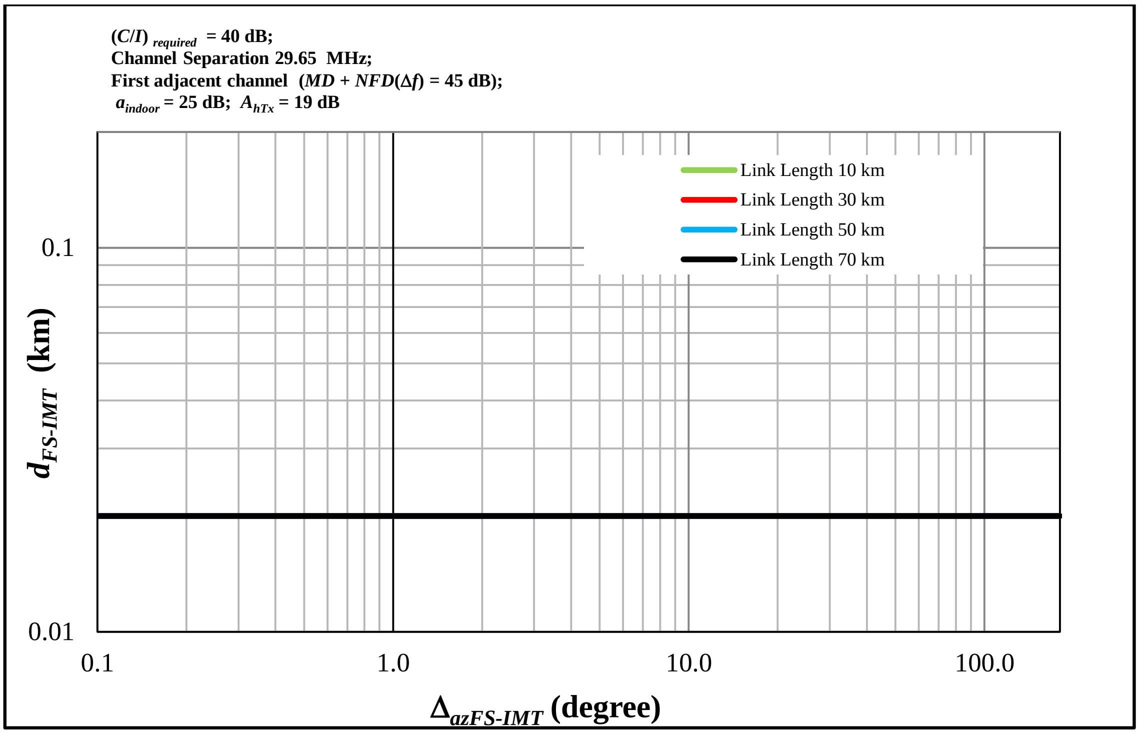


FIGURE 39

Required $d_{FS\text{-}IMT}$ which is a function of angle $\Delta_{az\ FS\text{-}IMT}$ (PP FS System type 2)



4.4 Results

The calculation results derived from Figs 12 and 14 show that the permissible I/N = –10 dB with IMT transmitters operating in co-channels with point-to-point FS receivers could be reached starting from 20 to 200 m distances in most directions, except for the main and first side lobes of antenna pattern. In the main lobe direction of antenna pattern this distance corresponds to 8 to 50 km, depending on the value of additional losses due to local clutter shielding which will be present in IMT urban environment. With increased angle between the main lobes of the point-to-point FS antenna pattern and IMT base station direction, this distance is reduced down to 20 to 200 m.

The permissible I/N = –10 dB for IMT transmitters operating in adjacent channels with point-to-point FS receivers would be met at 700 m or less for all location conditions of the stations (Figs 13 and 15).

The additional calculation results derived from Figs 16, 18, 20, 22, 24 and 26 show that the permissible C/I = 55 dB for IMT transmitters operating co-channel with point-to-point FS receivers could be reached for link distances of a point-to-point FS network from 10 to 70 km starting from 20 to 150 m distances in most directions, except for the main and first side lobes of antenna pattern. In the main lobe direction of the antenna pattern these distances may be 0.4 to 35 km, depending on the link distance of the point-to-point FS network and the value of additional losses due to clutter shielding. With increased angle between the main lobes of the point-to-point FS antenna pattern and IMT base station direction, this distance rapidly reduces down to 20 to 150 m.

The permissible C/I = 55 dB for IMT transmitters operating in adjacent channels with point-to-point FS receivers would be met starting from 200 m for all co-location conditions of the stations (Figs 17, 19, 21, 23, 25 and 27).

The additional calculation results derived from Figs 28, 30, 32, 34, 36 and 38 show that the permissible *C*/*I* = 40 dB for IMT transmitters operating co-channel with point-to-point FS receivers could be reached for link distances of a point-to-point FS network from 10 to 70 km starting from 20 to 60 m in most directions, except for the main and first side lobes of the antenna pattern. In the main lobe direction of the antenna pattern these distances may be 0.2 to 6 km, depending on the link distance of the point-to-point FS network and the value of additional losses due to clutter shielding. With increased angle between the main lobes of point-to-point FS antenna pattern and IMT base station direction, this distance rapidly reduces down to 20 to 40 m.

The permissible *C*/*I* = 40 dB for IMT transmitters operating in adjacent channels with point-to-point FS receivers would be met starting from 40 m for all co-location conditions of the stations (Figs 29, 31, 33, 35, 37 and 39).

5 Summary

The results of the studies showed that the permissible *I*/*N* = –10 dB could be reached in the presence of indoor IMT small cells operating co-channel with point-to-point FS receivers at distances of 20 to 200 m in most directions, except for the main and first side lobes of the antenna pattern. In the main lobe direction of the antenna pattern this distance corresponds to 8 to 50 km, depending on the value of additional losses due to local clutter shielding, which will be present in an IMT urban environment. The likelihood of an IMT small cell lying within the main or first side lobes of a point-to-point antenna pattern has not been studied. These results are derived based on a single interferer and do not consider the cumulative effect, which could lead to different values.

When detailed information on point-to-point link deployment is available, more detailed planning of IMT systems could be performed to reduce the separation distances mentioned above.

The calculated separation distances are going to be dependent on a number of local considerations including deployment and geographical distribution of both IMT and FS stations at national level and may require coordination with neighbouring administrations.