CEPT ECC
Electronic Communications Committee

ECC Report 215

Assessment of the technical feasibility of introducing very narrow channel spacing in some existing plans, in guard bands and center gaps of FWS channel arrangement at 6 GHz and 10 GHz

Approved May 2014

0 EXECUTIVE SUMMARY

The aim of this report is to assess the feasibility of introducing narrow channel spacings for FS (25 kHz to 2 MHz), similar to those used in 1375-1400/1427-1452 MHz in some existing plans, in guard bands and center gaps of FS channel arrangement between 3 GHz and 15 GHz in terms of the compatibility and sharing considerations with others services as well as within the FS. These narrow channel FS links are used for fixed wireless services for a variety of applications including broadcasting, fixed networks, Oil & Gas, public safety and utilities, often for long hop narrowband communications. The largest users are public safety and utilities sectors. In developing this report it should be noted that the feasibility of using the bands within the range 3 to 15 GHz, for the applications that are currently used in the band 1375-1400 /1427-1452 MHz (in terms of hop length and link design), was not part of this work.

During this study, no information have been presented on the feasibility of FS equipment to facilitate these narrow channels on the 6 and 10 GHz bands as well as the availability of the equipment currently on the market supporting these channels. However, one administration who currently implements a large number of links operated in the 1375/1400 /1427/1452 MHz band indicated a steady increase of the need for implementing narrow channels.

The feasibility of narrow channels from compatibility/sharing point of view with others services and within FS for the following bands was carried out:

- Compatibility studies carried out for the 10 GHz band have shown that implementation of narrow channels in guard band and/or center gap would adversely impact the incumbent services, especially those below 10.5 GHz. However, from 10.5 to 10.6 GHz and with additional channels arrangements to those currently presented in CEPT/ERC/REC 12-05 [3], the 10 GHz band may be considered.

- The compatibility studies carried out for the 6 GHz band indicate that feasibility of small channel is possible in guard bands and/or center gap. Although the 6 GHz band is already allocated to fixed services as a primary allocation, several scenarios have been considered to take into account the impact of the increase of spectral power density with respect to other services like FSS. It must be noted that worst cases scenarios have pointed out the need of coordination between new FS using these small channels and other incumbent FS uses, as usually done in fixed service planning.

In summary, this report presents different options for those administrations wishing to implement narrow channels which could be considered at national level taking into account the above considerations.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
CEPT	European Conference of Postal and Telecommunications Administrations
CS	Channel spacing
ECC	Electronic Communications Committee
ENG	Electronic news gathering
FS	Fixed service
IT	Interfering transmitter
LOS	Line of sight
L6	Lower part of 6 GHz band (5925-6425 MHz)
MCL	Minimum coupling loss
PP (P-P)	Point to point
SAP/SAB	Services ancillary to program making – Service ancillary to broadcast
SEL	Spurious emissions level
TS	Terminal station
UWB	Ultra wide band
U6	Upper part of the 6 GHz band (6425-7125 MHz)
VR	Victim receiver

1 INTRODUCTION

The aim of the report is to assess the possibility of introducing narrow channel spacing in some existing plans, in guard bands and center gaps of ERC/ECC Recommendations defining for FWS channel arrangements between 3 GHz and 15 GHz. The following items are evaluated: compatibility /sharing studies, coordination issues, and demand versus equipment design/cost challenges.

2 CHARACTERISTICS OF VERY NARROW CHANNEL SPACINGS IN THE BAND 1375-1400 / 1427-1452 MHz

In some CEPT countries, the channel spacing's (CS) of the 1.4GHz bands are 0.0250 MHz, 0.250 MHz and 0.500 MHz, 1 MHz, 2 MHz and 3.5 MHz in accordance with ERC/REC T/R 13-01 [4] - annex A and B.

The tables presented below are extracts from Recommendation ITU-R F.758 [22] and ERC/REC T/R 13-01 [4]. They are presented in this document in order to have up-to-date technical characteristics for FS P-P applications in the 1.4 GHz frequency bands.

2.1 RECOMMENDED FREQUENCY BAND PLAN FOR THE 1375-1400 / 1427-1452 MHz

The following figure presents the recommended frequency band plan for the 1375-1400/1427-1452 MHz from the ERC/REC T/R 13-01 [4].

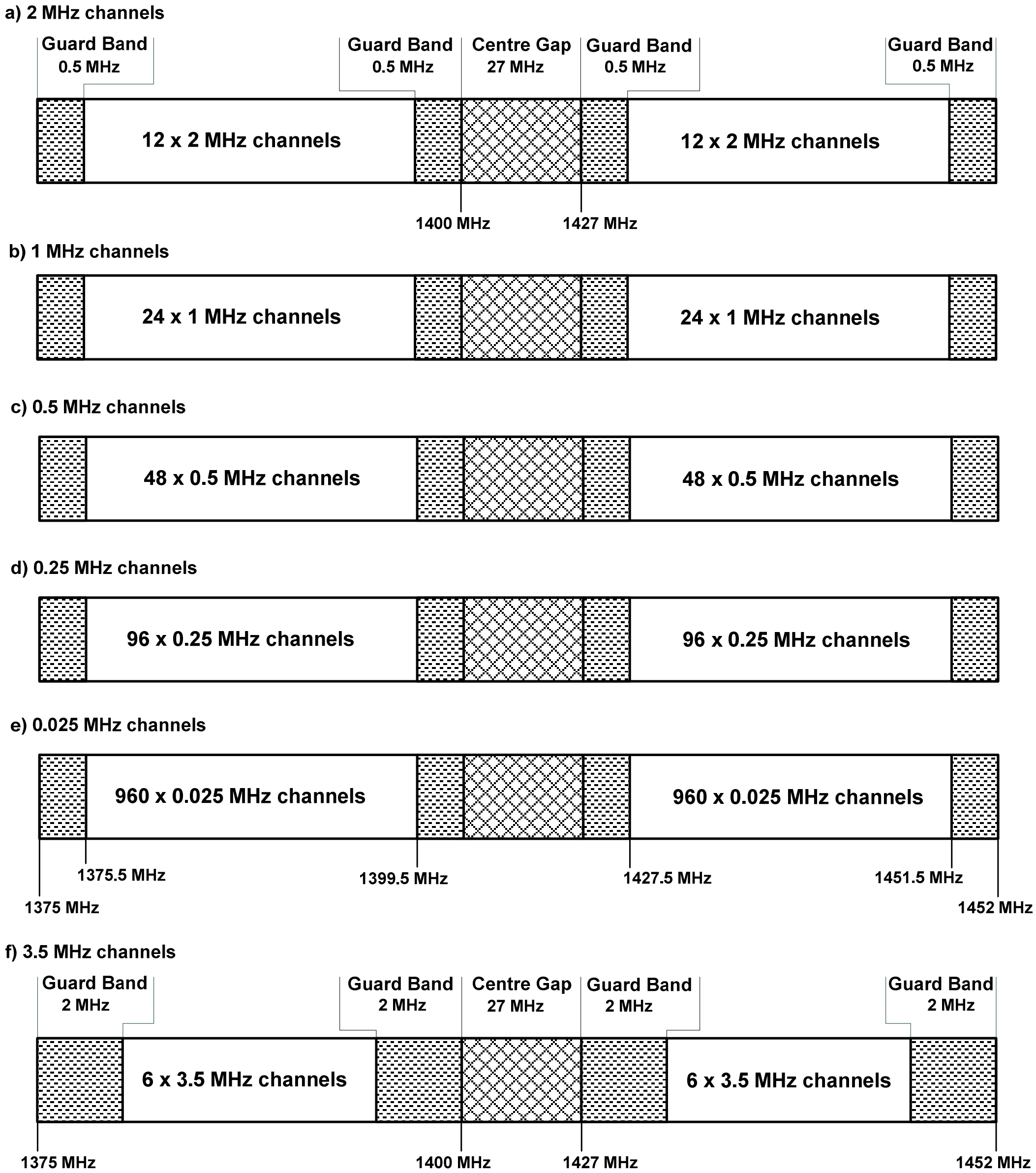


Figure 1: Extract of ERC/REC T/R 13-01 for Frequency band 1375-1400 MHz paired with 1427-1452 MHz

2.2 SYSTEM PARAMETERS FOR POINT-TO-POINT FS SYSTEMS

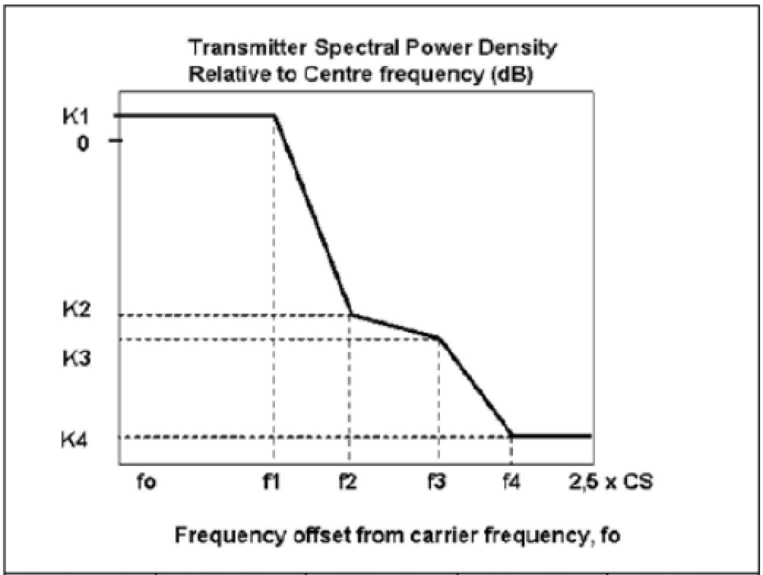
2.2.1 General parameters

Table 1: System parameters for point-to-point FS systems in band 1.4 GHz

Parameters		
Frequency range (GHz)	1.350-1.530	1.350-1.530
Reference ITU-R Rec.	F. 1242 [24]	F. 1242 [24]
Modulation	MSK	QPSK
Channel spacing and receiver noise bandwidth (MHz)	0.25, 0.5, 1, 2, 3.5	0.25, 0.5, 1, 2, 3.5
Maximum Tx output power range (dBW)	7	0…7
Maximum Tx output power density range (dBW/MHz) (1)	4.0	−3.0…7
Minimum feeder/multiplexer loss range (dB)	5	1…5
Maximum antenna gain range (dBi)	16	16…33
Maximum e.i.r.p. range (dBW)	20	20…39
Maximum e.i.r.p. density range (dBW/MHz) (1)	17	17…39
Receiver noise figure (dB)	4	4…7
Receiver noise power density typical (=NRX) (dBW/MHz)	−140	−140…−137
Normalized Rx input level for 1 × 10–6 BER (dBW/MHz)	−126.5	−126.5…−123.5
Nominal long-term interference power density (dBW/MHz) (2)	−140 + I/N	−140…−137 + I/N

2.2.2 FS spectrum emission masks to be used in the 1.4 GHz band

Based on ETSI EN 301 390 v1.2.1 [17] A3 the Spurious Emission Levels (SEL) for application for frequencies above 1 GHz is equal SEL = -50 dBm/1MHz. However for Fixed Service there is ETSI 301 390 A3 (also ITU-R SM.329 [30] Annex 6) determines that reference bandwidth is reduced. The range of reduction is variable from 0.3 kHz up to 100 kHz and is presented in Figure 3 (ETSI document figure A.1 on p.15).



Number of segments	K1 in dB f1 in MHz	K2 in dB f2 in MHz	K3 in dB f3 in MHz	K4 in dB f4 in MHz
5	K1/f1	K2/f2	K3/f3	K4/f4

Figure 2: FS Transmitter emission mask (ETSI EN 302 217-2-2 V2.1.1 [18])

Table 2: FS transmitter emission mask

Channel separation [MHz]	K1 (dB)	f1 (MHz)	K2 (dB)	f2 (MHz)	K3 (dB)	f3 (MHz)	K4 (dB)	f4 (MHz)
2	+3	0.84	-25	1.3	-25	1.8	-45	3.2

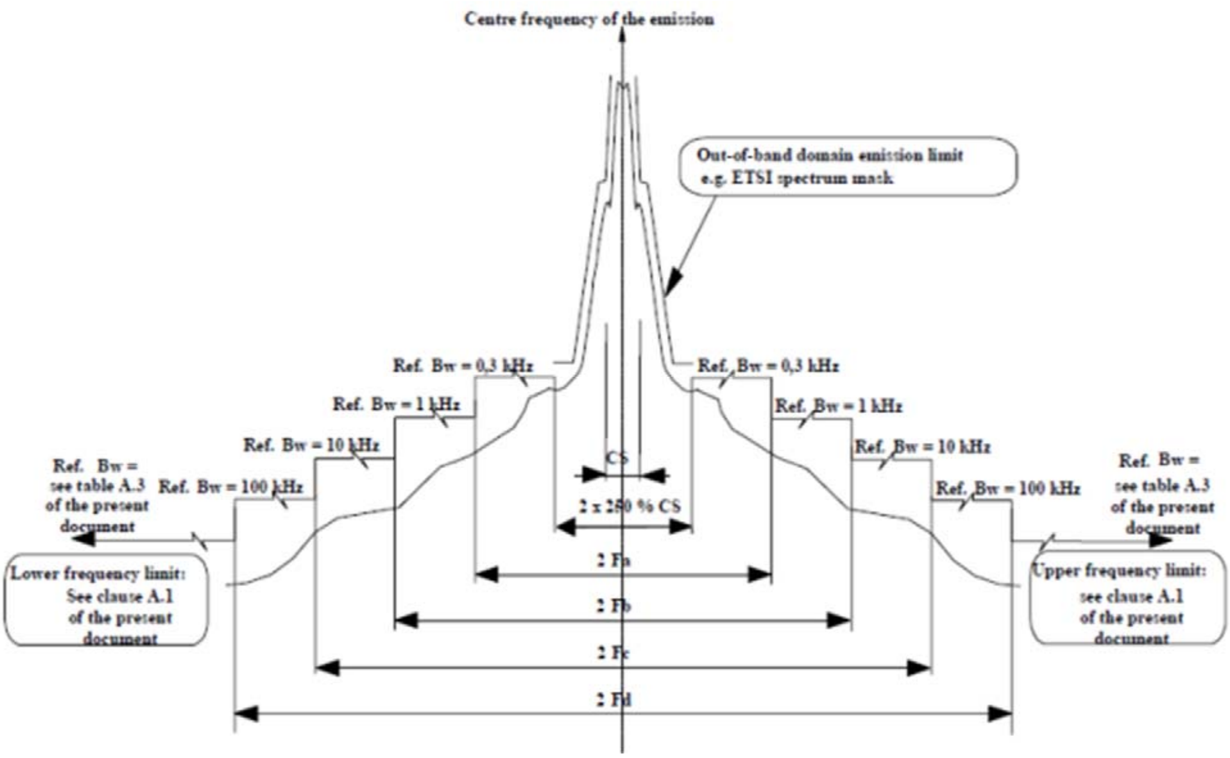


Figure 3: Spectrum emission level from ETSI EN 302 217-2-2 V1.3.1 [18]

2.3 NATIONAL EXAMPLE OF NARROW CHANNEL SPACINGS DEPLOYMENTS

2.3.1 Example in France (1375-1400 / 1427-1452 MHz)

Distribution of French narrow channel spacing in the L band is the following one (excerpt from French public consultation on FH (ARCEP, April 2012)).

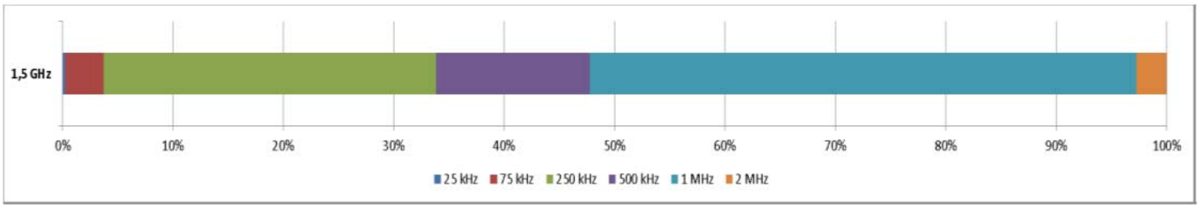


Figure 4: Distribution of French narrow channel spacing in the L band is the following one (excerpt from French public consultation on FH (ARCEP, April 2012))

From this figure, it can be seen that the more numerous CS are

- first 1 MHz CS
- then the 250 kHz CS
- then the 500 kHz CS
- then the 75 KHz CS
- then the 2 MHz CS
- then the 25 kHz CS

Information provided by administrations in the ECC Report 173 [1], reports an average hop length of 28 km in this band.

2.3.2 Example in the UK (1350-1375 / 1492-1517MHz band)

The 1350-1375 / 1492-1517 MHz is used in the UK for fixed wireless services for a variety of applications including broadcasting, fixed networks, Oil & Gas, public safety and utilities. The largest users are public safety and utilities sectors. The channel plans in use are in accordance with ERC/REC T/R 13-01 [4] Annex A.

Table 3: Typical parameters used in the UK

Parameters	value
Antenna gain range and typical (dBi)	4.5 – 29; 16 (typical)
Antenna types	Yagi, flat panel, parabolic
Path length range (km)	0.3 – 77
e.i.r.p. Range (dBW)	-38 to +33
Channel bandwidths	25KHz, 75KHz, 250KHz, 500KHz, 1MHz, 2MHz and 3.5MHz.

3 FREQUENCY BANDS CONSIDERED FOR THE INSERTION OF THE NARROW CHANNELS

3.1 10 GHz BAND

3.1.1 Allocation in 10 GHz band in the RR

In the frequency band 10 - 10.68 GHz, there is primary allocation to FS in Region 1 except for the band 10.45 - 10.5 GHz (see excerpt from Radio Regulations in Table 1 below).

Table 4: Radio Regulation, allocation to FS and MS. Frequency band 10 – 10.68 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>10-10.45
FIXED
MOBILE
RADIOLOCATION
Amateur
5.479</td><td>10-10.45
RADIOLOCATION
Amateur
5.479 5.480</td><td>10-10.45
FIXED
MOBILE
RADIOLOCATION
Amateur
5.479</td></tr>
<tr><td colspan="3">10.45-10.5 RADIOLOCATION
Amateur
Amateur-satellite
5.481</td></tr>
<tr><td>10.5-10.55
FIXED
MOBILE
Radiolocation</td><td colspan="2">10.5-10.55
FIXED
MOBILE
RADIOLOCATION</td></tr>
<tr><td colspan="3">10.55-10.6 FIXED
MOBILE except aeronautical mobile
Radiolocation</td></tr>
<tr><td colspan="3">10.6-10.68 EARTH EXPLORATION-SATELLITE (passive)
FIXED
MOBILE except aeronautical mobile
RADIO ASTRONOMY
SPACE RESEARCH (passive)
Radiolocation
5.149 5.482 5.482A</td></tr>
</table>

3.1.2 Allocation in 10 GHz band in the CEPT

Table 5: Applications in 10.15 - 10.65 GHz (source: www.efis.dk)

Frequency	Application	Short Comments
10.150 - 10.300 GHz	SAP/SAB and ENG/OB	
10.150 - 10.300 GHz	Defence systems	
10.150 - 10.300 GHz	Radiolocation (civil)	Civil and military radars. Low

Frequency	Application	Short Comments
		power radars in certain subbands
10.150 - 10.300 GHz	Amateur	
10.150 - 10.300 GHz	Radiodetermination applications	Within the band 10.5 - 10.6 GHz, and within the band 8.5 - 10.6 GHz for TLPR application
10.150 - 10.300 GHz	BFWA	Including Point-to-Multipoint
10.150 - 10.300 GHz	Fixed	
10.300 - 10.450 GHz	Defence systems	
10.300 - 10.450 GHz	PMSE	SAP/SAB
10.300 - 10.450 GHz	Radiodetermination applications	Within the band 8.5 - 10.6 GHz for TLPR application
10.300 - 10.450 GHz	Radiolocation (civil)	Civil and military radars. Low power radars in certain subbands
10.300 - 10.450 GHz	Amateur	
10.450 - 10.500 GHz	Defence systems	
10.450 - 10.500 GHz	Radiolocation (civil)	Civil and military radars
10.450 - 10.500 GHz	Radiodetermination applications	Within the band 10.5 - 10.6 GHz, and within the band 8.5 - 10.6 GHz for TLPR application
10.450 - 10.500 GHz	Amateur	
10.450 - 10.500 GHz	Amateur-satellite	
10.450 - 10.500 GHz	Fixed	
10.450 - 10.500 GHz	PMSE	SAP/SAB
10.500 - 10.550 GHz	Fixed	
10.500 - 10.550 GHz	PMSE	SAP/SAB
10.500 - 10.550 GHz	BFWA	Including Point-to-Multipoint
10.500 - 10.550 GHz	Radiodetermination applications	Within the band 8.5 - 10.6 GHz for TLPR application
10.550 - 10.600 GHz	Radiodetermination applications	Within the band 10.5 - 10.6 GHz, and within the band 8.5 - 10.6 GHz for TLPR application
10.550 - 10.600 GHz	BFWA	Including Point-to-Multipoint
10.550 - 10.600 GHz	PMSE	SAP/SAB
10.550 - 10.600 GHz	Fixed	
10.600 - 10.650 GHz	Fixed	

The current state of the art for the 10 GHz band for different CEPT countries are presented in ANNEX 3:.

3.1.3 Current implementation of FS in the 10 GHz band

Among the different bands to be considered, the center gap of 10.3 - 10.5 Ghz band was proposed.

Before introducing any new services in center gap, potential coexistence risks should be estimated. In this section applications, which may be interfered (Table 1) and its system parameters were presented. The parameters were extracted from CEPT ECC Reports and Recommendations.

The centre gap of the 10150-10650 MHz CEPT band plan (Figure 5) provides a slot with 200 MHz width (10300-10500 MHz) and in a strictly technical point of view, in terms of occupancy, the 50 MHz could also be accommodated in this centre gap between 10300 and 10500 MHz (actually probably between 10300 MHz and 10450 MHz as the band 10450-10500 MHz is identified for Fixed service in the RR only for a few CEPT countries). A proposal of channel arrangement for this 10300-10450 MHz is given in ANNEX 2: of this document (The proposal is given for a 2x50 MHz channel arrangement as the gap is so wide).

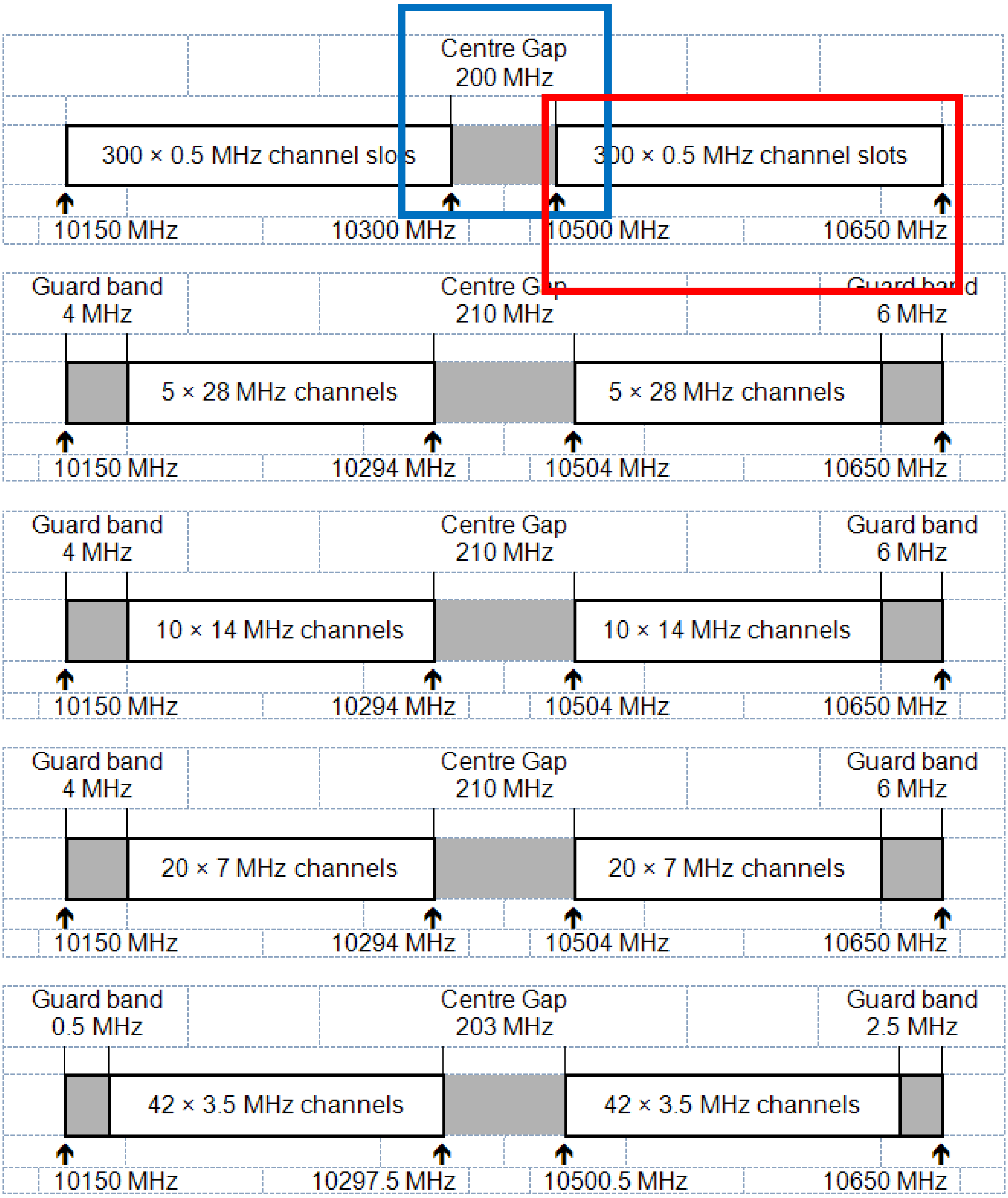


Figure 5: Extract from CEPT/ERC/REC 12-05 [3]

3.1.4 Characteristics of systems working in the 10.3 - 10.5 GHz band center gap

3.1.4.1 PMSE (Video Services Ancillary to Program-making/Services Ancillary to Broadcasting SAP/SAB links ENG/OB)

The following types of SAP/SAB video links (ENG/OB) might be considered within the frequency band 10.0-10.68 GHz:

- cordless cameras,
- portable video links,
- temporary point to point video links.

Table 6: Characteristics of video SAP/SAB links assumed for this study (ERC Report 038 [11])

Type of Link	Range	Max e.i.r.p.	Min Tx ant. gain	Min Rx ant. gain	Radio Link Path	Description
Cordless Camera	<500m	6dBW	0dBi	6dBi	Usually clear line of sight.	Handheld camera with integrated transmitter, power pack and antenna.
Portable Link	<2km	16dBW	6dBi	17dBi	Not always clear line of sight.	Handheld camera but with separate body worn transmitter, power pack and antenna.
Temporary Point-to-point Link	<80km each hop for links at <10GHz	40dBW	13dBi	17dBi	Usually clear line of sight for OB, but often obstructed for ENG use.	Link terminals are mounted on tripods, temporary platforms, purpose built vehicles or hydraulic hoists. Two-way links are often required.

Table 7: Further parameters for cordless camera, portable video link and temporary P-P links

	cordless camera	portable video link	temporary P-P link
Carrier frequency (MHz)	10305	10305	10305
Channel spacing and receiver noise bandwidth (MHz)	10/20 [8] [22]	10/20 [8] [22]	7/8/10/20/14/28 [8] [22]
Receiver antenna gain (dBi)	typ. 6 [11]	typ. 17 [11]	0.6m parabolic dish [11] 34
Antenna pattern	Omni-directional(1)	Omni-directional2	Directional based on ITU-R F.699-7 [25] ITU-R F.1245-1 [26]
Receiver antenna height (m)	from 2 to10 [9] 2	from 2 to10 [9] 3	20

[1] According to ECC Report 38 [11] SAP/SAB receivers on the roof of communication vehicles can use both omnidirectional and directional antennas. Omnidirectional antennas were assumed as the worst case scenario.

	cordless camera	portable video link	temporary P-P link
e.i.r.p. range (dBm)	36 [11]	46 [11]	70 [11]
e.i.r.p. density range (dBm/MHz)	26	36	60
Receiver noise figure (dB)	5 [9]	5 [9]	5 [9]
Receiver noise power density typical (=NRX) (dBm/MHz)	-109	-109	-109
I/N criterion	-6 [9]	-6 [9]	-6 [9]

Table 8: SAP/SAB (ENG OB) parameters from ITU-R F.1777 [27]

Parameters	Value		
Frequency band (GHz)	5.850 < f < 8.500 10.250 < f < 13.250		
Modulation	QPSK-OFDM 16-QAM-OFDM 32-QAM-OFDM 64-QAM-OFDM		QPSK 16-QAM 32-QAM 64-QAM
Capacity (Mbit/s)	Up to 30	Up to 60	Up to 66
Channel spacing (MHz)	9	18	18
Maximum Rx antenna gain (dBi)	35	35	35
Feeder/multiplexer loss (minimum) (dB)	Tx 1 Rx 1	Tx 1 Rx 1	Tx 1 Rx 1
Antenna type (Tx and Rx)	Parabolic ITU-R F.699-7 [25] ITU-R F.1245-1 [26]	Parabolic ITU-R F.699-7 [25] ITU-R F.1245-1 [26]	Parabolic ITU-R F.699-7 [25] ITU-R F.1245-1 [26]
Maximum Tx output power (dBW)	4	7	1.76
e.i.r.p. (maximum) (dBW)	38	41	36
Receiver IF bandwidth (MHz)	9	18	18
Receiver noise figure (dB)	4	4	4
Receiver thermal noise (dBW/MHz)	–130.5	–127.4	–127.4
Nominal Rx input level (dBW)	–88	–85	–91
Rx input level for 1 × 10–3 BER (dBW)	–120 –113 –110.7 –108.2	–116.9 –109.9 –107.6 –105.1	–116.9 –109.9 –107.6 –105.1
Nominal long-term interference (dBW) [2]	–140.5	–137.4	–137.4
Spectral density (dB(W/MHz))	–146.0	–146.0	–146.0

[2] Based on an *I*/*N*-th criterion of –10 dB.

3.1.4.2 Fixed Services Point to Multipoint in 10.15 - 10.68 GHz frequency band

Table 9: FS P-MP parameters from ITU-R F.758-5 [22]

Parameters	Value	
Frequency range (GHz)	10.15 - 10.68	10.15 - 10.68
Reference ITU-R Rec.	F.747 [31], F.1568 [32]	F.747 [31], F.1568 [32]
Modulation format	Central Stations 64-QAM	Terminal Station 64-QAM
Channel spacing and receiver noise bandwidth (MHz)	1.75 (3), 2.5, 5, 28(5), 30(5)	1.75 (3), 2.5, 5, 28(5), 30(5)
Tx output power range (dBW)	−3	−12
Tx output power density range (dBW/MHz)(1)	−5.43	−14.4
Feeder/multiplexer loss range (dB)	0.5	0
Antenna type and gain range (dBi)	15 (90° microstrip sectoral)	18 (panel)
e.i.r.p. range (dBW)	11.5	6
e.i.r.p. density range (dBW/MHz)	9.07	3.57
Receiver noise figure typical (dB)	5	5
Receiver noise power density typical (=NRX) (dBW/MHz)	−139	−139
Normalized Rx input level for 1 × 10–6 BER (dBW/MHz)	−112.5	−112.5
Nominal long-term interference power density (dBW/MHz)(2)	−139 + I/N	−139 + I/N

3.1.4.3 UWB services working in 8.5-10.6 GHz frequency band

Mean e.i.r.p. density is -65dBm/MHz. UWB emission mask is presented in figure below.

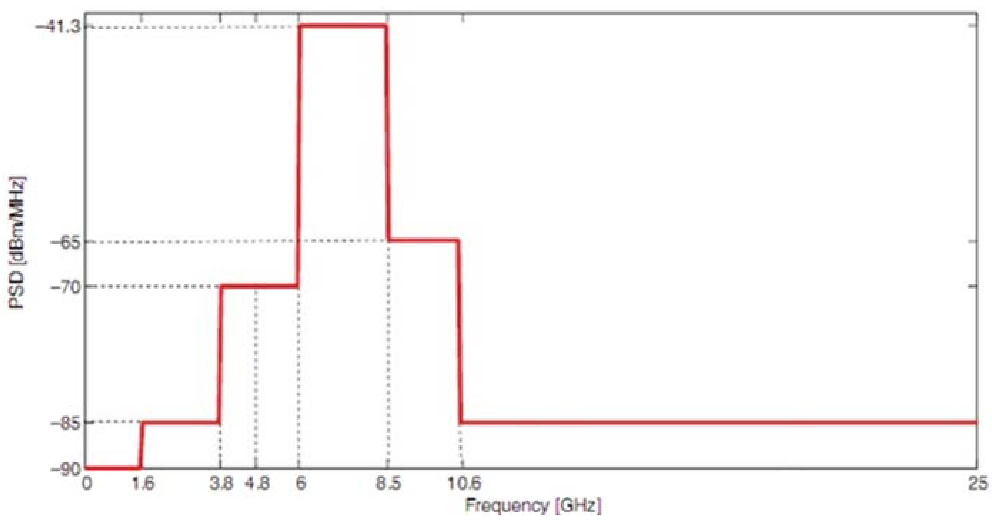


Figure 6: UWB emission mask

According to ECC/DEC/(06)04 [1] UWB systems operate on a non-interference and non-protected basis - comp ability studies are not required.

3.1.4.4 Amateur Satellite Services in 10-10.5 GHz frequency band

Table 10: System parameters extracted from ECC Report 064

Radiocommunications Service			System description
Application			Receiver stations in the Amateur (Satellite) Service
Frequency band			10000-10500 MHz
Receiver station	Station description		Low noise narrow band receiver
	Receiver characteristics		
		Bandwidth	3 kHz or 500 Hz
		Noise figure / Noise temperature	1 dB
		Signal model	Signals to be received are SSB-Telephony and/or morse telegraphy
	Receiver antenna		
		Type	Parabolic dish
		Gain	33 dBi boresight/ 0 dBi off boresight
		Model	
	Protection requirement		
		Criterion	The receiver systems noise shall not increase by more than 1 dB due to the interfering UWB signal
			The “reference/protection distance” between the UWB device is 10 meter

The interference criterion for Amateur Service receivers is <1 dB increase of the receiver noise level at a “protection distance” of 10 m.

3.1.4.5 Radiolocation

Radiodetermination

Table 11: Radiodetermination radar parameters

Characteristics	Airborne radiodetermination radars (A4)	Shipborne radiodetermination radars (S2)	Ground-based radiodeterminatio n radars (G4)	Other radars (G14)
Function	Track radar	Track radar	**Tracking radar**	Intrusion detection
Platform type	-	Shipborne	**Ground (trailer)**	Ground
Tuning range (MHz)	10 000-10 500	10 000-10 500	**10 000-10 500**	10.15-10.65
Modulation	CW, FMCW	CW, FMCW	**CW, FMCW**	CW
Peak power into antenna (kW)	1.5	13.3	**14**	10
Pulse width (μs) and pulse repetition rate (pps)	Not applicable	Not applicable Not applicable	**Not applicable** **Not applicable**	Not applicable
Maximum duty cycle	1	1	**1**	100
Pulse rise/fall time (μs)	Not applicable	Not applicable	**Not applicable**	Not applicable
Output device	Travelling wave	Travelling wave	**Travelling wave**	

Characteristics	Airborne radiodetermination radars (A4)	Shipborne radiodetermination radars (S2)	Ground-based radiodeterminatio n radars (G4)	Other radars (G14)
	tube	tube	**tube**	
Antenna pattern type	Pencil	Pencil	**Pencil**	Parabolic
Antenna type	Planar array	Planar array	**Planar array**	Parabolic
Antenna polarization	Linear	Linear	**Linear**	Vertical
Antenna main beam gain (dBi)	35.5	43	**42.2**	42
Antenna elevation beamwidth (degrees)	2.5	1	**1**	2
Antenna azimuthal beamwidth (degrees)	2.5	1	**1**	1.2
Antenna horizontal scan rate (°/s)	90	90	**90**	Not specified
Antenna horizontal scan type (continuous, random, sector, etc.)	Sector: ±60° (mechanical)	360° (mechanical)	**360° (mechanical)**	Not specified
Antenna vertical scan rate (°/s)	90	90	**90**	Not specified
Antenna vertical scan type	Sector: ±60° (mechanical)	Sector: +83/–30° (mechanical)	**Sector: 90° ± array tilt (mechanical)**	Not specified
Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi)	Not specified	23 (1st SL)	**Not specified**	22 at 3°
Antenna height	Aircraft altitude	Mast/deck mount	**Ground level**	Not specified
Receiver IF 3 dB bandwidth (MHz)	0.48	0.5	**0.52**	Not applicable
Receiver noise figure (dB)	3.6	3.5	**3.4**	3.6
Minimum discernible signal (dBm)/ Sensitivity (dBm)		–113/-	**–113/-**	-/–152
Chirp bandwidth (MHz)	Not specified	Not specified	**Not specified**	Not applicable
RF emission bandwidth (MHz)	Not specified	Not specified	**Not specified**	-40 dB -> 3.2
Antenna radiation pattern	ITU-R M.1851 [28]	ITU-R M.1851 [28]	**ITU-R M.1851 (COS type) [28]**	ITU-R M.1851 [28]
I/N	-6	-6	**-6**	-6

Figure 7 presents radar antenna radiation pattern derived from Recommendation ITU-R M.1851 [28].

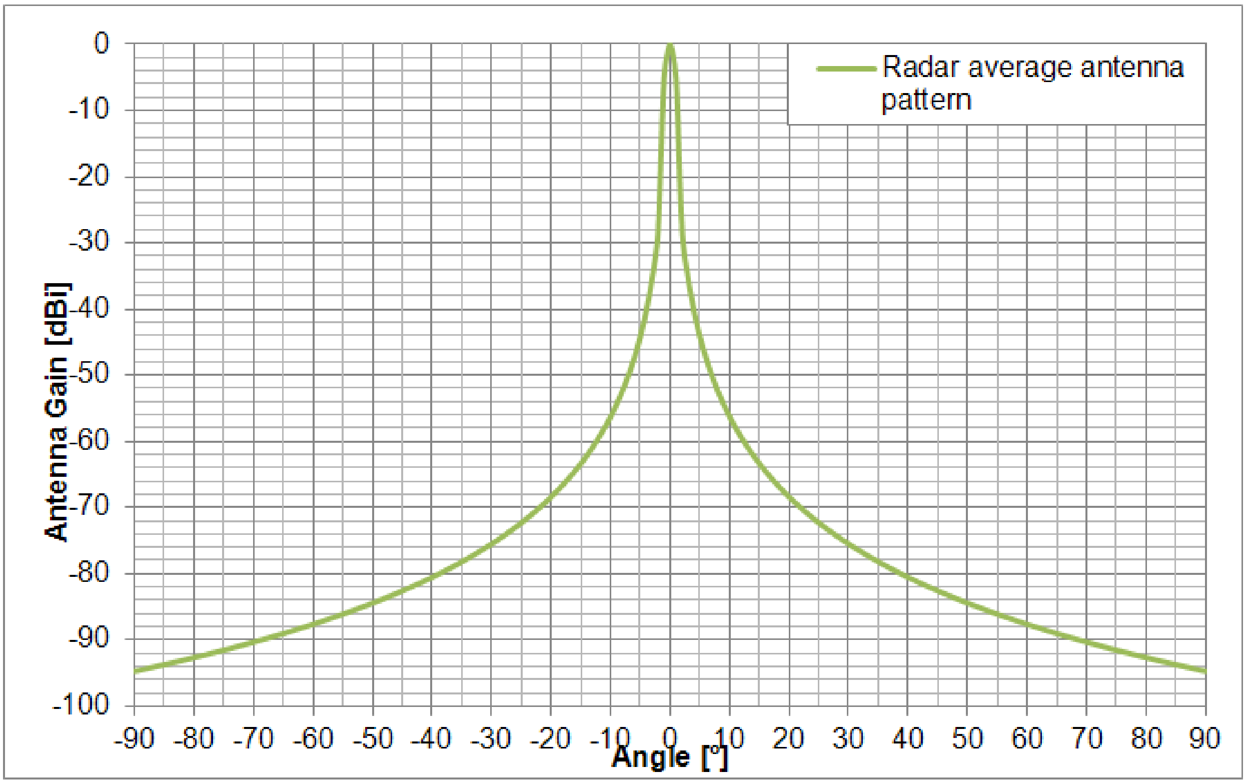


Figure 7: Terminal station horizontal antenna radiation pattern envelope based on ITU-R M.1851 [28]

SRD

SRD devices operates on non-interference and non-protected basis, therefore interference studies with these services were not carried out.

3.1.4.6 Military

All defense systems and radiolocation military radars are taken under considerations. Studies have not been performed due to the lack of system parameters.

3.1.5 Characteristics of systems working in adjacent band to 10.3 - 10.5 GHz band

Motion sensors / interrogation systems are operating in the frequency band 10.5 - 10.6 GHz. ERC Report 047 [12] “Compatibility fixed service and motion sensors at 10.5 GHz” deals with compatibility issues between the Fixed Service and motion sensors / interrogation systems in the frequency band 10.5 - 10.6 GHz.

3.2 6 GHZ BAND

3.2.1 The 5925 - 6425 MHz band

The proposal is to pair the A block (5.375MHz) with the C block (upper part of 14.84 MHz), and, pair the B block (lower part of 14.84MHz) with the D block (5.376MHz) or a part of these blocks. This illustrated in Figure 8 and Figure 9 in as an example of implementation with 0.250 MHz channels.

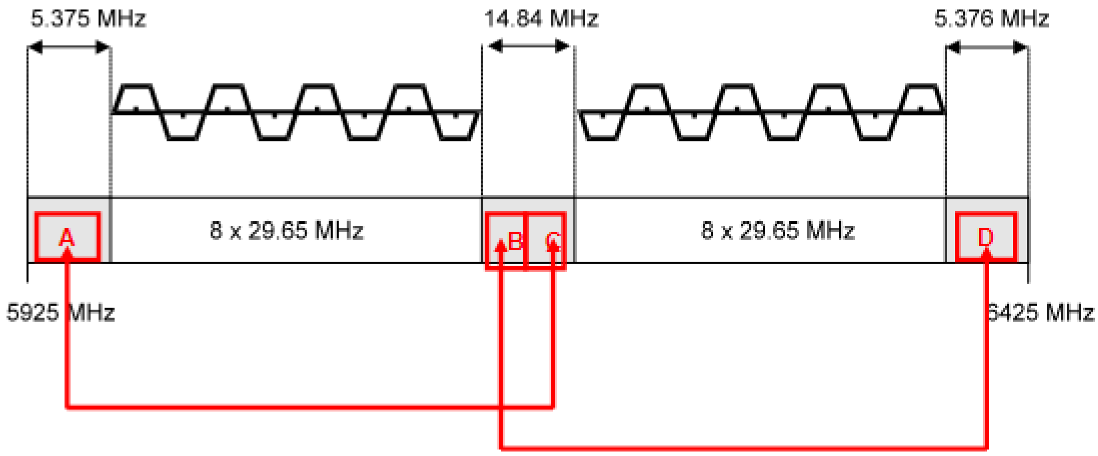


Figure 8: Illustration of the channel arrangements and an example about the paired band for the fixed links

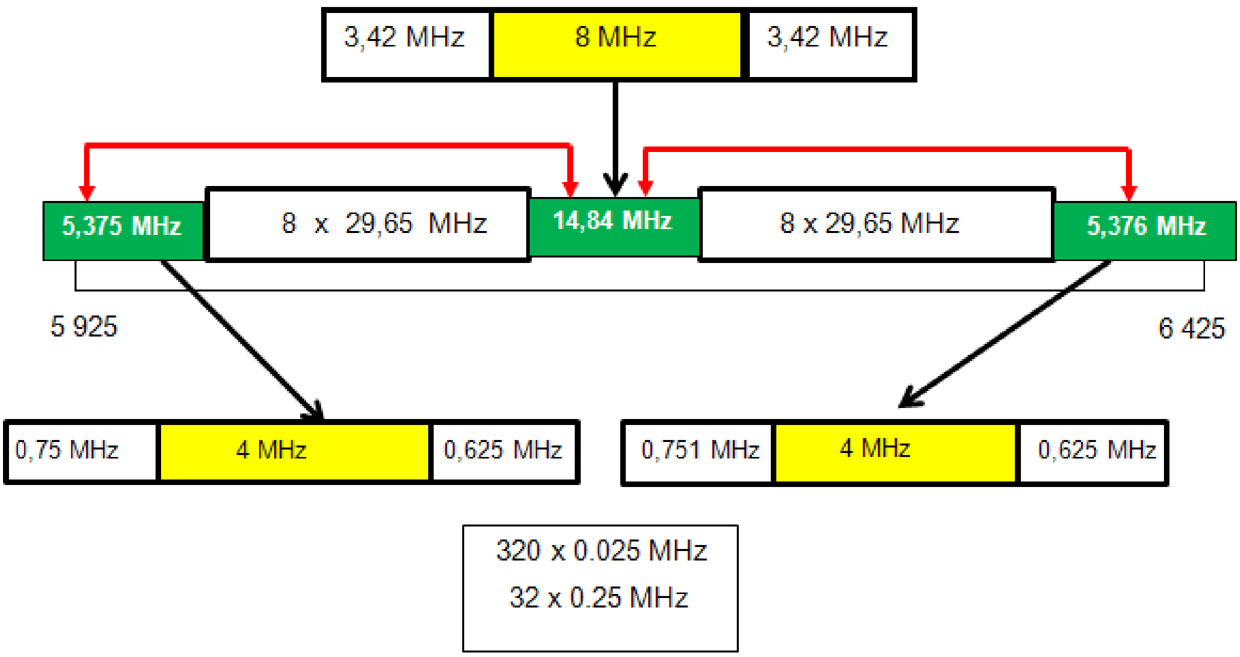


Figure 9: Example of implementation with 0.250 MHz channels

3.2.2 Allocation in the 5925-6425 MHz band in the RR

Table 12: Allocation in the 5925-6425 MHz band

Frequency	Allocation	Short Comments/Notes
5850-5925 MHz	FIXED FIXED-SATELLITE MOBILE	Footnote 5.150 => The following bands: 5725-5875 MHz (centre frequency 5800 MHz), are also designated for industrial, scientific and medical (ISM) applications. Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications. ISM equipment operating in these bands is subject to the provisions of No. 15.13
5925-6700 MHz	Earth Exploration-Satellite (passive) FIXED-SATELLITE (EARTH-TO-SPACE) FIXED	Footnote 5.457A => In the bands 5925-6425 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 (WRC-03). (WRC-03)

3.2.3 Applications in the 5925-6425 MHz band in the CEPT

Table 13: Applications in the 5925-6425 MHz band

Frequency	Allocation	Short Comments/Notes
5850-5925 MHz	ISM	Within the band 5725-5875 MHz
5850-5925 MHz	FSS Earth stations	Priority for civil networks
5850-5925 MHz	Non-specific SRDs	Within the band 5725-5875 MHz
5850-5925 MHz	Radiodetermination applications	Within the band 4500-7000 MHz for TLPR application
5850-5925 MHz	BFWA	Within the band 5725-5875 MHz
5850-5925 MHz	ITS	Within the bands 5875-5925 MHz and 5855-5875 MHz
5925-6700 MHz	Fixed	Point-to-point
5925-6700 MHz	UWB applications	Generic UWB
5925-6700 MHz	Radiodetermination applications	Within the band 4500-7000 MHz for TLPR application and 6000-8500 MHz for LPR applications
5925-6700 MHz	Passive sensors (satellite)	For sea surface temperature, sea surface wind speed and soil moisture measurements
5925-6700 MHz	FSS Earth stations	Priority for civil networks
6425-6700 MHz	Radio astronomy	Spectral line observations (Methanol: 6650-6675.2 MHz)

3.3 U6 GHz BAND

3.3.1 U6 band in the CEPT

CEPT/ERC/REC 14-02 [5] sets channel arrangements for fixed service in the band from 6425 MHz up to 7125 MHz as shown below:

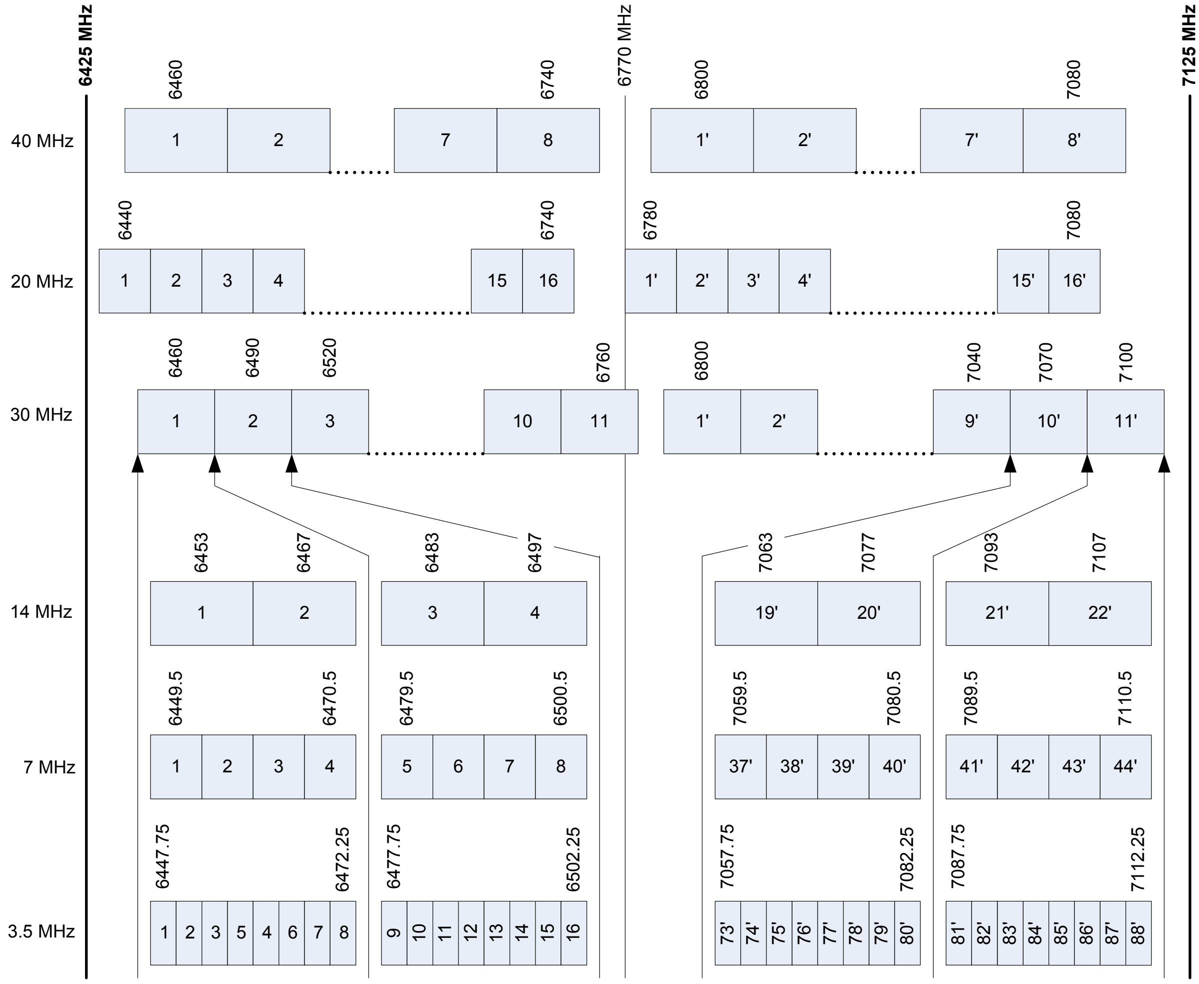


Figure 10: Channel arrangements of the U6 band according CEPT/ERC/REC 14-02 [5] provisions

3.3.2 Implementation of narrow channels

As it can been seen above, the fixed service is already implemented in the U6 band in sharing conditions with other services.

Hence, narrow channels could potentially be added in guard bands and center gap as examples shown by figures below.

3.3.2.1 Implementation with 40 MHz channel arrangement

Option 1

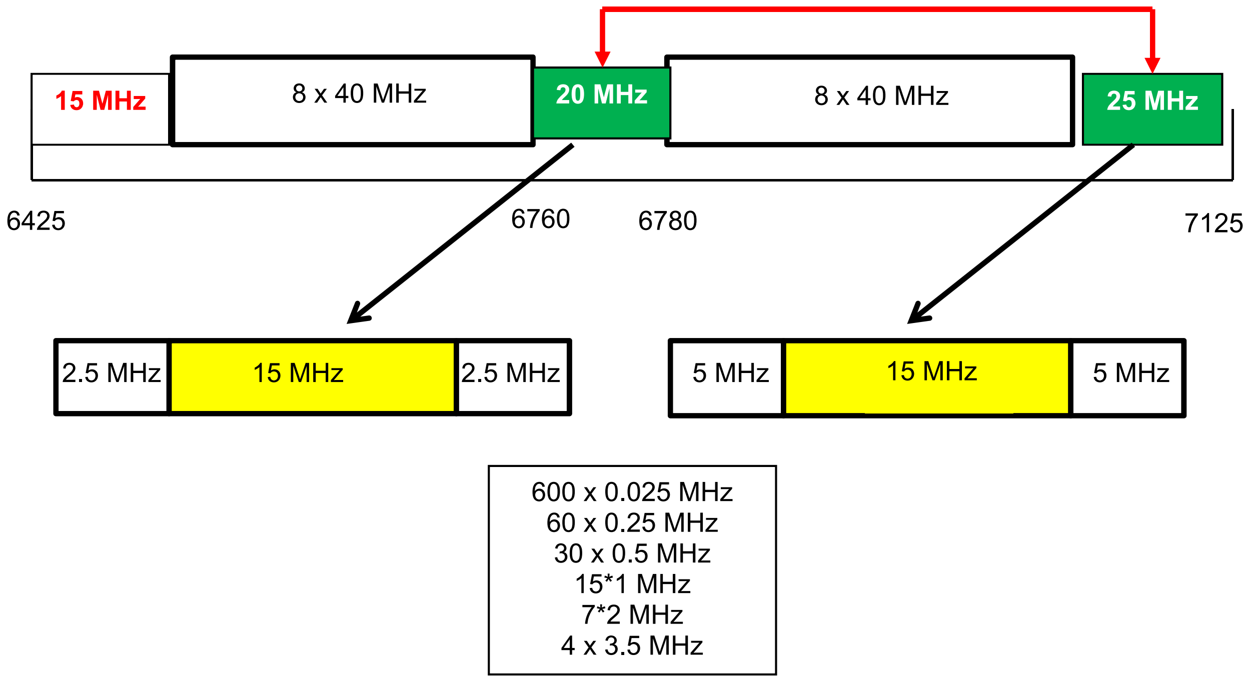


Figure 11: Narrow channels in U6 band with 40 MHz channels option 1

Option 2

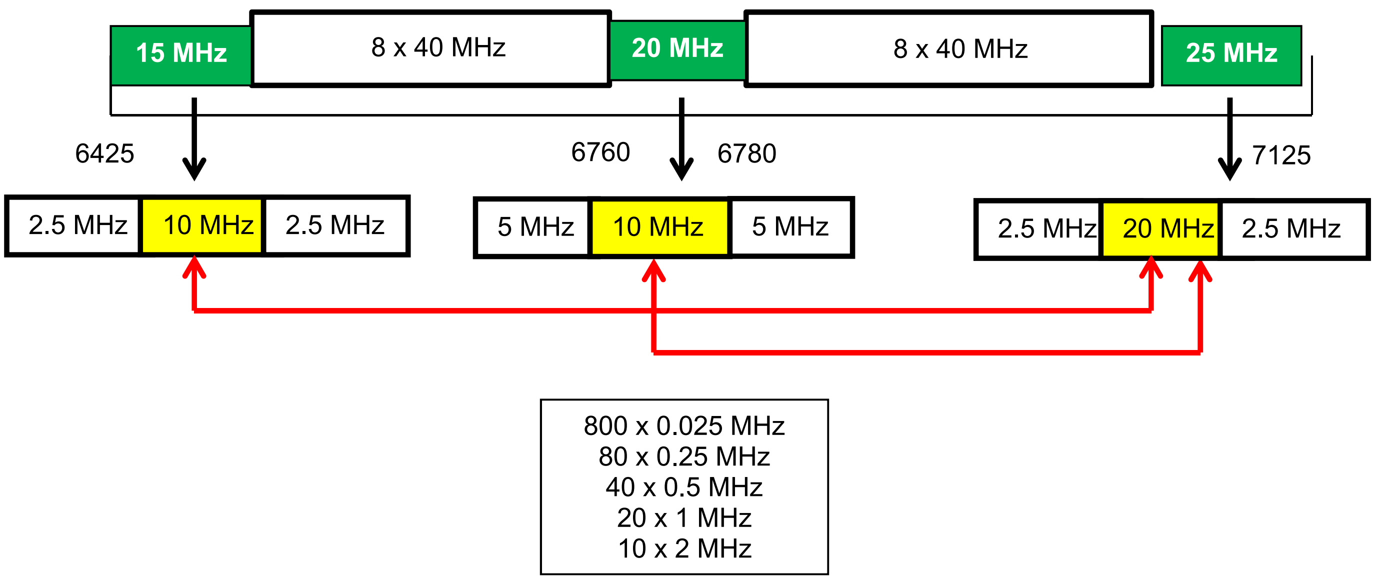


Figure 12: Narrow channels in U6 band with 40 MHz channels option 2

Option 3

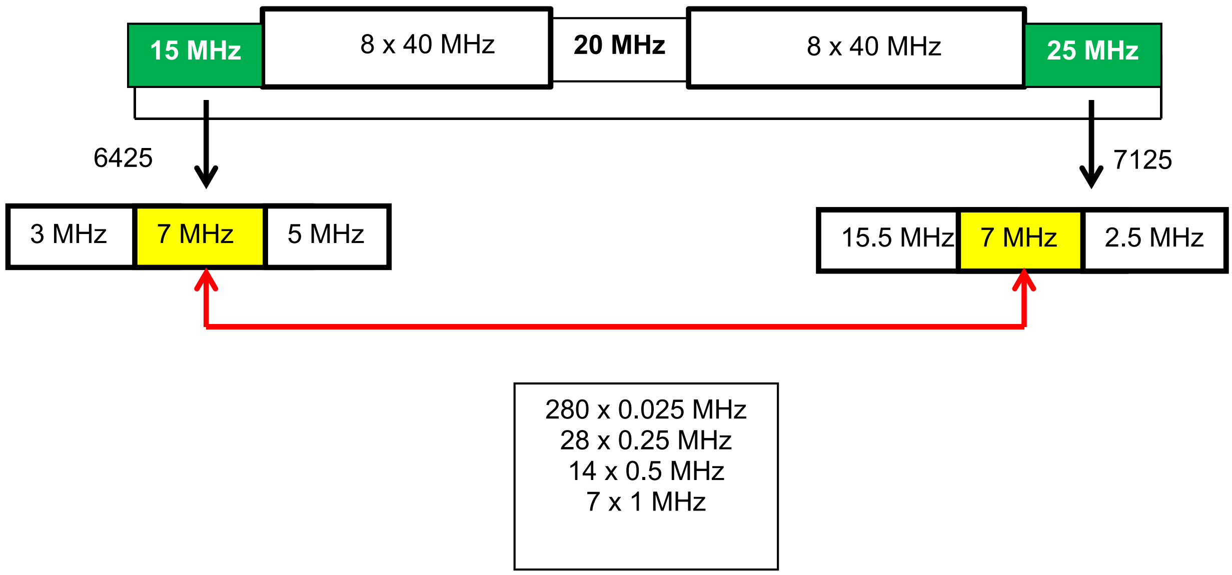


Figure 13: Narrow channels in U6 band with 40 MHz channels option 3

3.3.2.2 *Implementation with 30 MHz channel arrangement*

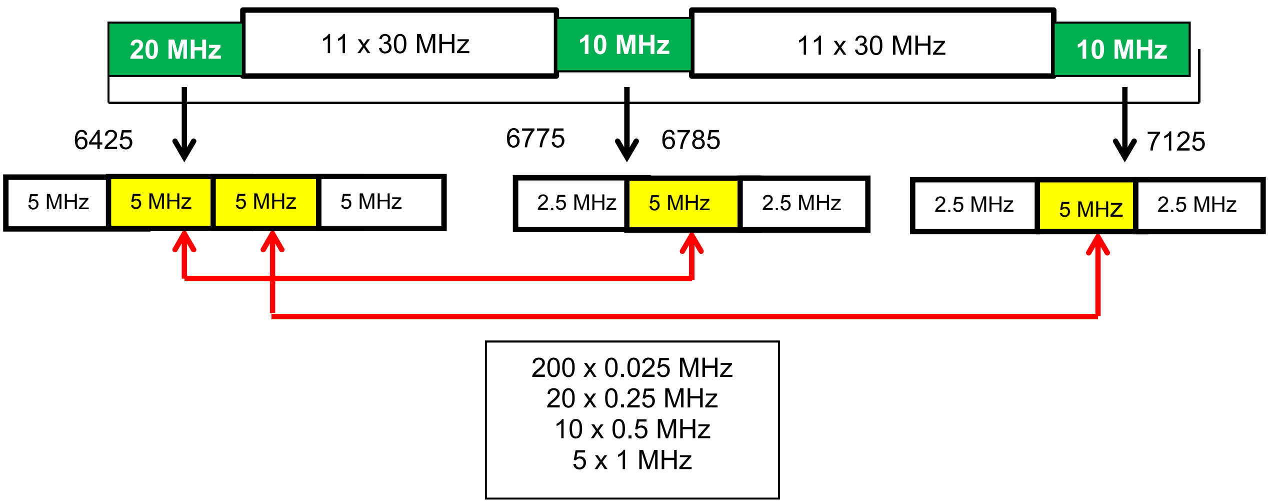


Figure 14: Narrow channels in U6 band with 30 MHz channels option

3.3.2.3 Implemention combining L6 and U6

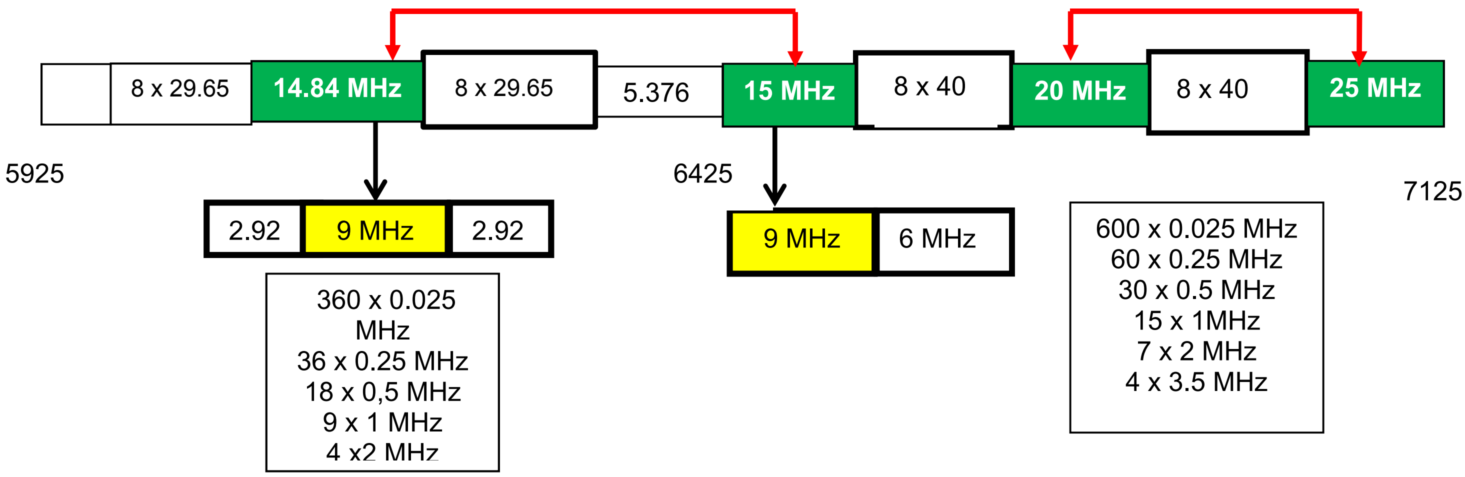


Figure 15: Narrow channels in L6 and U6 band (L6 combined with option 1 in U6 band)

It can be seen that this option provide 24 MHz for implementation of narrow channels without interfering on services below 5925 MHz (with regard with 25 MHz currently used in 1375-1400/1427-1452 MHz).

3.3.3 Spectrum masks

According to Recommendation ITU-R SM.329-12 [30] and the application to fixed service provided by Recommendation ITU-R F.1191-3 [33], CEPT/ERC/REC 74-01 [40] defines spurious emissions as any emission at frequencies which are outside the nominal carrier frequency by more than ± 250%.

As illustrated in

Figure 11 to Figure 15, the frequency bands dedicated for introducing narrow channels are limited by “sub-guard bands”, which allow considering only spurious domain levels for adjacent channel compatibility studies in countries which implement only one bandwidth. Those spurious emissions are defined in Recommendation ITU-R SM.329 [30] at -50dBm/0.3KHz or -14.77dBm/MHz for channel spacing lower than 1 MHz.

Table 14: Generic Category B fixed service mask for unwanted emissions in the spurious domain (extract from Recommendation ITU-R SM.329 [30])

Fundamental emission frequency	CS (MHz)	Typical symbol frequency (~Mbit/s)	Ref. BW 0.3 kHz Fa (MHz)	Ref. BW 1 kHz Fb (MHz)	Ref. BW 10 kHz Fc (MHz)	Ref. BW 100 kHz Fd (MHz)
Below 21.2 GHz (terminal stations)	0.01 ≤ CS < 1	Fs ≅ 0.006 – 0.8	–	–	14	70
	1 ≤ CS < 10	Fs ≅ 0.6 – 8	–	–	28	70
	CS ≥ 10	Fs ~ > 6	–	–	49(1)	70(1)
Below 21.2 GHz (other stations)	0.01 ≤ CS < 1	Fs ≅ 0.006 – 0.8	3.5	7	14	70
	1 ≤ CS < 10	Fs ≅ 0.6 – 8	–	14(1)	28	70
	CS ≥ 10	Fs ~ > 6	–	–	49(1)	70(1)
Above 21.2 GHz (all stations)	1 ≤ CS < 10	Fs ≅ 0.6 – 8	–	–	–	70
	CS ≥ 10	Fs > ~ 6	–	–	–	–

(1) Not applicable for CS which 250% exceed these values.

ETSI document EN 302 217-2-2 [18] (table A.4) provides following limits of transmitter spectral power density highlighting differences between class 1and 2 (4QAM) and class 4L (16QAM):

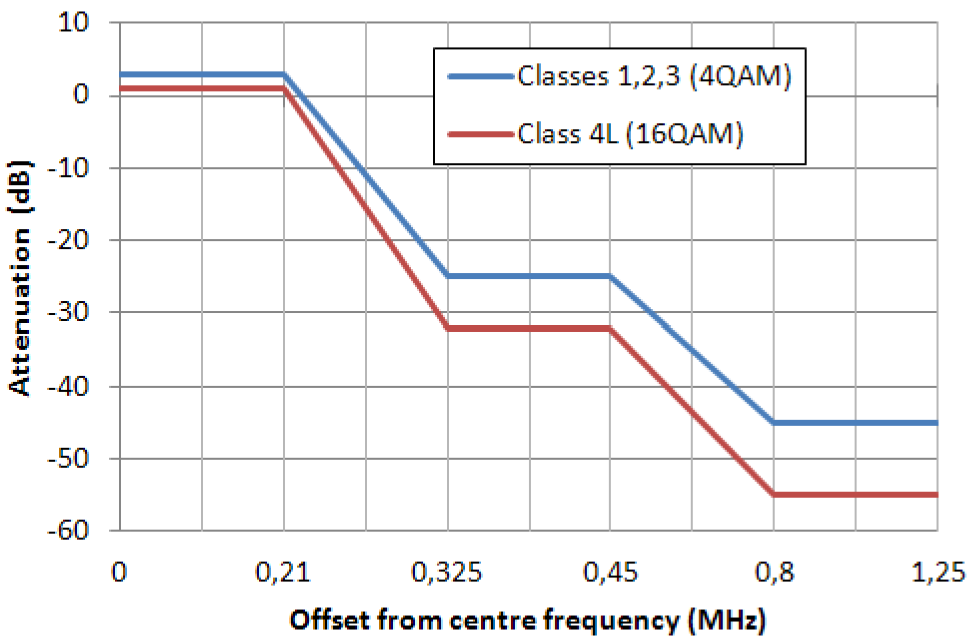


Figure 16: Emission mask for 0.5 MHz channels according ETSI EN 302 217-2-2 [18]

4 COMPATIBILITY AND SHARING STUDIES

4.1 COMPATIBILITY/SHARING STUDIES IN THE 10 GHZ BAND

4.1.1 Introduction to compatibility and sharing studies

In the case, the narrow channels are inserted in the 10300-10450 MHz band, the compatibility and sharing studies to be done are presented in the tables below

Table 15: Overview of the study carried out

x indicates that studies are needed	Co-channel band (sharing)					
	SAP/SAB	FS P-MP	UWB	Radiolocation	Amateur Satellite Services	Military
FS working in 10.3-10.5 GHz center gap	performed	performed	Not needed	Performed	performed	Not available

x indicates that studies are needed	Adjacent channel band (compatibility)		
	FS P-P	Motion sensor	SRD
FS working in 10.3-10.5 GHz center gap	performed	ERC Report 047 [12]	Not needed

In all coexistence studies the Recommendation ITU-R P.452 [34] method is proposed.

All defense systems and radiolocation military radars are taken under considerations. Studies have not been performed due to the lack of system parameters.

4.1.2 Propagation model in 10 GHz frequency band

Two different methods might be considered coexistence studies:

1. Free space model describes the theoretical minimum propagation path loss between transmitter and receiver in free space, when direct line of sight (LOS) is assumed (earth curvature is not taken into consideration) The model is used for frequency above 30 MHz

$$FSL[dB] = 32.44 + 20\log f + 20\log d$$

where;

f is the frequency in MHz and d is the distance between transmitter and receiver in km.

2. Recommendation ITU-R P.452-14 [34] “Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above 0.1 GHz” is a method which consider additional losses due to atmospheric gases, rain etc. and also assumes that Earth is curved. In this method also time percentage is taken into consideration (for more details see Recommendation ITU-R P.452-14 [34]). Fixed Services are designed with the time availability of at least 99.99%, which means that interfering signal may occur in 0.01% of time.

Figure 17 presents a comparison of propagation loss between Free space and the ITU-R P452 [34].

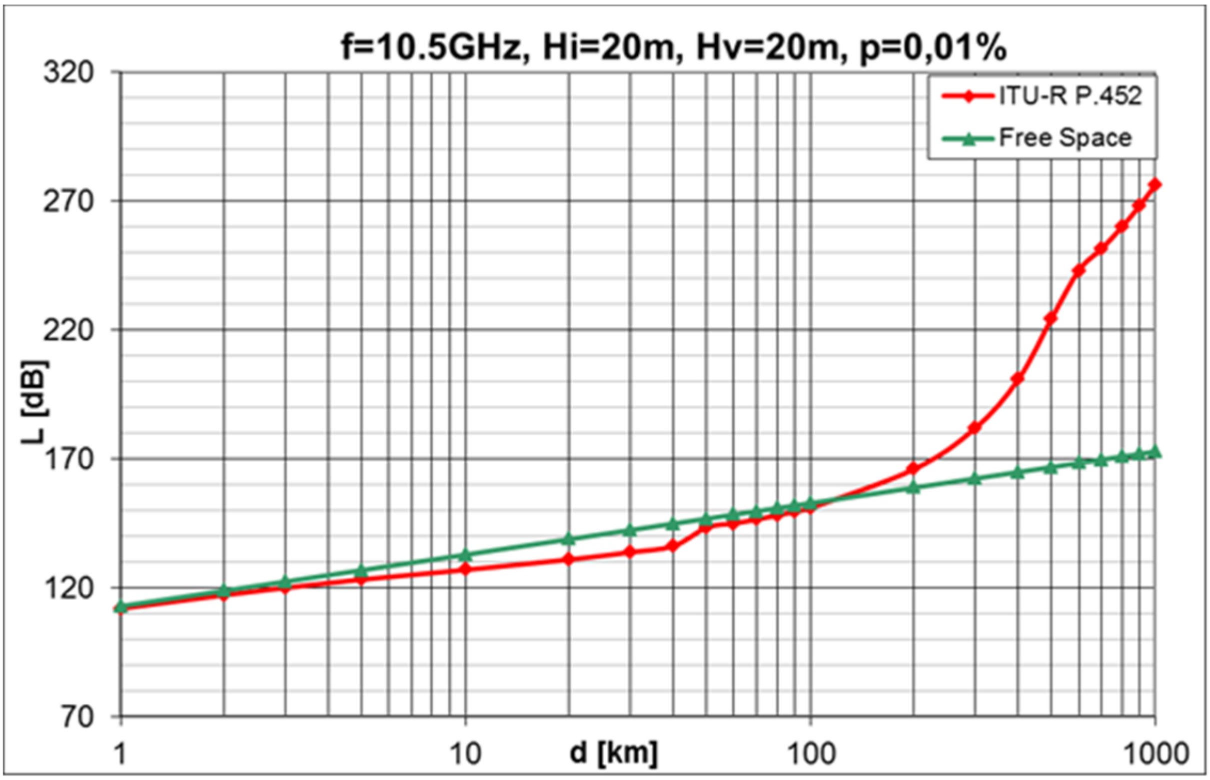


Figure 17: Comparison between free space and Recommendation ITU-R P.452 [34] model

For coexistence study model Recommendation ITU-R P.452 [34] is proposed to be chosen. It is seen that for some distances the Recommendation ITU-R P.452 [34] model gives lower propagation loss than free space model. It is because of subpath diffraction that causes a slight increase in signal level above that normally expected and also because of focusing effects resulting from atmospheric stratification. These two effects are especially important for the short periods of time (low time percentages).

Recommendation ITU-R P.452 [34] method is used for calculation of interfering signal level. Time percentage of 0.01 % is assumed as the worst case scenario. The prediction procedure employs radio-meteorological parameters to describe the variability of background and anomalous propagation conditions at the different locations. In calculations refraction index gradient ΔN =50 (value for worst-monthly prediction is considered) and sea-level surface refractivity of N0= 325 is used. Both values are typical of temperate climates.

4.1.3 MCL based calculation method

In order to evaluate maximum interference range of single narrow channel FS P-P to particular victim receiver, MCL-based principles for calculating compliance with I/N criteria methodology will be used. Using I/N criteria has a distinct advantage, there is no need to consider entire victim system for calculating useful received carrier signal (which would be necessary if using C/I-based methods). When using I/N criteria, it is sufficient to consider just the fundamental parameters of victim receiver, such as reference bandwidth and noise figure/temperature, whereas interfering signal could be considered as component degrading the noise floor level of victim receiver.

This study applies the method by following steps:

Step 1: Evaluation of noise power density and I/N interference threshold of victim receiver

Evaluation of noise floor is done by applying the following expressions, derived from fundamental equation of thermal noise:

The victim receiver's noise power is defined through noise figure for nominal bandwidth:

$$N_{Rx}[dBm] = -114dBm/MHz + NF[dB] + 10 \cdot \log(channel\_spacing\_in\_MHz)$$

where:

-114 dBm/MHz is a value of thermal noise power density. Thermal noise power is given as:

PN=kTΔf, where k=1.38e-23 J/K, T=290K and Δf=1MHz.

The interference threshold is then obtained by referring to I/N objective. Expressed as power level at victim receiver antenna:

$$I_{MAX}[dBm] = N_{Rx} + I/N_R$$

where:

- NRx victim receiver's noise power,
- I/NR noise to interference ratio,

Step 2: Evaluation of MCL

Minimum Coupling Loss is evaluated as path loss isolation that is necessary to shunt interfering signal to below interference threshold identified in step 1. This condition may be expressed as follows:

$$MCL = P_{IT} + G_{IT}(\theta) - L_{IT} + G_R(\theta) - L_{VR} + mask(\Delta f) - I_{MAX} + BWcorr\_factor$$

where:

- P_{IT}- maximum interfering transmitter output power [dBm],
- $G_{IT}(\theta)$- interfering transmitter antenna gain in direction of victim receiver [dBi],
- θ - azimuth angle between victim receiver and interfering transmitter
- L_{IT}- transmitter's feeder loss,
- $G_R(\theta)$ – victim receiver's antenna gain in direction of interfering transmitter [dBi],
- L_{VR}- receiver's feeder loss [dB],
- mask(Δf)- spectrum mask attenuation at Δf,

where

- Δf is a difference between carrier frequencies of victim receiver and interfering transmitter ,
- I_{max} -interference threshold,
- BWcorr_factor- correction factor of band ratio:
- $$BWcorr\_factor = \begin{cases} -10\log(\frac{BW_{IT}}{BW_{VR}})\_if\_BW_{IT} \geq BW_{VR} \\ 0\_otherwise. \end{cases}$$

Step 3: Physical separation calculations based on MCL value

MCL result is taken as a minimum value of path attenuation between victim receiver (VR) and interfering transmitter (IT). The final evaluation of distance (d [km]) between victim receiver and interfering transmitter, which guarantees that systems will not interfere each other is done using specific path loss model i.e. for free space model calculation is as follows:

$$d[km] = 10^{\frac{MCL - 32.44 - 20\log(f[MHz])}{20}}$$

4.1.4 Interfering transmitter parameters

In compatibility studies with Fixed Services some parameters have to be assumed. One of the key parameter is antenna radiation pattern, which is defined for FS in two ITU-R Recommendations:

- Recommendation ITU-R F.699 [25] gives the peak envelope of side-lobe patterns,
- Recommendation ITU-R F.1245 [26] describes antennas radiation patterns with average side-lobe levels.

If the peak envelope radiation pattern is used in the assessment of the aggregate interference consisting of many interference entries, the predicted interferences will result in values that are greater than interferences obtained with average envelope radiation pattern. Figure 18 presents the comparison between the two recommendations for maximum antenna gain of 43 dBi.

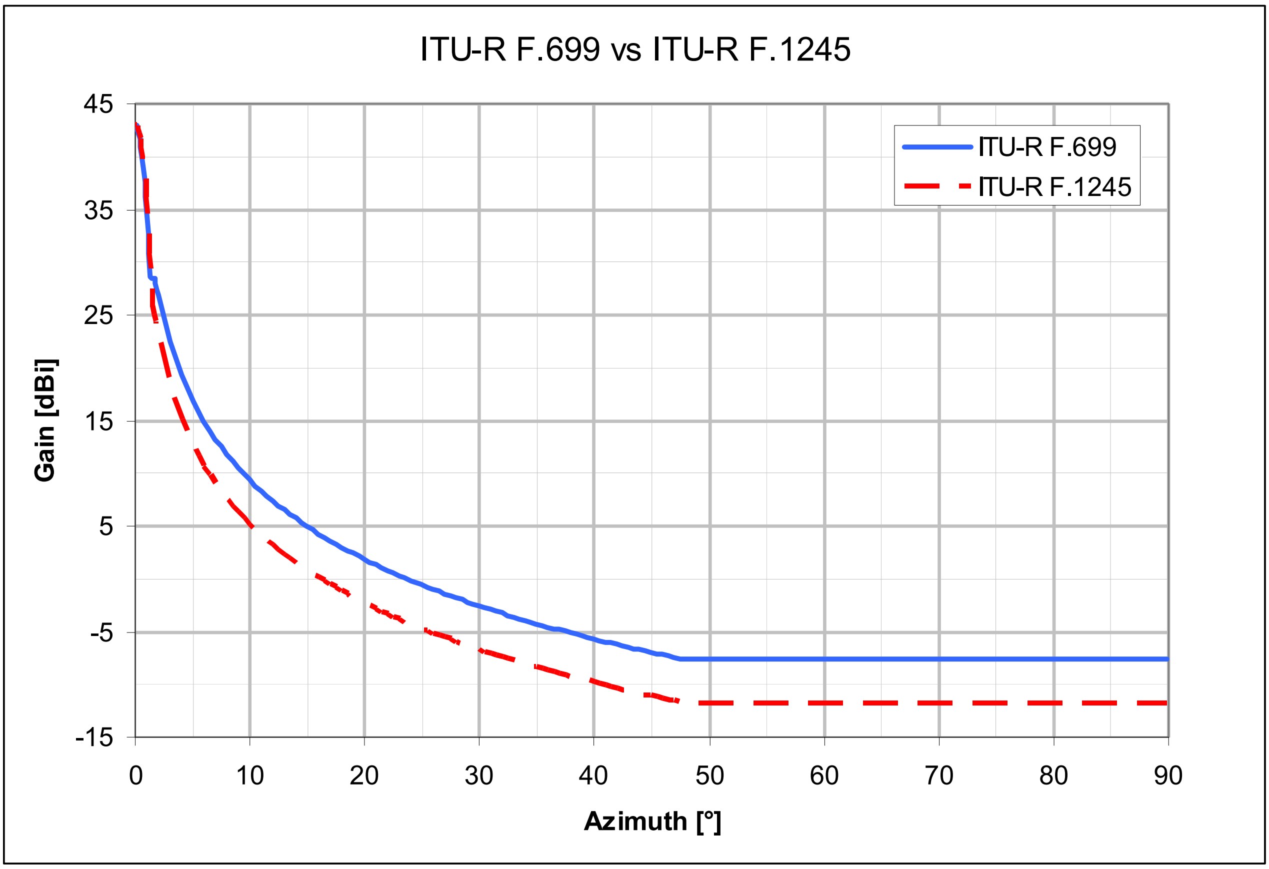


Figure 18: Comparison between peak and average antenna radiation pattern side-lobe levels

Recommendation ITU-R F.1245 [26]. The Recommendation gives 3-4 dB lower side-lobe levels than Recommendation ITU-R F.699 [25]. On the other hand for very small azimuth angles Recommendation ITU-R F.1245 [26] gives higher values than Recommendation ITU.R F-699 [25] (see Figure 19).

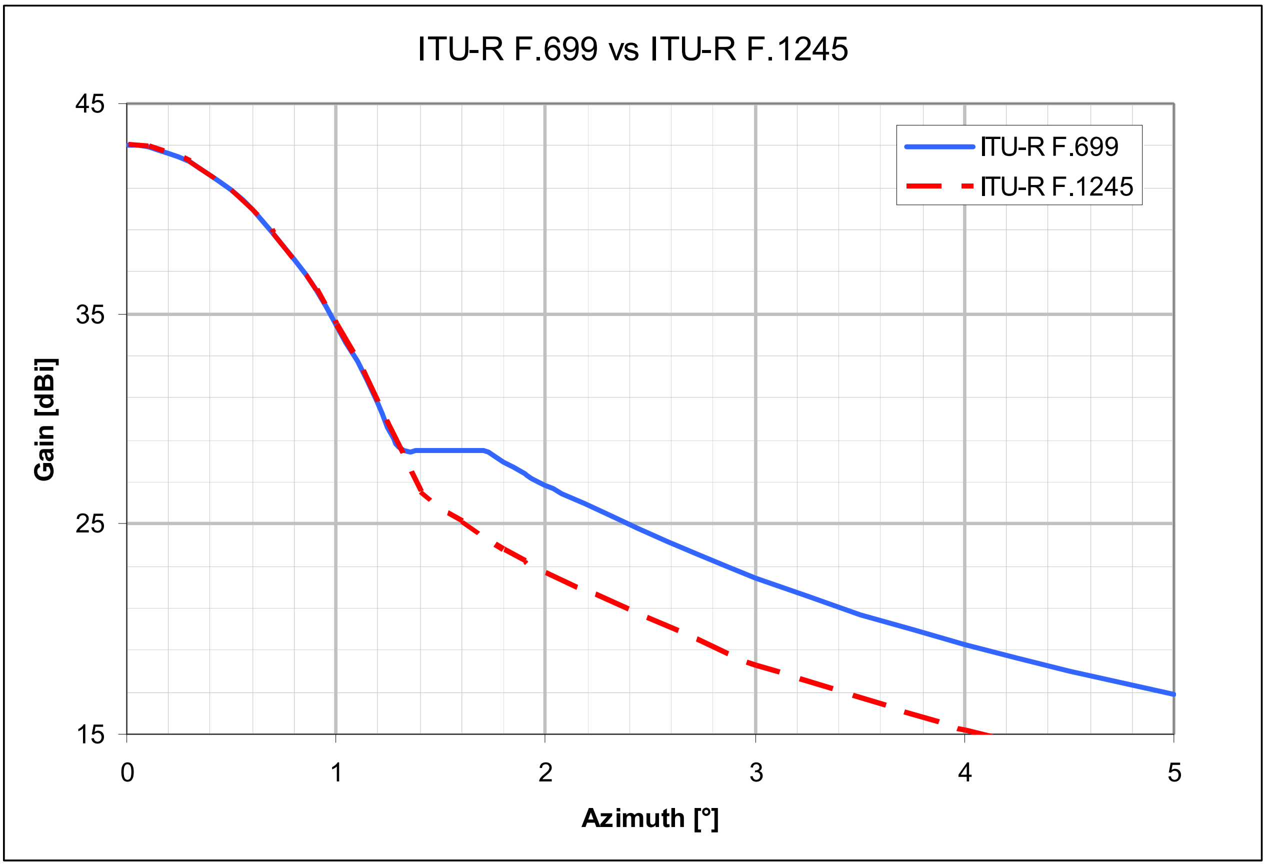


Figure 19: Comparison between peak and average antenna radiation pattern side-lobe levels (azimuth zoom)

In calculations worst case scenario is considered assuming flat terrain without obstacles between interfering transmitter and victim receiver (LOS) and antennas working with the same polarizations.

It is assumed that angles between victim receiver and interfering transmitter are changed in horizontal plane (azimuth). In calculations two separate cases are considered:

1. azimuth change of interfering transmitter antenna when victim receiver antenna is not moving (stable/fixed);
2. azimuth change of victim receiver antenna when interfering transmitter antenna is not moving (stable/fixed).

Both cases are considered because of different antenna patterns of the victim receiver and interfering transmitter, which cause different results of calculations. In the whole document figures, which present calculation results, are done for both cases mentioned above. For example in figure 7 for case 1 distance as a function of Recommendation ITU-R F.699 [25] and Recommendation ITU-R F.1245 [26] antenna angle (blue and red curve) is presented. For case 2 distances as function of terminal station antenna angle (green curve) is given.

Due to considerations of the worst case scenario, impact of vertical antenna gain is not taken into account.

Other interfering transmitter parameters used in calculations are summarized.

Table 16: FS P-P narrow channel Interfering transmitter parameters

Parameters	Value
Carrier frequency (MHz)	scenario dependent
Channel spacing and receiver noise bandwidth (MHz)	2
Maximum Tx power (dBm)	28
Maximum TX output power density range (dBm/MHz)	25
Antenna gain (dBi)	43
Antenna pattern	Recommendation ITU-R F.699-7 [25] Recommendation ITU-R F.1245-1 [26]
Antenna height (m)	20
Minimum feeder/multiplexer loss range (dB)	0
e.i.r.p. (dBm)	71
e.i.r.p. density (dBm/MHz)	68
Receiver noise figure (dB)	3
Receiver noise power density typical (=NRX) (dBm/MHz)	-111
Transmitter emission mask	ETSI EN 302 217 [18]
Transmitter spurious emission	ETSI EN 301 390 [17]
I/N criterion	-10
Nominal long-term interference power density (dBm/MHz)	NRX + I/N

In calculations maximum interfering transmitter power of 28 dBm is used. This value is assumed as the highest possible value of in channel power (maximum transmission power within emission mask). Figure 20 presents FS transmitter emission mask derived from ETSI EN 302 217 [18] and EN 302 390 [17].

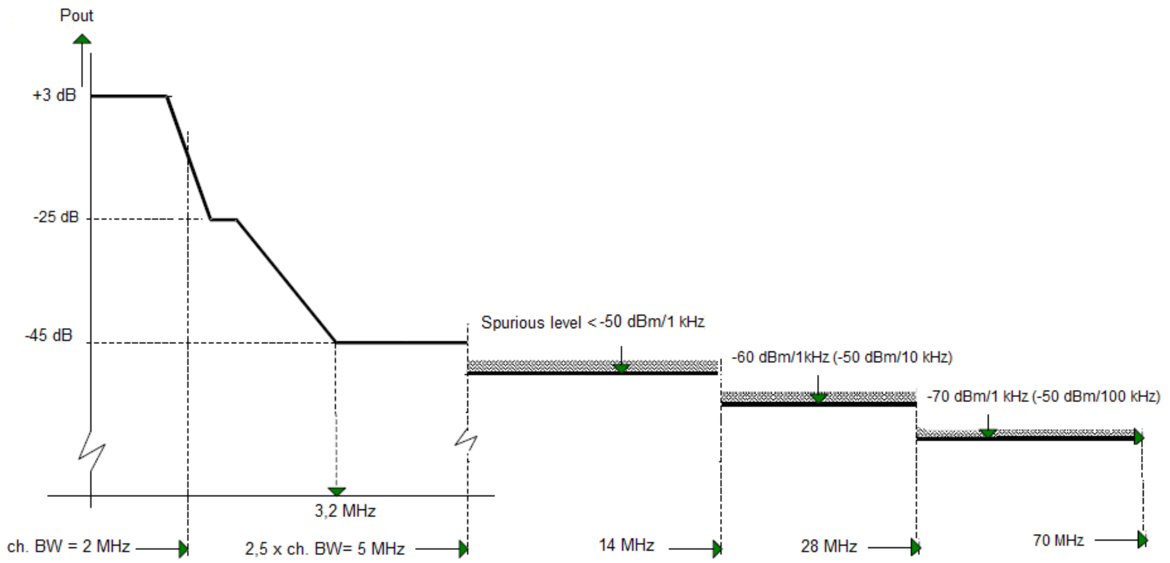


Figure 20: FS transmitter emission mask derived from ETSI EN 302 217 [18] and EN 301 390 [17]

4.1.5 Co-channel sharing

4.1.5.1 Studies with SAP/SAB

ENG parameters taken from Recommendation ITU-R F.1777 [27]

Interferences from FS P-P introduced to 10.3-10.45 GHz center gap to ENG working in 10.3-10.5 GHz were estimated.

The interfering transmitter and victim receivers' frequency carrier are 10309 MHz. In the calculations, the parameters indicated in bold letter from table above are used. Victim receiver antenna height is equal to 3 m.

Table 17: Summary of the results for SAP/SAB

Results	Value
MCL (dB)	212.4* for I/N=-10 208.4* for I/N=-6
Distance (km)	467.1* for I/N=-10 450.4* for I/N=-6
Minimum distance between IT and VR/antenna azimuth ≥48 °	269.99/230.11** km for I/N=-10 244.38/203.32** km for I/N=-6

*VR and IT antenna are pointing to each other
** in red colour results for Recommendation ITU-R F.1245 [26] antenna radiation pattern are presented

In Figure 21, the distance between interfering transmitter and victim receiver as a function of victim receiver antenna azimuth is presented. In this case victim receiver has the same antenna radiation pattern as interfering transmitter that is why only one case is considered. Antenna azimuth θ is changed between 0.5° and 90°.

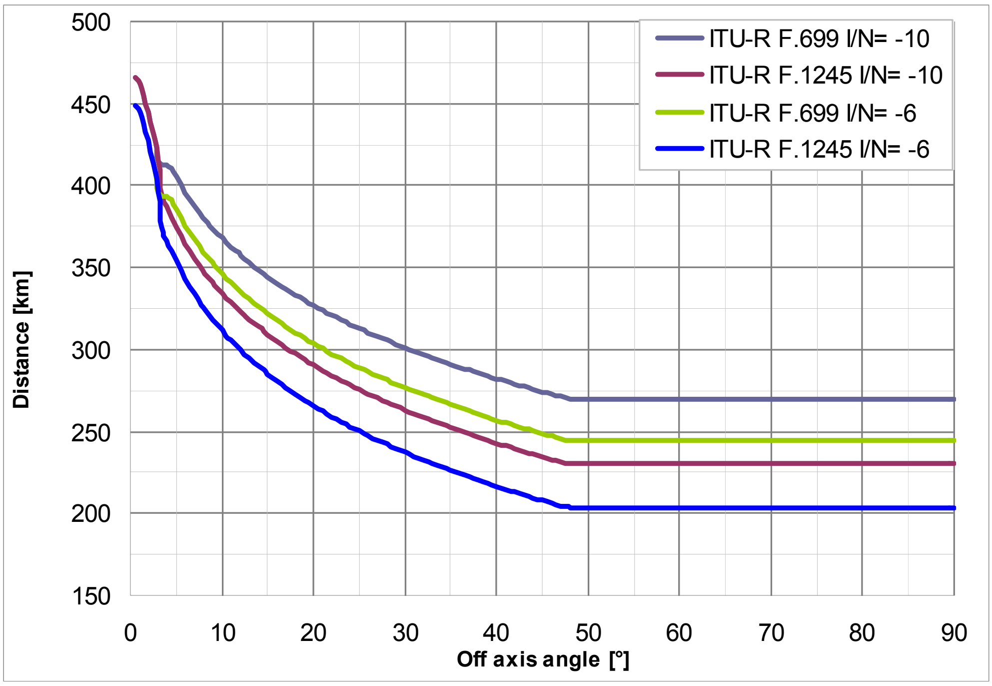


Figure 21: Distance between IT and VR as a function of victim and interfering antenna angle (victim antenna radiation patterns are the same as interfering antenna patterns)

Calculation example:

Step 1: Evaluation of noise power density and I/N interference threshold of cordless camera

Victim receiver's noise power is defined through noise figure for nominal bandwidth:

$$N_{Rx}[dBm] = -114 + 4 + 10 \cdot \log(18) = -97.4$$

The interference threshold expressed as power level at victim receiver antenna:

$$I_{MAX}[dBm] = -97.4 + (-10) = -107.4 \text{ or}$$

$$I_{MAX}[dBm] = -97.4 + (-6) = -103.4$$

Step 2: Evaluation of MCL

$$MCL = P_{IT} + G_{IT} - L_{IT} + G_R(\theta) - L_{VR} + mask(\Delta f) - I_{MAX} + BWcorr\_factor$$

PIT+GIT+LIT in calculations were replaced as interfering transmitter e.i.r.p power:

$$MCL = e.i.r.p_{IT} + G_R(\theta) - L_{VR} + mask(\Delta f) - I_{MAX} + BWcorr\_factor$$

$$MCL = 71 + 35 - 1 + 0 - (-107.4) + 0 = 212.4dB \text{ or}$$

$$MCL = 71 + 35 - 1 + 0 - (-103.4) + 0 = 208.4dB$$

Step 3: Physical separation calculations based on MCL value

According to Recommendation ITU-R P.452 [34] for time percentage of p=0.01%, required distance between IT and VR is equal to:

d= 467.1 km (for I/N=-10) or

d= 450.4 km (for I/N=-6).

Based on parameters from ECC/ERC Reports

Interfering transmitter's frequency carrier is 10.305 GHz. In this case victim receiver has omnidirectional antenna or the same antenna radiation patterns as interfering transmitter (temporary point to point link), that is why only one case is considered.

Table 18: Summary of the results

Column title (style: Arial 10pt bold white)	Cordless camera	Portable video link	Temporary P-P link
MCL (dB)	182	193	210*
Distance (km)	319.5	379	457*

*VR and IT antenna are pointing to each other

In Figure 22 the distance between interfering transmitter and victim receivers as a function of victim receiver antenna azimuth is presented. Antenna azimuth θ is changed between 0.5° and 90°.

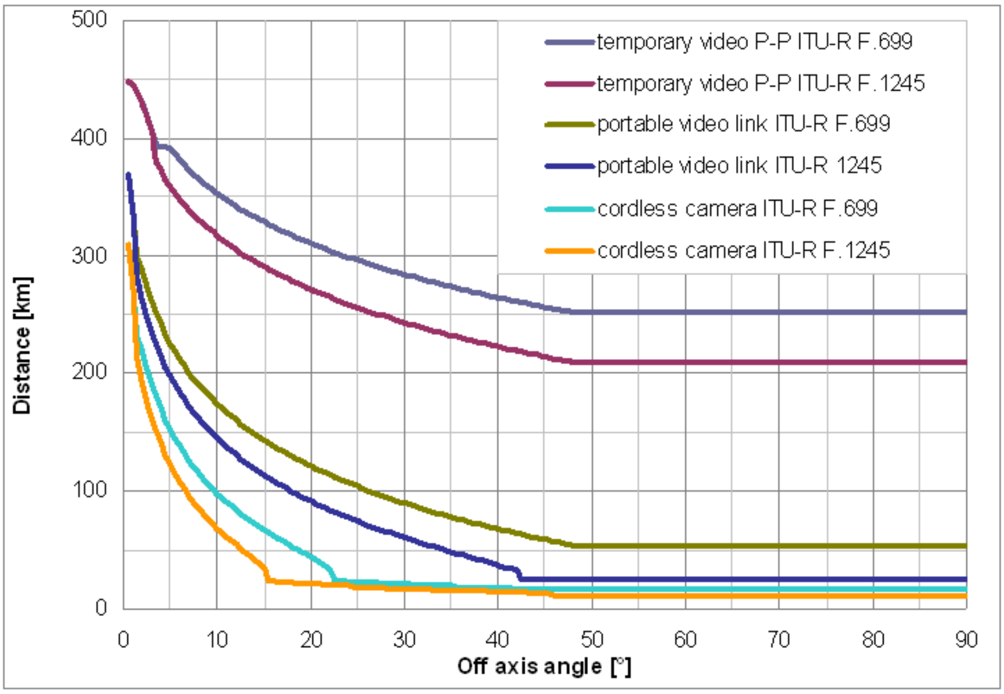


Figure 22: Distance between IT and VR as a function of victim and interfering antenna angle (victim antenna radiation patterns are omnidirectional or the same as interfering antenna patterns)

Table 19 presents results for Recommendation ITU-R F.1245 [26] antenna radiation pattern.

Table 19: Summary of the results

	Cordless camera	Portable video link	Temporary P-P link
Minimum distance required when Interfering Transmitter antenna is pointing to victim receiver	319.5 km	379 km	457 km*
Minimum distance required when antenna azimuth is 0.5°	309.01 km	368.23 km	448.15 km
Minimum distance between IT and VR/antenna azimuth ≥48 °	16.26 km	54.07 km	252 km
Minimum distance between IT and VR/antenna azimuth ≥48 ° (Recommendation ITU-R F.1245 [26] antenna radiation pattern)	10.97 km	24.91 km	209.59 km

*VR and IT antenna are pointing to each other

4.1.5.2 Multimedia Multipoint Distribution System MMDS (downlink)

Interferences from FS P-P introduced to 10.3-10.45 GHz center gap to MMDS terminal station (TS) working on 10336 MHz were estimated.

Table 20: Victim receiver parameters

Parameters	Value
Carrier frequency (MHz)	10336
Channel spacing and receiver noise bandwidth (MHz)	8(DL)/6.4(UL)
Antenna gain (dBi)	24
Antenna pattern	Directional (ETSI EN 302 326 [19])
Antenna height (m)	20
Minimum feeder/multiplexer loss range (dB)	0
e.i.r.p. range (dBm)	23
Receiver noise figure (dB)	5 (ITU-R F.758-5 [23])
Receiver noise power density typical (=NRX) (dBm/MHz)	-109
I/N criterion (dB)	-10
Nominal long-term interference power density (dBm/MHz)	NRX+I/N

Figure below presents terminal station horizontal antenna radiation pattern derived from ETSI EN 302 326 [19].

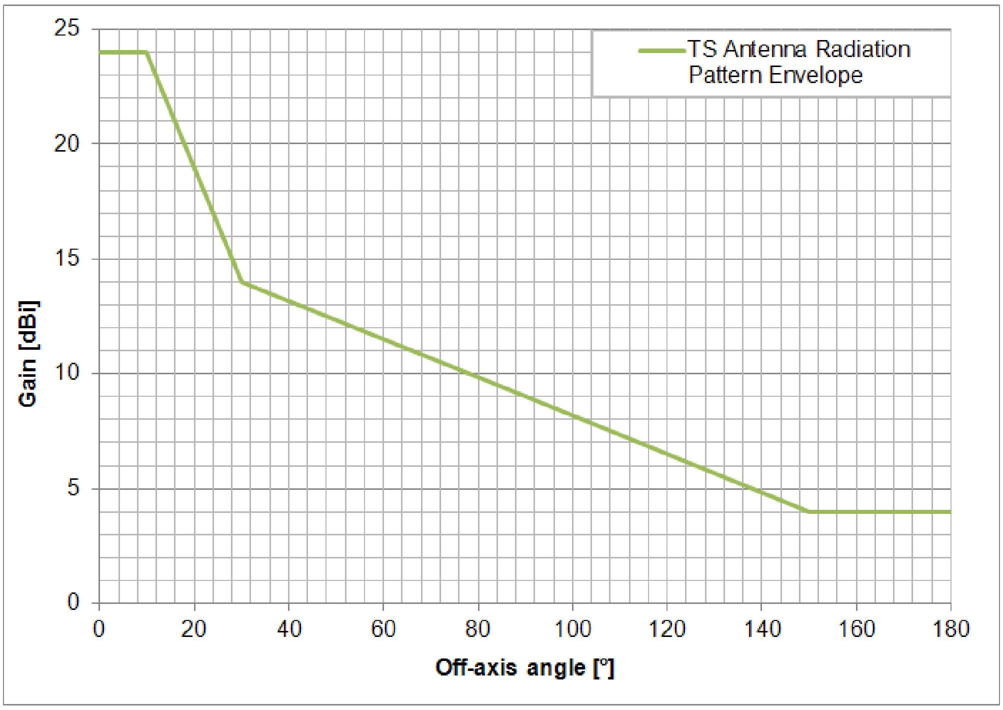


Figure 23: Terminal station horizontal antenna radiation pattern envelope based on ETSI EN 302 326 [19]

Interfering transmitter and victim receivers' frequency carrier is 10.336 GHz. Victim receiver antenna height is equal to 20 m.

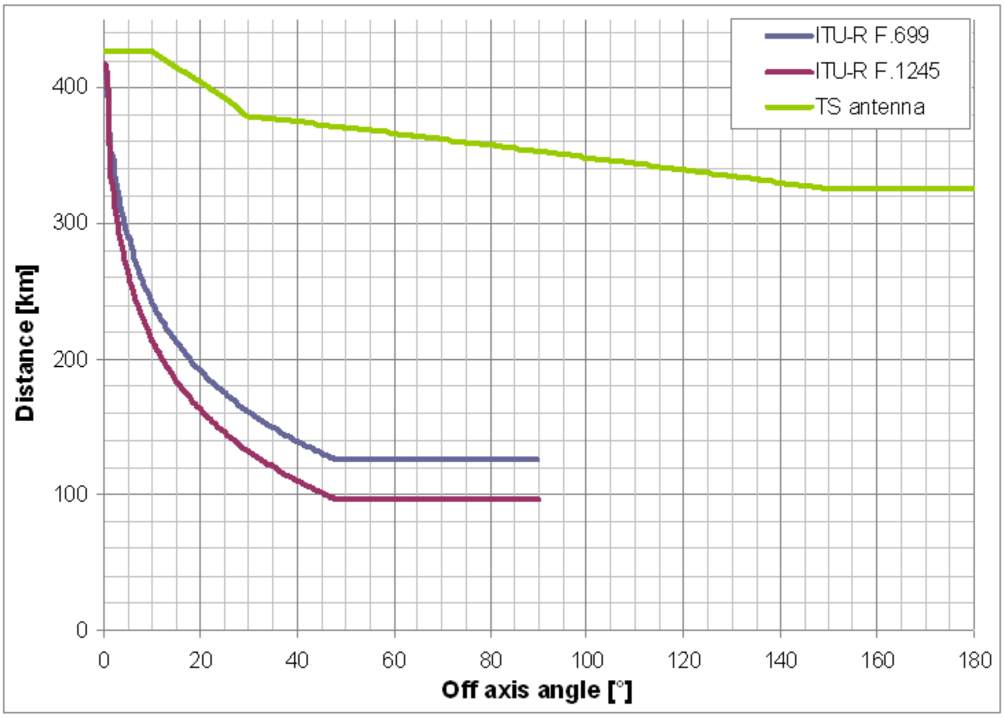


Figure 24: Distance between IT and VR as a function of victim antenna angle (TS antenna) and interfering antenna angle (ITU-R F.699 [25] / F.1245 [26])

In Figure 24 the distance between interfering transmitter and victim receiver as a function of antenna azimuth angle of interfering transmitter (1 case) and victim receiver (2 case) is presented. Antenna azimuth was changed between 0 and 180°. Detailed results are presented in Table 21.

Table 21: Summary of the results for TS

	ITU-R F.699 [25]	ITU-R F.1245 [26]	TS antenna
Minimum distance required when antennas are pointing each other	426.8 km	426.8 km	426.8 km
Minimum distance required when antenna azimuth is 0.5°	417.14 km	417.14 km	426.8 km
Minimum distance between IT and VR/antenna azimuth	125.95 km/≥48°	96.93 km/≥48°	325.35 km/≥150 °

4.1.5.3 Radiolocation

Radiolocation services are defined as radiodetermination service for the purpose of radiolocation. Radiodetermination is defined as the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves.

The system parameters were extracted from Recommendation ITU-R M.1796 [29] recommendation and there are presented in Table 11. The Interfering transmitter and victim receivers' frequency carrier is 10.301 GHz. The calculations parameters indicated in bold letter from Table 11 are used. The victim receiver antenna height is equal to 8 m. In Figure 25 the distance between interfering transmitter and victim receiver as a function of victim receiver and interfering transmitter antenna azimuth is presented. Antenna azimuth θ was changed between 0° and 90°.

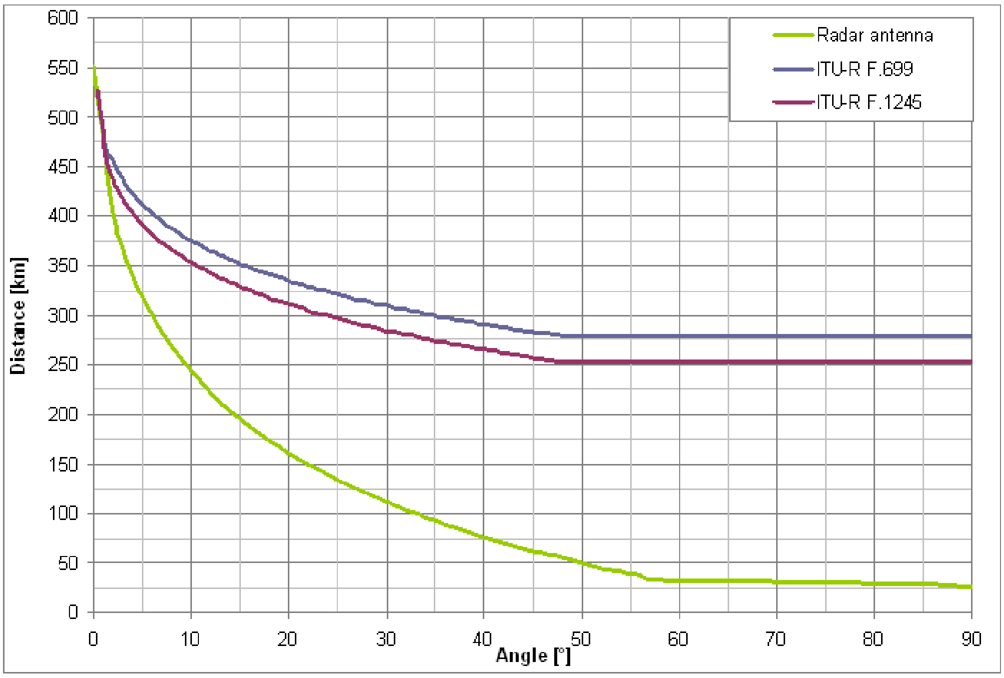


Figure 25: Distance between IT and VR as a function of victim antenna angle (radar antenna) and interfering antenna angle (ITU-R F.699 [25] and F.1245 [26])

Table 22: Summary of the results for ground tracking radar

	ITU-R F.699 [25]	ITU-R F.1245 [26]	TS antenna
Minimum distance required when antennas are pointing each other	551.25 km	551.25 km	551.25 km
Minimum distance required for specified azimuth	527.18 km/0.5°	527.18 km/0.5°	505.14 km/0.5°
Minimum distance between IT and VR/antenna azimuth	279.15 km/≥48°	252.69 km/≥48°	25.59 km/90°

4.1.5.4 Amateur and Amateur Satellite Services

According to ITU in frequencies between 10.3 - 10.45 GHz some amateur services may work on secondary basis. In the same frequencies also Fixed Services on primary basis are allocated.

Secondary services shall not cause harmful interference to stations of primary services and can't claim protection from harmful interferences from stations of primary services, therefore coexistence studies with these services are not required and are not performed here.

4.1.5.5 Summary of co-channel coexistence studies

Table 23: summary of the results

	ENG [27]		ENG ECC Reports			MMDS	Radar
	equipment with capacity up to 60 Mb/s		cordless camera	portable video link	temporary P-P link	DL	Ground tracking
Criterion	I/N=-6	I/N=-10	I/N=-6	I/N=-6	I/N=-6	I/N=-10	I/N=-6
Distance (km) when antennas are pointing each other	450.4	467.1	319.5	379	457	426.8	551.25
Minimum distance (km)	244.4	270	16.7	57.1	252	125.9	25.6
Minimum distance (km) (results for ITU-R F.1245 [26] antenna radiation pattern)	203.3	230.1	11	24.9	209.6	96.9	-

4.1.6 Adjacent channel compatibility studies

The study did not consider the impact of receiver selectivity, due to the absence of information on victim receiver selectivity masks. Therefore, only the out-of-band emissions of the narrow spacing FS PP interferences are considered in the conclusions. If the receiver selectivity was also taken into account, the needed separation distances for coexistence between FS and other services would be even higher than the calculated distances below.

4.1.6.1 Electronic News Gathering (ENG)

Based on Recommendation ITU-R F. 1777 [27] parameters

The victim receiver bandwidth is equal to 18 MHz. The first possible channel for ENG is on frequency from 10.300 GHz to 10.318 GHz, with frequency carrier on 10.309 GHz. Interfering transmitter channel bandwidth is 2 MHz, so the interfering FS PP adjacent to ENG, has frequency carrier on f_{IT}= 10.319 GHz (the whole channel is from 10.318 GHz to 10.320 GHz).

The distance between interfering transmitter and victim receiver as a function of antenna azimuth is presented in Figure 26. In this case victim receiver has the same antenna radiation patterns as interfering transmitter, that is why one case only is considered. Antenna azimuth φ was changed between 0.5° and 90°.

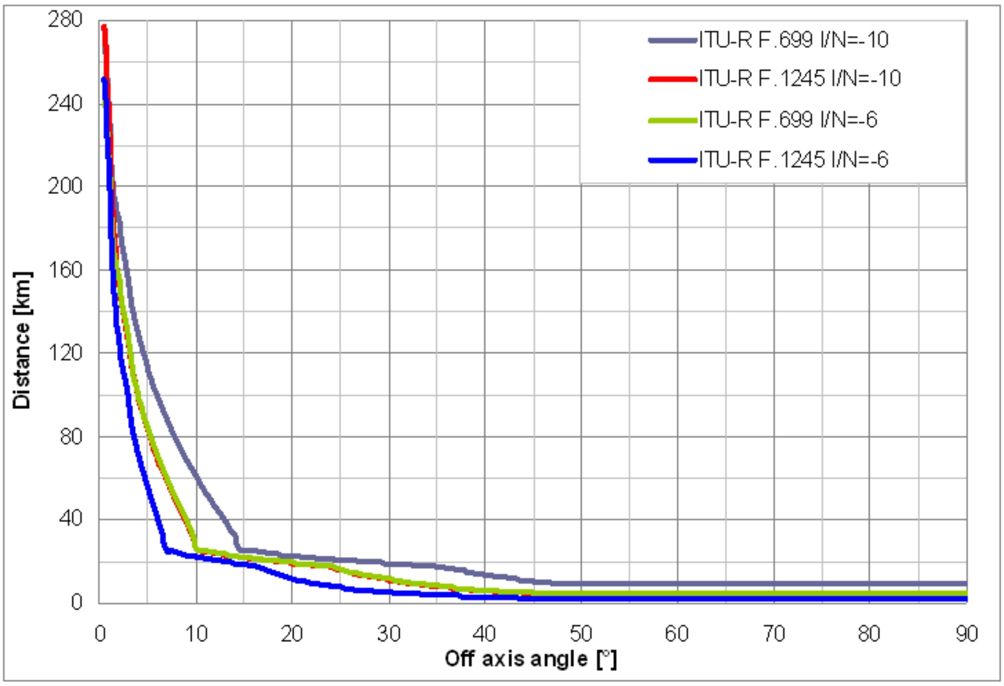


Figure 26: Distance between IT and VR as a function of victim and interfering antenna angle (victim antenna radiations are the same as interfering antenna patterns)

Detailed results are presented in table below (in red results for ITU-R F.1245 [26] are shown).

Table 24: Summary of the results

	I/N=-6	I/N=-10
Minimum distance required when antennas are pointing to each other	264.64 km	289.53 km
Minimum distance required for 0.5° azimuth	251.41 km	276.79 km
Minimum distance between IT and VR/antenna azimuth ≥48°	4.49 km	9.34 km
Minimum distance between IT and VR/antenna azimuth ≥48° (results for ITU-R F.1245 [26] antenna radiation pattern)	2.35 km	4.36 km

Calculation example:

Step 1: Evaluation of noise power density and I/N interference threshold of victim receiver

Victim receiver's noise power is defined through noise figure for nominal bandwidth:

$$N_{Rx}[dBm] = -114 + 4 + 10 \cdot \log(18) = -97.4$$

The interference threshold expressed as power level at victim receiver antenna:

$$I_{MAX}[dBm] = -97.4 + (-10) = -107.4 \text{ or}$$
$$I_{MAX}[dBm] = -97.4 + (-6) = -103.4$$

Step 2: Evaluation of MCL

$$MCL = P_{IT} + G_{IT} - L_{IT} + G_R(\theta) - L_{VR} + mask(\Delta f) - I_{MAX} + BWcorr\_factor$$

Due to separation between frequency carrier of interfering transmitter and victim receiver PIT +mask(Δf) is replaced by spurious emissions, that are defined as emissions at frequencies, which are ±250% of the relevant channel separation outside the nominal carrier frequency of very narrow FS P-P (spurious emission domain).

For separation of Δf=10 MHz between frequency carriers of VR and IT, spurious emission limit is equal to -50 dBm/1 kHz (see fig. 3).

MCL calculation is then as follows:

$$MCL = SEL + G_{IT}(\theta) - L_{IT} + G_R(\theta) - L_{VR} + 10\log\left(\frac{BW_{VR}}{SEL\_ref.BW}\right) - I_{MAX}$$

where:

- SEL- spurious emission limit [dBm],
- G_{IT}- interfering transmitter antenna gain in direction of victim receiver [dBi],
- L_{IT}- transmitter's feeder loss,
- BW_{VR}- victim receiver bandwidth [MHz],
- SEL_ref.BW- spurious emissions reference bandwidth

$$MCL[dB] = -50 + 43 - 0 + 35 - 1 + 10\log\left(\frac{18000}{1}\right) - (-107.4) = 176.95$$

$$MCL[dB] = -50 + 43 - 0 + 35 - 1 + 10\log\left(\frac{18000}{1}\right) - (-103.4) = 172.95$$

Step 3: Physical separation calculations based on MCL value

According to Recommendation ITU-R P.452 [34] required distance between IT and VR is equal to:

d= 289.53 km (for I/N=-10) or

d= 264.64 km (for I/N=-6).

Based on parameters from ECC/ERC Reports

Victim receiver bandwidth is equal to 10 MHz. The first possible channel for ENG is on frequency from 10300 MHz to 10310 MHz, with frequency carrier on 10305 MHz. Interfering transmitter channel bandwidth is 2 MHz, so the interfering FS PP adjacent to ENG, has frequency carrier on f_{IT}= 10311 MHz (the whole channel is from 10310 MHz to 10312 MHz).

Distance between interfering transmitter and victim receiver as a function of antenna azimuth is presented in figure below. In this case victim receiver has omnidirectional antenna or the same antenna radiation patterns as interfering transmitter (temporary point to point link), that is why only one case is considered. Antenna azimuth ϕ was changed between 0.5° and 90°.

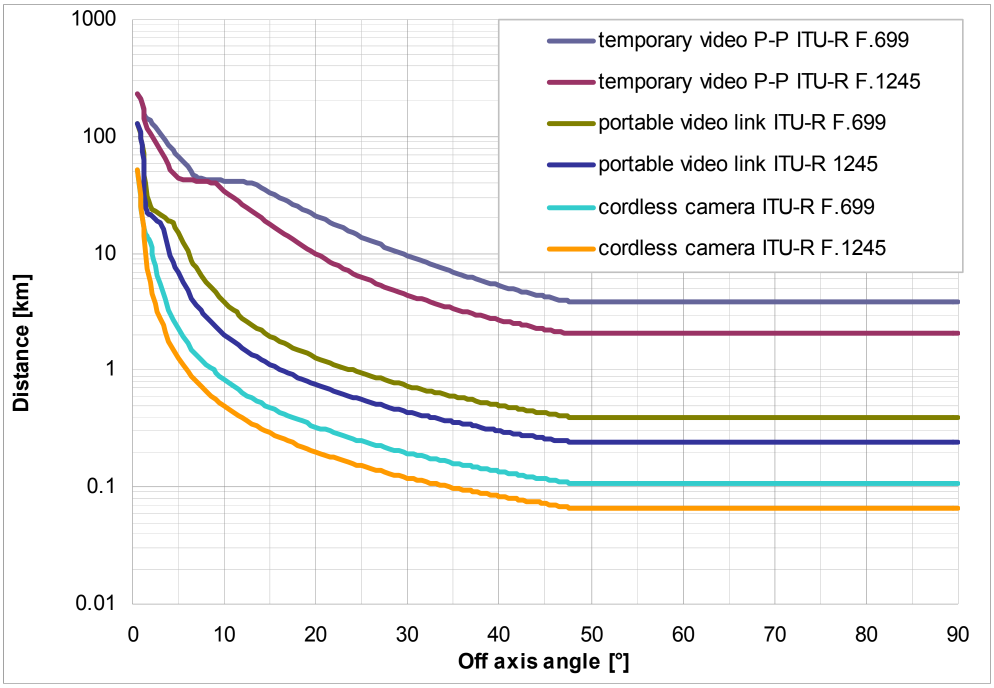


Figure 27: Distance between IT and VR as a function of victim and interfering antenna angle (victim antenna radiation patterns are omnidirectional or the same as interfering antenna patterns) Log scale

In table below in red colour results for Recommendation ITU-R F.1245 [26] antenna radiation pattern are presented.

Table 25: summary of the results for SAP/SAB

	Cordless camera	Portable video link	Temporary P-P link
Minimum distance required when antennas are pointing each other	67.15 km	143.69 km	246.49 km
Minimum distance required when antenna azimuth is 0.5°	141.88 km	152.88 km	169.88 km
Minimum distance between IT and VR/antenna azimuth ≥48 °	0.108 km	0.4 km	3.81 km
Minimum distance between IT and VR/antenna azimuth ≥48 ° (results for ITU-R F.1245 [26] antenna radiation pattern)	0.067 km	0.24 km	2.04 km

4.1.6.2 MMDS

MMDS terminal station (TS) is working on 10.336 GHz with 8 MHz channel bandwidth. The first adjacent channel is on 10.341 GHz. On this frequency very narrow FS P-P link is introduced. Results for coexistence are presented in Table 26 and Figure 28.

Table 26: Summary of the results for MMDS system (TS – victim antenna, F.699 [25] and F.1245 [26] – interfering transmitter antennas)

	ITU-R F.699 [25]	ITU-R F.1245 [26]	TS antenna
Minimum distance required when antennas are pointing each other	206.34 km	206.34 km	206.34 km
Minimum distance required when antenna azimuth is 0.5°	191.98 km	191.98 km	206.34 km
Minimum distance between IT and VR/antenna azimuth	1.58 km/≥48°	0.91 km/≥48°	68.71 km/≥150 °

In Figure 28 the distance between interfering transmitter and victim receiver as a function of azimuth antenna angle of interfering transmitter (1 case) and victim receiver (2 case) is presented. Antenna azimuth θ was changed between 0.5° and 90°(0°- 180° for TS antenna).

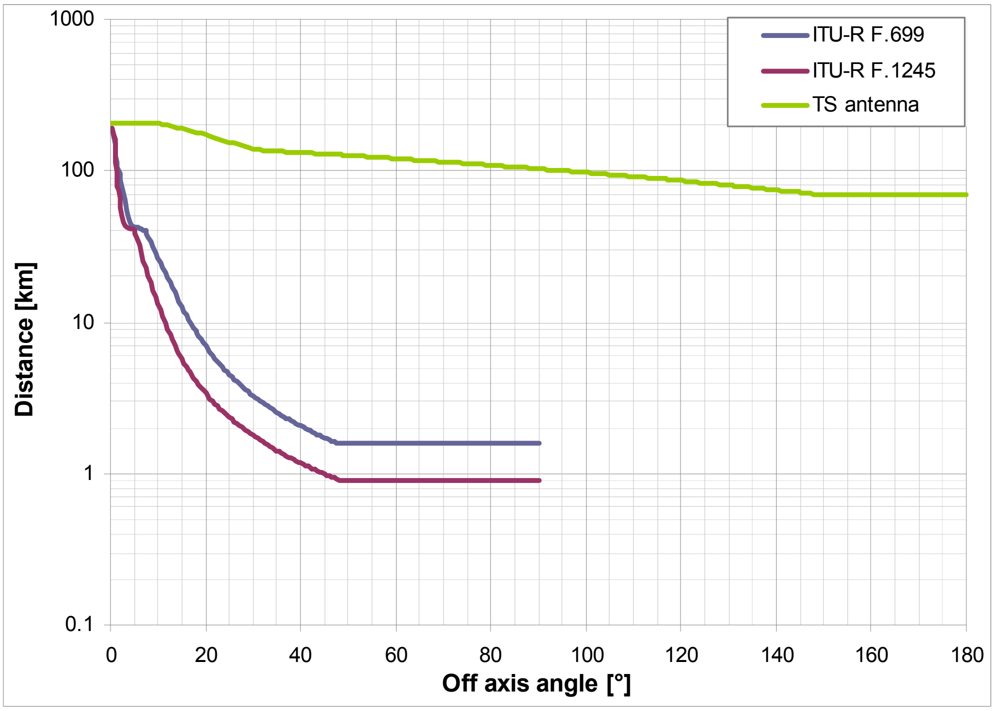


Figure 28: Distance between IT and VR as a function of victim antenna angle (TS antenna) and interfering antenna angle (ITU-R F.699 [25] and ITU-R F.1245 [26]) – Log scale

4.1.6.3 Radiolocation

Ground tracking radar is working on 10.301 GHz with 0.52 MHz channel bandwidth. The first adjacent channel is on 10301.52 MHz, the second is on 10302.04 and the third is on 10302.56 MHz. Very narrow FS P-P link with 2 MHz bandwidth is introduced on 10302.56 MHz in order to be adjacent channel to the existing victim receiver.

In the figure below distance between interfering transmitter and victim receiver as a function of victim receiver and interfering transmitter antenna azimuth is presented. Antenna azimuth θ was changed between 0° and 90°.

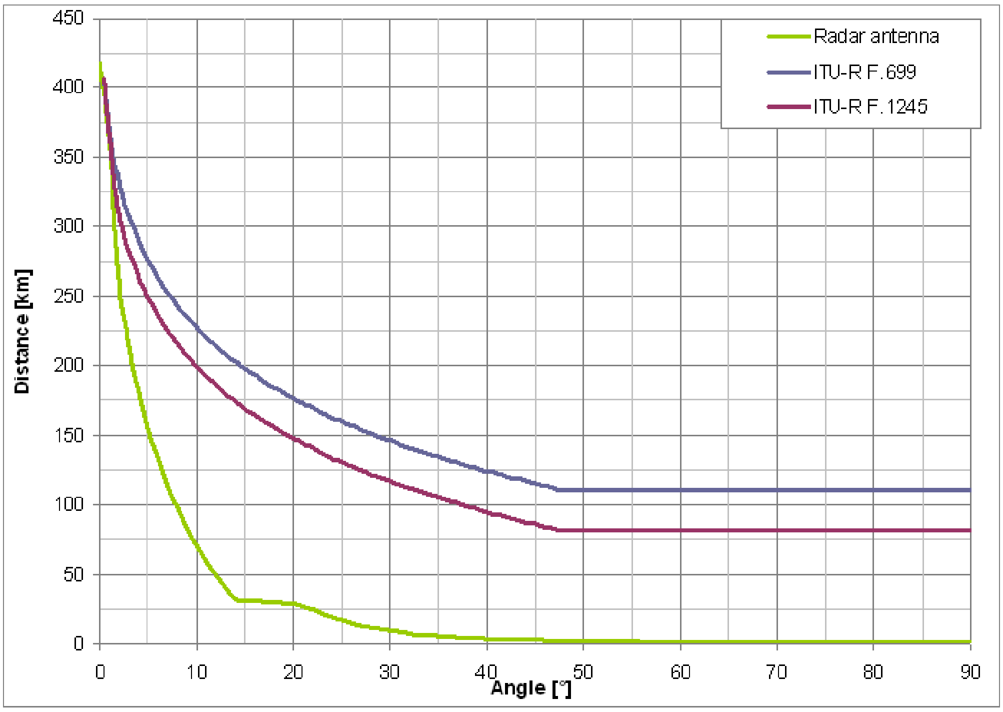


Figure 29: Distance between IT and VR as a function of victim antenna angle (radar antenna) and interfering antenna angle (F.699 and F.1245)

Table 27: summary of the results for ground tracking radar

	ITU-R F.699 [25]	ITU-R F.1245 [26]	Radar antenna
Minimum distance required when antennas are pointing each other	417.27 km	417.27 km	417.27 km
Minimum distance required when antenna azimuth is 0.5°	407.39 km/0.5°	407.39 km/0.5°	393.1 km/0.5°
Minimum distance between IT and VR/antenna azimuth	110.58 km/≥48°	81.38 km/≥48°	0.55 km/≥90°

Step 1: Evaluation of noise power density and I/N interference threshold of ground tracking radar:

Victim receiver's noise power is defined through noise figure for nominal bandwidth:

$$N_{Rx}[dBm] = -114 + 3.4 + 10 \cdot \log(0.52) = -113.4$$

The interference threshold expressed as power level at victim receiver antenna:

$$I_{MAX}[dBm] = -113.44 + (-6) = -119.44$$

Step 2: Evaluation of MCL

$$MCL = P_{IT} + G_{IT}(\theta) - L_{IT} + G_R(\theta) - L_{VR} + mask(\Delta f) - I_{MAX} + BWcorr\_factor$$

According to ETSI EN 302 217 [18], FS PP emission mask for Δf=1.3 MHz introduces 25 dB of attenuation (mask(Δf)=25 dB). Moreover correction factor of 5.85 dB in this case is taken into account. MCL calculation is as follows:

$$MCL = 28 + 43 - 0 + 42.2 - 0 + (-25) - (-119.44) + (-5.85) = 201{,}79dB$$

Step 3: Physical separation calculations based on MCL value

According to Recommendation ITU-R P.452 [34] required distance between IT and VR is equal to:

d=417.27km

4.1.6.4 Summary of adjacent channel coexistence studies

Table 28: summary of the results

	ENG ITU-R F.1777 [27]		ENG ECC Reports			MMDS	Radar
	equipment with capacity up to 60 Mb/s		cordless camera	portable video link	temporary P-P link	DL	Ground tracking
Criterion	I/N=-6	I/N=-10	I/N=-6	I/N=-6	I/N=-6	I/N=-10	I/N=-6
Distance (km) when antennas are pointing each other	264.64	289.53	67.15	143.69	246.49	206.34	417.27
Minimum distance (km)	4.49	9.34	0.108	0.4	3.81	1.58	0.55
Minimum distance (km) (results for ITU-R F.1245 [26] antenna radiation pattern)	2.35	4.36	0.067	0.24	2.04	0.91	-

4.1.7 Summary of coexistence studies

Calculations have shown that SAP/SAB (ENG), MMDS and Radiolocation are the systems, which may be interfered by introducing new FS PP services.

Based on MCL calculations it seems that introducing very narrow channel FS PP in 10.3 - 10.45 GHz band might be difficult. Results show that compatibility with existing systems may be achieved only with some strict coordination. It should be remembered that in calculations the worst case scenario was only considered. Especially antennas vertical radiation patterns were not taken into account. In reality distances between potential narrow channel spacing FS and other services working within center gap might be lower, but coordination would be still needed to make sure that systems are not interfering each other. Note that the calculations were done only with narrow channel spacings of 2 MHz. If the calculations had been made with narrower channel spacings, the results would have been even worse (the coordination distances would have been higher because of the higher power density of the channels). Therefore it was not considered useful to do the calculations with narrower channel spacings as, if it was done, it would not have changed the conclusion that is that it’s not advised to introduce narrow CS in the band 10.3 - 10.45 GHz.

For introducing very narrow FS PP, we recommend use of existing FS band plan which is probably more suitable than use of 10.3 - 10.45 GHz frequency gap.

Note that the interferences from narrow channel spacings toward wide channel spacings of FS regular plan was not studied. Actually it was not considered useful as the coexistence studies with other systems have shown that the introduction of narrow channel spacings in 10.3-10.45 GHz band would be difficult.

Between 10500 and 10650 MHz a quantity of 150 MHz spectrum is already allocated to Fixed Service and could be used for the implementation of FS channel arrangements as they are defined in Annex B of the ERC/REC T/R 13-01 [4] (see Figure 3 in 4.1). In this 150 MHz of spectrum it could be noted that between 10500 MHz and 10600 MHz there is a quantity of 100 MHz spectrum that is primary allocated to Fixed service / Mobile service (10500-10550 MHz) and to Fixed service/Mobile service except aeronautical mobile (10550-10600 MHz) in the three regions (See Table 1). From a technical point of view the 50 MHz of spectrum corresponding to 2x25 MHz between 1375-1400 MHz and 1427-1452 MHz could be included in the channel arrangement between 10500-10600 MHz as defined in Table 2 of Annex A in the CEPT/ERC/REC 12-05 [3] which defines the harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10.0-10.68 GHz, (Table 2 is reported in Figure 2 of this document). The Annex 1 describes a proposal of channel arrangement for this 100 MHz band. In this annex 1 channel arrangement proposal, the duplex bands have 26 MHz widths (10510-10536 MHz and 10564-10590 MHz) while in the 1.5 GHz band, the duplex bands have 25 MHz widths (1375-1400 MHz and 1427-1452 MHz). Also in this annex 1, the duplex gap is 28 MHz (10536-10564 MHz) while in the 1.5 GHz band, the duplex gap is 27 MHz (1400-1427 MHz).

4.2 COMPATIBILITY/SHARING STUDIES IN THE L6 GHz BAND

4.2.1 Compatibility and sharing studies with fixed service

The interfering transmitter parameters are presented in

Table 29: FS P-P narrow channel interfering transmitter parameters

Parameters	Value
Carrier frequency (MHz)	scenario dependent
Channel spacing and receiver noise bandwidth (MHz)	2
MaximumTx power (dBm)	32
Maximum TX output power density range (dBm/MHz)	28.99
Antenna gain (dBi)	45
Antenna pattern	ITU-R F.699-7 [25] ITU-R F.1245-1 [26]
Antenna height (m)	20
Minimum feeder/multiplexer loss range (dB)	5.6
e.i.r.p. (dBm)	71.4
e.i.r.p. density (dBm/MHz)	68.4
Receiver noise figure(dB)	5
Receiver noise power density typical (=NRX) (dBm/MHz)	-109
Transmitter emission mask	ETSI EN 302 217 [18]
Transmitter spurious emission	ETSI EN 301 390 [17]
I/N criterion (dB)	-6
Nominal long-term interference power density (dBm/MHz)([3])	NRX +I/N

[3] I/N-th = –6 dB is applicable to cases of sharing with other FS applications.

During coexistence studies two different FS radiation patterns are considered. Antenna radiation patterns are defined in ITU-R Recommendations:

- Recommendation ITU-R F.699 [25], which gives the peak envelope of side-lobe patterns,
- Recommendation ITU-R F.1245 [26], which describes antennas radiation patterns with average side-lobe levels.

In calculations worst case scenario is considered assuming flat terrain without obstacles between interfering transmitter and victim receiver (LOS) and antennas working with the same polarizations.

It is assumed that angles between victim receiver and interfering transmitter are changed in horizontal plane (azimuth).Due to considerations of the worst case scenario, impact of vertical antenna gain is not taken into account.

In calculations maximum interfering transmitter power of 32 dBm is used. This value is assumed as the highest possible value of in channel power (maximum transmission power within emission mask). Figure 30 below presents FS transmitter emission mask derived from ETSI EN 302 217 [18] and EN 301 390 [17].

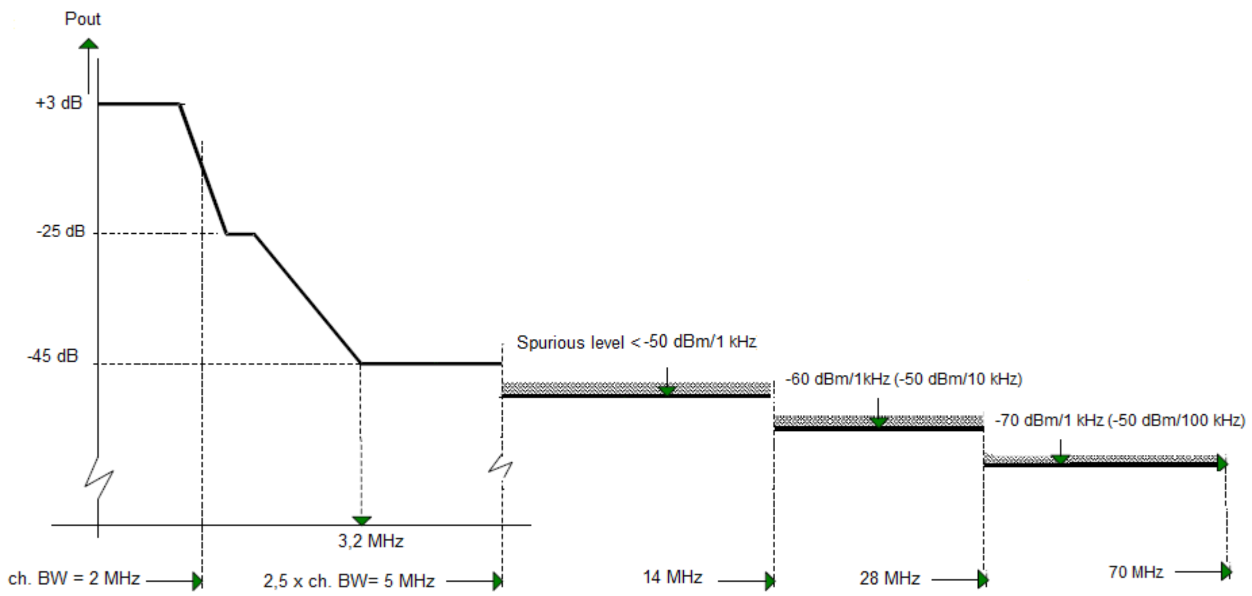


Figure 30: FS transmitter emission mask derived from ETSI EN 302 217 [18] and EN 301 390 [17]

Free Space Model is used for calculation of interfering signal level when satellite systems are considered as victim.

4.2.2 Co-channel sharing studies

4.2.2.1 Fixed Satellite Service

Studies with FSS are presented in paragraph 4.3.4

4.2.2.2 UltraWideband systems/applications (UWB)

According to ECC/DEC/(06)04 [1] UWB systems operate on a non-interference, non-protected basis, therefore compatibility studies are not performed.

According to ECC/DEC/(11)02 [2] that LPR shall operate on a non-interference, non-protected basis, therefore coexistence studies are not performed.

4.2.2.3 Short Range Devices radiodetermination applications

SRD devices operates on non-interference and non-protected basis, therefore interference studies with these services are not required.

4.2.2.4 Summary of co-channel coexistence studies

Revision of systems, which may work in the same channel with new narrow channel FS PP shows, that only uplink part of ESV systems might suffer from harmful interferences. However coexistence studies prove that narrow channel fixed links will not cause interference to satellite receivers. The number of fixed links which may work simultaneously is high however probability of having so many fixed links pointing to the satellite is quite low.

4.2.3 Adjacent channel compatibility studies

4.2.3.1 Intelligent Transport System (ITS)

Two ITS devices are considered:

- OBU (On Board Unit): mobile ITS device mounted on a car;
- RSU (Road Side Unit): fixed ITS device placed on the ground.

The antenna patterns for these two devices are shown below:

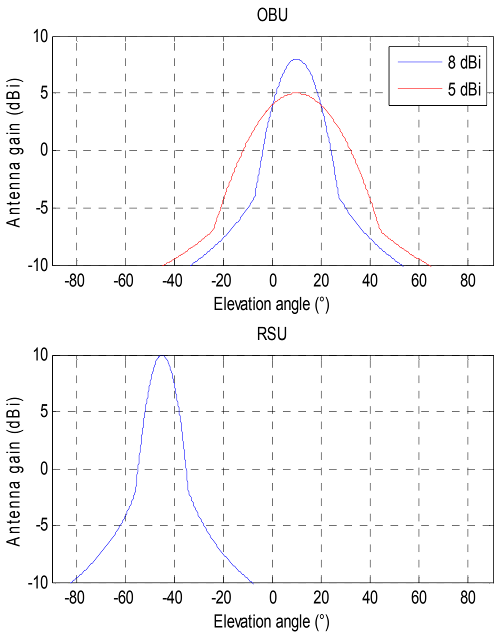


Figure 31: OBU and RSU antenna patterns

The technical parameters used for interference assessment are given in the following tables.

Table 30: ITS receiver characteristics derived from ECC Report 101 [13]

Parameters	Value
Carrier frequency (MHz)	5920
Channel spacing and receiver noise bandwidth (MHz)	10 MHz
Antenna gain (dBi)	8

Parameters	Value
Antenna pattern	Omnidirectional (horizontal)
Antenna height (m)	1.7 m
Minimum feeder/multiplexer loss range (dB)	5.6
Receiver sensitivity (dBm)	-82
Receiver sensitivity at antenna input (dBm/MHz)	-100
C/I(dB)	-6
Allowable Interfering Power at receiver antenna input (dBm/MHz)	-106

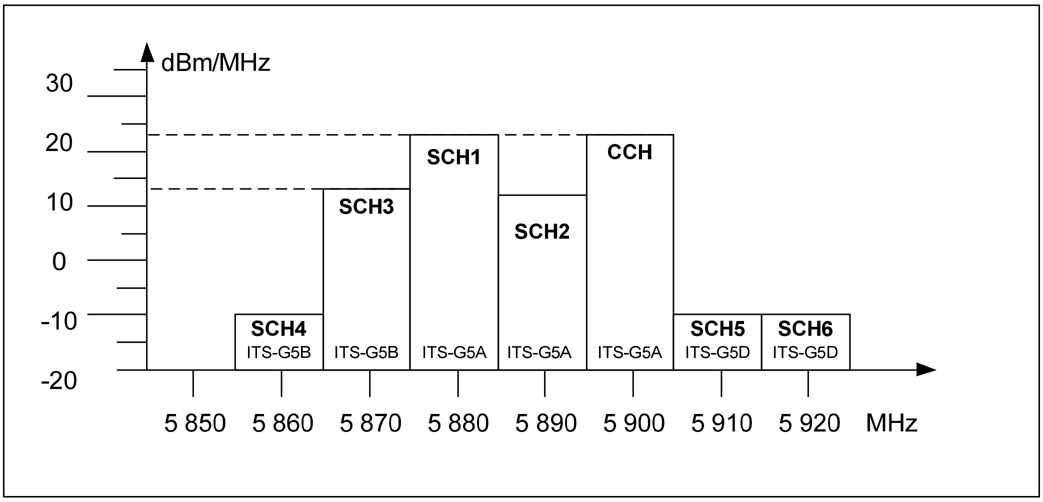


Figure 32: Maximum limit of mean spectral power density for each channel type in ITS-G5A, ITS-G5B, and ITS-G5D (extract from ETSI EN 302 663 [20])

Table 31: Transmitter unwanted emission limits inside the 5 GHz ITS bands (e.i.r.p.) (extract from ETSI EN 302 571 [15])

Power spectral density at the carrier center fc (dBm/MHz)	±4.5 MHz Offset (dBm/MHz)	±5.0 MHz Offset (dBm/MHz)	±5.5 MHz Offset (dBm/MHz)	±10 MHz Offset (dBm/MHz)	±15 MHz Offset (dBm/MHz)
-10 (SCH 5 and 6)	-10	-36	-42	-50	-60

Due to the low elevation of ITS On Board Unit and as mentioned in ECC Report 101 [13], the following propagation model is used for ground to ground propagation:

$$L_{FS} = \begin{cases} 20Log\left(\frac{\lambda}{4\pi d}\right) & \text{if } d \le d_0 \\ 20Log\left(\frac{\lambda}{4\pi d_0}\right) - 10n_0 Log\left(\frac{d}{d_0}\right) & d_0 < d \le d_1 \\ 20Log\left(\frac{\lambda}{4\pi d_0}\right) - 10n_0 Log\left(\frac{d_1}{d_0}\right) - 10n_1 Log\left(\frac{d}{d_1}\right) & d > d_1 \end{cases}$$

Table 32: Propagation parameters

	Urban	Suburban	Rural
Breakpoint distance d0 (m)	64	128	256
Pathloss factor n0 beyond the first break point	3.8	3.3	2.8
Breakpoint distance d1 (m)	128	256	1024
Pathloss factor n1 beyond the second breakpoint	4.3	3.8	3.3

Using the parameters of Table 32, Figure 33 depicts propagation loss in various environments.

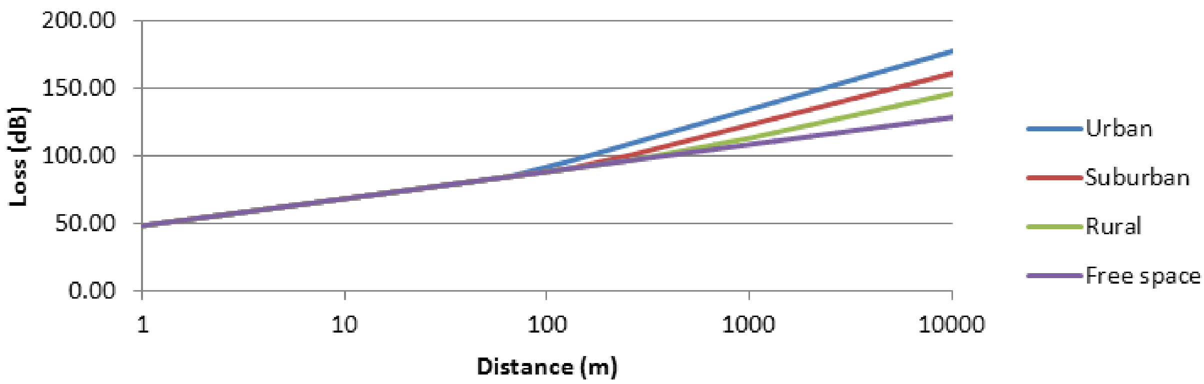


Figure 33: propagation loss for various environments in comparison with free space model

Table 33: Fixed service characteristics

Parameters	Value	Reference
Carrier frequency Receiver Frequency (MHz)	5925.875	
Channel spacing and receiver noise bandwidth (MHz)	0.250	
Tx power (dBW)	-3	ETSI TR 102 243-1 [21]
Antenna gain (dB)	45	ETSI TR 102 243-1 [21]
Typical feeder loss (dB)	2	
Antenna height (m)	20	
Receiver noise figure(dB)	5	ITU-R F.758-5 [23]
Receiver noise power (dBm/MHz) (1)	-109	

The separation distances calculation to protect ITS On board unit from FS emissions is presented below:

For the following calculation, the fixed service Tx power in spurious domain (note 1) is defined with a value of -24 dBm/MHz:

27 dBm – 2 (feeder loss) – 10 Log (250) – 55 (mask att) = -54dBm/KHz

Note (1): Taking in account ITS at 5920 MHz and FS at 5925.875 MHz.

The required propagation loss LFS is given by the following equation:

LFS = e.i.r.p – Imax + Gr - LITS

where:

- Imax is the maximum interference power (-106 dBm/MHz at receiver antenna input);
- Gris the victim antenna gain in dBi;
- e.i.r.p. is the e.i.r.p. of the interferer in dBm.

Based on LFS value, the physical separation is derived from propagation model.

LFS = -24 dBm/MHz + 45 dBi (FS antenna gain pointing ITS) +106 dBm/MHz (Imax)

LFS = 127 dB

Table 34 defines separation distance for few values of «off axis» between ITS and Fixed Service (ITS antenna always pointing at FS).

Table 34: Separation distance between ITS and FS to ensure compatibility (Protection of ITS from FS emissions)

Results	Value					
FS/ITS Off axis (°)	0	1	5	10	15	20
FS Antenna Gain (dBi)	45	36.22	12.66	5.14	0.73	-2.39
Required Loss (dB)	127.00	118.22	94.66	87.14	82.73	79.61
Separation distance (m) (Rural)	2715	1471	215	91	55	38
Separation distance (m) (Suburban)	1308	769	175	91	55	38
Separation distance (m) (Urban)	689	430	121	77	55	38

Considering the required low separation distances between FS and ITS OBU, and the strong level of down tilt for RSU antenna gain, no study have been carried out for this equipment (much shorter distances should be expected).

The separation distances to protect FS from ITS emissions are studied below where only ITS channel SCH6 has been considered.

ITS power density: -10 dBm/MHz

ITS unwanted emission power density: -42 dBm/MHz at 5920 ± 5.5 MHz

Fixed service maximum allowable interference: - 129 dBm/MHz (I/N = -20 dB)

The same methodology as in 2.1 has been used.

LFS = -42 dBm/MHz + 8 (ITS Ant Gain) – 5.6 (ITS feeder loss) + 45 (FS antenna gain pointing ITS) + 129 dBm/MHz

LFS = 134.4 dB

Table 35 defines separation distance for few values of «off axis» between ITS and Fixed Service (ITS antenna always pointing at FS).

Table 35: Separation distance between ITS and FS to ensure compatibility (Protection of FS from ITS emissions)

Results	Value					
FS/ITS Off axis (°)	0	1	5	10	15	20
FS Antenna Gain (dBi)	45	36.22	12.66	5.14	0.73	-2.39
Required Loss (dB)	134.40	125.62	102.06	94.54	90.13	87.01
Separation distance (m) (Rural)	4548	2565	415	212	128	90
Separation distance (m) (Suburban)	2048	1203	289	174	128	90
Separation distance (m) (Urban)	689	640	181	120	92	77

The review of the results highlights the fact that the coexistence between ITS in the band 5855-5825 MHz and FS with narrow channel (250 KHz) may be achievable with acceptable conditions.

Note that the 250 kHz channel spacing case was only studied here. In this lower part of the 6 GHz band (L6), the bandwidth available is rather restricted compared to the U6. Therefore, it is advised to consider lower narrow channel spacings (between 25 kHz up to 250 kHz) in the L6 whereas it would be more suitable to put higher channel spacings (above 250 kHz) in the U6 where the bandwidth available is higher. That is the reason why only the 250 KHz case was studied here.

4.2.3.2 Fixed Satellite Systems (FSS)-uplink

Studies with FSS are presented in paragraph 4.3.4

4.2.3.3 Earth Exploration Satellite Service (EESS)

The EESS systems are divided into three kinds of systems:

- EESS (passive) - where on-board satellite receivers (radiometers) are able to observe natural emissions of the Earth and its atmosphere;
- EESS (active) - where radar signals are sent towards the Earth in order to get an accurate mapping of Earth surface;
- EESS - where signals are sent from the Earth to satellites to control them in orbit, and from satellites to the Earth to collect on-board information.

Frequency bands designed for different EESS:

- EESS (passive) allocated around 6.9 GHz,
- EESS (active) allocated in 5250-5570 MHz frequency band. Two types of EESS space are operated in this band:
  - Synthetic Aperture Radars (SAR) with frequency carrier on 5 405 MHz;
  - Altimeters with frequency carrier on 5 410 MHz.

The 6-7 GHz band channel is essential for observing global soil moisture, global sea surface temperature, temperature of sea ice and sea surface wind through cloud, in combination with other channels.

EESS passive

Table 36 presents parameters for EESS passive. In the calculations, the bold parameters are taken into account.

Table 36: EESS (passive) sensor characteristics in the 6.425-7.25 GHz band (from Recommendation ITU-R RS.1861 [35])

	Sensor B1	Sensor B2	Sensor B3	Sensor B4
Sensor type	Conical scan			
Orbit parameters				
Altitude	705 km	**828 km**	835 km	699.6 km
Inclination	98.2°	**98.7°**	98.85°	98.186°
Eccentricity	0.0015	**0**	0	0.002
Repeat period	16 days	**17 days**	N/A	16 days
Sensor antenna parameters				
Number of beams	1			
Reflector diameter	1.6 m	**2.2 m**	0.6 m	2.0 m
Maximum beam gain	38.8 dBi	**-**	-	40.6 dBi
Polarization	V,H			
–3 dB beamwidth	2.2°	**1.65°**	-	1.8°
Off-nadir pointing angle	47.5°	**46.8°**	55.4°	47.5°
Beam dynamics	40 rpm	**31.6 rpm**	2.88 s scan period	40 rpm
Incidence angle at Earth	55°	**55.7°**	65°	55°
–3 dB beam dimensions	40 km (cross-track)	**24 km**		35 km (cross-track)
Instantaneous field of view	43 km × 75 km	**68 km × 40 km**	112 km × 260 km	35 km × 61 km
Main beam efficiency	95.1%	**95%**		92%
Swath width	1450 km	**1700 km**	2000 km	1450 km
Sensor antenna pattern	See Recommendation ITU R RS.1813 [36]			
Cold calibration ant. Gain	25.1 dBi	N/A		25.6 dBi
Cold calibration angle (degrees re. satellite track)	115.5º	N/A		115.5º
Cold calibration angle (degrees re. nadir direction)	97.0º	N/A		97.0º
Sensor receiver parameters				
Sensor integration time	2.5 ms	**5 ms**	N/A	2.5 ms
Channel bandwidth	350 MHz centred at 6.925 GHz	**350 MHz centred at 6.625 GHz**	350 MHz centred at 6.9 GHz	350 MHz centred at 6.925 GHz and at 7.3 GHz
Measurement spatial resolution				
Horizontal resolution	43 km	**15-50 km**	38 km	35 km
Vertical resolution	74 km	**24 km**	38 km	61 km

Protection criterion for protecting operation of EESS (passive) in 6425-7250 frequency bands is given by Recommendation ITU-R RS. 1029 [37] as -166 dBW in 200 MHz reference bandwidth. This is described as a maximum interference level from all sources. Interference threshold can be exceeded in 0.1% of area or time. Calculations assume the worst case scenario - main lobe to main lobe coupling (victim receiver antenna is pointing directly to interfering transmitter antenna).

In calculations following formula is used:

$$P_{IT} + G_{IT}(\theta) - L_{IT} - L - G_R(\varphi) < -166 dBW / 200 MHz$$

where:

- P_{IT}- interfering transmitter power;
- $G_{IT}(\Theta)$- interfering transmitter antenna gain in direction of victim receiver;
- L_{IT}- transmitter's feeder loss;
- L- space loss based on free space model for d=828 km L=167.22 dB,
- $G_R(\varphi)$- victim receiver antenna gain in direction of interfering transmitter.

The interfering transmitter frequency carrier is on 6424 MHz, victim receiver frequency is on 6424 MHz which gives 201 MHz frequency separation. FS PP spurious emission level (SEL) for such separation is -50 dBm/1MHz. The calculation for that case is as follows:

$$SEL + 10\log(BWvic) + G_{IT}(\theta) - L_{IT} - L + G_R(\varphi) < -166 dBW / 200 MHz$$

$$-80\left(\frac{dBW}{MHz}\right) + 10\log(200) + 45 - 5.6 - 167.22 + 40 = -144.81\ dBW\ in\ 200MHz$$

This constitutes a deficit of 21.19 dB with respect to sensor protection level of -166 dBW for bandwidth of 200 MHz. This deficit would occur for single FS PP and does not take into account aggregate effect of multiple FS PP links.

However, situation described above is very unlikely to occur. In figure below power received by EESS receiver as a function of interfering antenna azimuth/elevation angle is presented (antenna has the same horizontal and vertical radiation pattern). Antenna azimuth/elevation θ is changed between 0.5° and 90°.

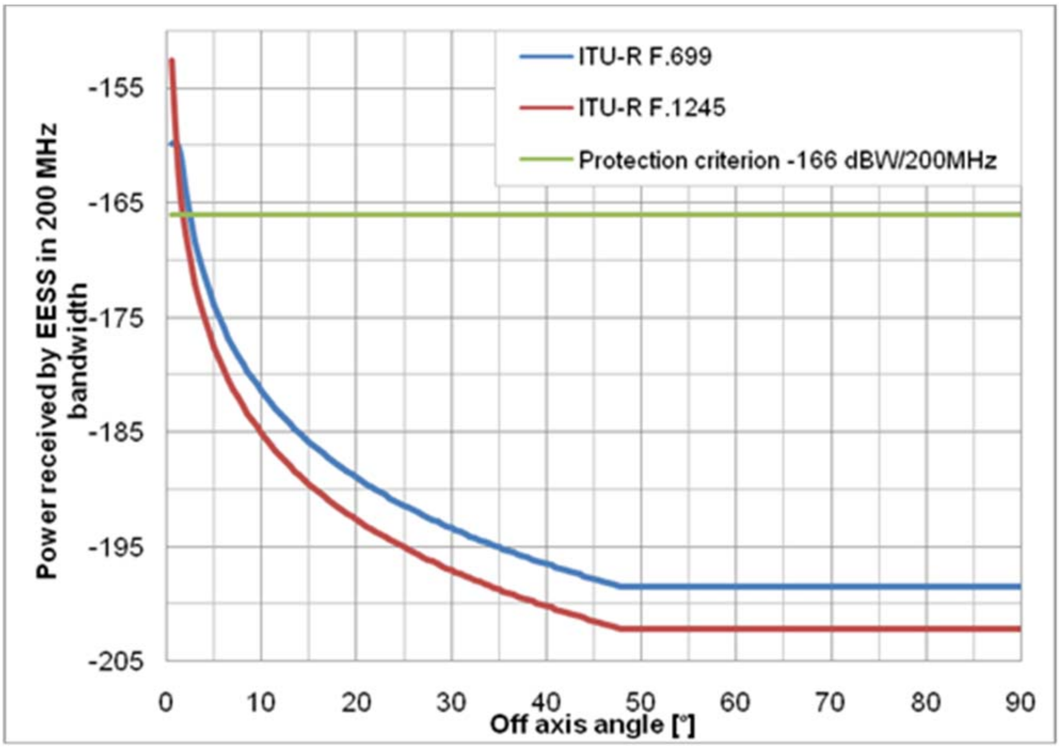


Figure 34: Power received by EESS receiver as a function of interfering antenna angle

As it can be seen only for very low interfering antenna angles protection criterion for EESS receiver is not met.

Table 37: Summary of the results

	ITU-R F.699 [25]	ITU-R F.1245 [26]
Interfering antenna angles for which EESS criterion is met	≥ 2.5°	≥ 2°

Note that above calculations are valid only for single FS PP and aggregate effect for multiple FS PP links is not taken into consideration.

EESS active

Taking into account the lowest frequency separation between interfering transmitter (fi=5926 MHz) and victim receiver (i.e. f_v= 5410 MHz), no coexistence study is needed. There would be no interference from narrow band FS PP to EESS active.

4.2.4 Summary on Lower 6 GHz coexistence studies

Based on calculations it is shown that introducing very narrow channel FS PP in 5925-6425MHz band gaps might be possible with coordination (actually narrow FS PP may cause the most harmful interferences to system working in adjacent channel/band).

Results of calculation show that there is low probability of interference between very narrow channel FS PP and satellite services.

In this study, the coexistence with FS PP in the harmonized band plan was not addressed. However use of classical rules used in classical FS band plan can help insertion of narrow band FS within center gaps and guard bands:

- avoid use of the closest adjacent channel between center gap and regular plan,
- make/use profits of duplex filter attenuation of fixed links working within harmonized band plan,
- Use of different antenna polarizations,
- Use of regular FS coordination rules specified by national administrations.

4.3 COMPATIBILITY/SHARING STUDIES IN THE U6 GHZ BAND

4.3.1 Fixed service characteristics

Table 38, the interfering transmitter and victim receiver parameters are presented.

Table 38: interfering transmitter and victim receiver parameters

	FS P-P narrow channel interfering transmitter	FS P-P victim receiver	Reference
Carrier frequency Receiver Frequency (MHz)	6762.75	6740	
Channel spacing and receiver noise bandwidth (MHz)	0.5	40	
Tx power (dBW)	-3		ETSI TR 102 243-1 [21]
Antenna gain (dB)	45	45	ETSI TR 102 243-1 [21]
Typical feeder loss (dB)	2		
Antenna height (m)	20	20	

	FS P-P narrow channel interfering transmitter	FS P-P victim receiver	Reference
Receiver noise figure(dB)		5	ITU-R F.758-5 [23]
Receiver noise power (dBm/MHz) (1)		-109	

(1) N_{Rx} = -114 dBm/MHz + NF

Antenna radiation pattern from Recommendation ITU-R F.1245 [26]:

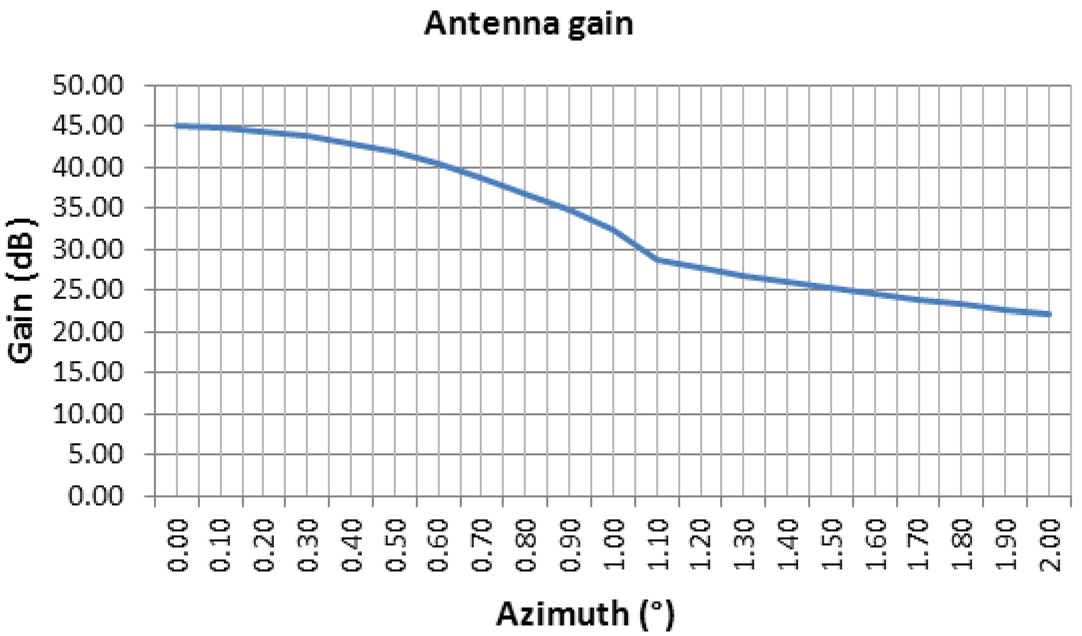


Figure 35: Antenna pattern derived from ITU-R F.1245-2 [26] (f=7100 MHz)

4.3.2 Compatibility with FS in adjacent channels

This scenario takes in account the assumption that only bandwidth is implemented, as reported by administrations on their current use of the U6 band (either 40 MHz or 30 MHz channels). Narrow are defined according

Figure 11.

The results are presented through following figure which shows the distance between IT and VR as a function of victim and interfering antenna angle (off axis).

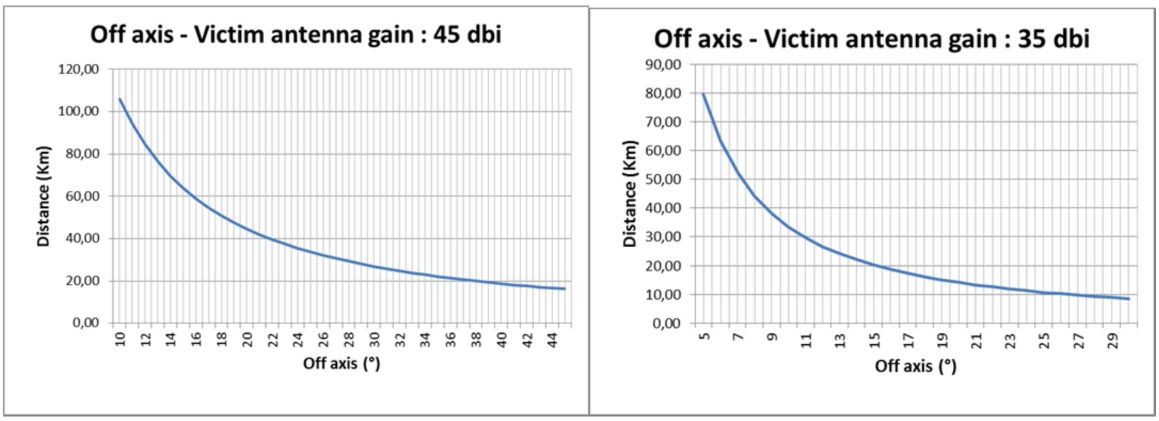


Figure 36: Distance between IT and VR as a function of victim and interfering antenna angle (Tx_{int} power in spurious domain according to ITU-R SM.329 [30])

with:

$$MCL = -14.77\ dBm/MHz + Gant_{int}\ f(\text{off axis angle}) + Gant_{vict}\ (45\ \text{or}\ 35\ dBi)+115\ (I/N=-6\ dB)$$

$$\text{Distance}=d= 10^{[MCL-32.44-20\log(f)]/20}$$

-14.77 = spurious emission level according Recommendation ITU-R SM.329 [30]

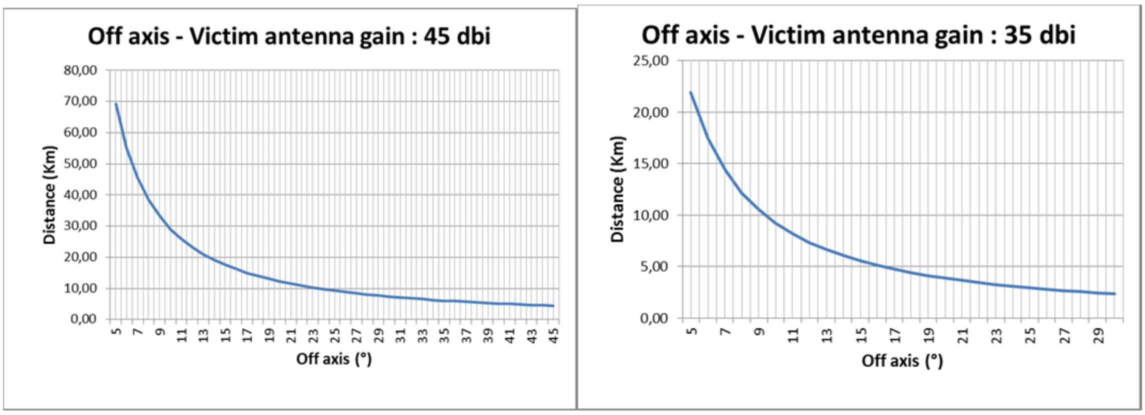


Figure 37: Distance between IT and VR as a function of victim and interfering antenna angle (Tx power according ETSI EN 302 217-2-2 [18] Class 4L-16QAM)

MCL = -25.75 dBm/MHz + Gantint [f(off axis angle)]+ Gantvict (45 or 35 dBi) + 115 (I/N=-6dB)

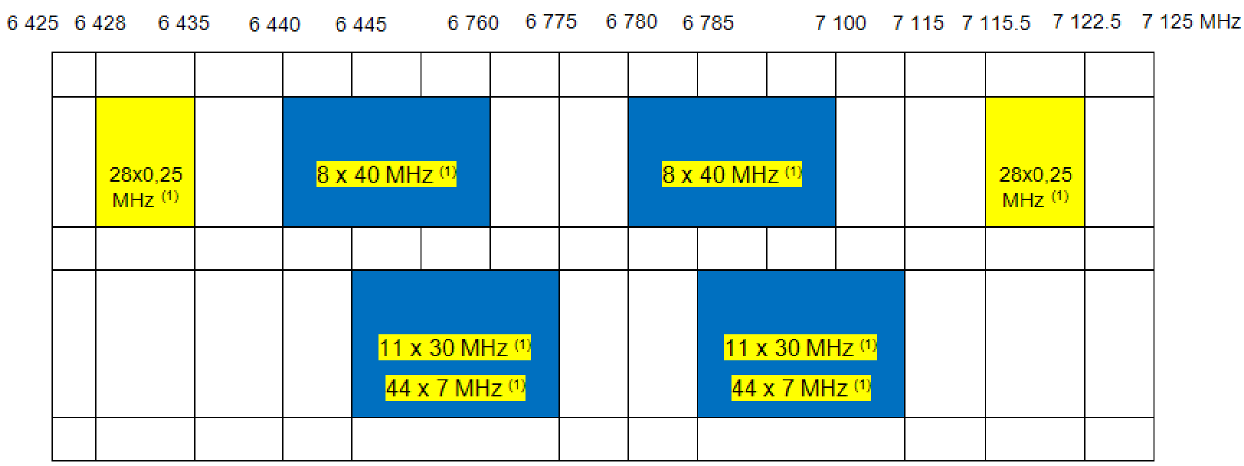
The value of -25.75 dBm/MHz is obtained as shown below:

Tx – Feeder loss: 25 dBm/500KHz

25 – 10 Log (500*0.75) – 55 (mask att) = -55.75 dBm/KHz = -25.75 dBm/MHz

The “0.75” factor is used to take in account average channel occupation.

When applying the option 3 (Figure 13) with simultaneous use of two channel arrangements in the U6 band (e.g. 40 MHz and 30 MHz), the compatibility is achieved in the same fashion that the one described in section 5.2.



(1) The occupied spectrum includes frequency carrier ± bandwidth

Figure 38: Occupied spectrum with 40 MHz and 30 MHz channels and narrow channels

4.3.3 Compatibility with FS in the same band

In the cases where several channels arrangements (40 MHz, 30 MHz and 20 MHz) are simultaneously implemented in the same large area, the administrations already have to set coordination requirements.

Consistent coordination may be readily achieved with frequency offset of 2.5x narrow channel spacing and/or cross-polar discrimination.

4.3.4 Compatibility with other services

4.3.4.1 Fixed satellite service (Uplink)

Typical fixed satellite service (FSS) parameters at 6/8 GHz are presented in Table 39.

Table 39: Typical FSS parameters at 6/8 GHz (Uplink) (from ECC Report 064 [16])

Parameter	Unit	Typical geostationary satellite system
Uplink band	GHz	5725 - 7075, 7900 - 8400(1)
Free-space loss	dB	199.5
Clear-air loss	dB	0.1
Satellite antenna gain	dBi	35
Noise temperature	K	600

(1 These typical FSS parameters were assumed to also apply to the 7250-7750 MHz band and 7900-8400 MHz [Note : it has to be confirmed for the European case]

Typical feeder link satellite parameters are presented in Table 40.

Table 40: Typical MSS parameters at 6/8 GHz (Uplink) (from ECC Report 064 [16])

Parameter	Inmarsat-3	Units
Beam	Global	
Frequency Band	6425-6575	MHz
System noise temperature	891	K
Bandwidth	32.7	MHz

Recommendation ITU-R S.1432 [38] contains the allowable degradations to the FSS below 15 GHz. The Recommendation states that for all sources of long-term interference from systems having co-primary status, the allowable interference noise contribution is 6%.

This study adopts the ΔT/T approach described in Appendix 8 of the ITU Radio Regulations[4]

The limitation of increase of equivalent noise temperature is expressed by the following relationship:

$$\frac{\Delta T_{sat}}{T_{sat}} < Y\ \%$$

where:

- ΔT_{sat} : apparent increase in the receiving system noise temperature at the satellite, due to an interfering emission (K);

[4] ITU Radio Regulations Appendix 8:Method of calculation for determining if coordination is required between geostationary-satellite networks sharing the same frequency bands

- T_{sat}: the receiving system noise temperature at the satellite referred to the output of the receiving antenna of the satellite (K)
- Y : noise increase allowed (6% in case of FS).

In the case under consideration here, ΔT_{sat} is the contribution of aggregate emissions from FS P-P devices at the input of satellite receiver.

Assuming that FS P-P interference can be treated similarly to thermal noise, the following relationship can be assumed (linear scale, not dB):

$$\Delta T_{sat} = \frac{e.i.r.p.\cdot G_{sat}}{k \cdot l} \quad K$$

where:

- $e.i.r.p._{FS}$: the aggregate e.i.r.p. spectral density of the FS P-P transmitters in the satellite beam and in the direction of the satellite (W*Hz^{-1});
- G_{sat}: the gain of receiving antenna of the satellite in the direction of FWA interferer (linear ratio, relative to isotropic);
- k : Boltzmann's constant (1.38x10^{-23} J.K^{-1});
- l : uplink Free Space path loss (linear power ratio). Note that this could also include gaseous attenuation due to absorption by water vapour and oxygen molecules;

Combining above equations:

$$e.i.r.p._{FS} = 10 \cdot \log(X) - 29.1 - 10 \cdot log\left(\frac{G_{sat}}{T_{sat}}\right) dB(WHz^{-1})$$

$$e.i.r.p._{FS} = 10 \cdot \log(X) - 29.1 - G_{sat} + 10 \cdot log(T_{sat}) dB(WHz^{-1})$$

where:

G_{sat}/T_{sat} is the "G/T" at the satellite receiver input derived from the values of G_{sat} and T_{sat} given in Table 2 and a particular value of l (10*log(l)=199.5dB) has been derived from table 2 as free space loss for a distance of 38000 km (distance from Europe to a satellite at the same longitude).

The following presents an example of calculation for Scenario a:

FS location: 48N 2E - FS elevation : 0° - Pointing satellite longitude

Satellite longitude: 7E – Elevation off axis with FS: 34°

$$e.i.r.p._{FS} = 10 \cdot \log(0.06) - 29.1 - 35 + 10 \cdot log(891) = -46.82 \ dB(WHz^{-1})$$
$$e.i.r.p._{FSchannel} = EIRP_{FS} + 10 \cdot \log(B) = -46.82 + 10 \cdot \log(500\,000) = 10.18 \ dBW/0.5MHz$$

e.i.r.p.$_{\text{Device channel}}$ is the e.i.r.p. density range in dBW/channel of one single FS PP device in the direction of

$e.i.r.p._{Device\ channel}$ = -3 dBW – 8.54 dBi – 2 dB = - 13.54 dBW/0.5 MHz

(-8.54 dBi = antenna gain at 34° elevation – ref ITU-R F.1245-2 [26])

Number of active devices: $10 \log(N) = e.i.r.p._{FSchannel} - e.i.r.p._{Device\ channel}$

Number of active devices: 10.18 dBW – (-13.54dBW) = 23.72 or 235 fixed service devices over 0.5 MHz.

Considering a 15 MHz band (option 1: 7050 fixed service devices over 15 MHz.

Table 41: Summary of sharing studies with FSS

Scenario	a	b	c	d	e	f
FS Bandwidth (MHz)	0.5	0.5	0.5	0.25	0.25	0.25
Satellite receiving noise temp. (K)	891	891	700	891	700	700
Aggregate FS e.i.r.p for ΔTsat/T=6% (dBW/Hz)	-46.82	-46.82	-47.56	-46.82	-47.56	-47.56
Satellite antenna gain (dBi)	35	35	34.7	35	34.7	34.7
Max aggregate FS e.i.r.p in one channel (dBW/Bandwidth)	10.18	10.18	9.44	7.15	6.44	6.44
FS Location	48N 2E	48N 2E	48N 2E	48N 2E	48N 2E	48N 2E
FS Elevation (°)	0	5	0	5	0	5
Satellite longitude	7E	7E	66E	7E	66E	66E
FS Azimuth (°)	173.2	173.2	109.9	173.2	109.9	109.9
Fixed service off axis/Satellite (°)	34	29	8.45	29	8.45	3.45
FS Antenna Gain (dB)	-8.54	-6.82	6.57	-6.82	6.57	16.3
Number of FS links over 15 MHz	7050	4950	183.6	4933	183.6	19.2
% of total FS(1)	>100%	88%	3.2%	88%	3.2%	0.3%

(1) 5600 links reported in Europe between 1350 – 1800 MHz (from 2010 questionnaire – ECC Report 173 [1])

These results disregard the 3 dB factor of polarisation that could be used to improve the compatibility calculations and complete line of sight link between FS and FSS space stations.

Taking in account that the studies have highlighted the major impact of spectral power density when assessing the impact of fixed service links with narrow channels, and with the view of setting relevant parameters for FS links, complementary analysis must be carried out.

4.3.4.2 Fixed satellite service – complementary study

Article 21 of the Radio Regulations contains the appropriate provisions to protect FSS satellites on geostationary orbit from FS emissions.

Moreover, with the view to implement narrow channels on the 6 GHz band in accordance with the applicable requirements, it is proposed to set suitable parameters taking in account the e.i.r.p. spectral density as a relevant basis.

According Recommendation ITU-R F.758 [23], fixed service parameters for 5925-6425 MHz are defined as following:

Minimum bandwidth: 5 MHz
Maximum Tx power: 2 dBW
Maximum antenna gain: 46.6 dB
Minimum feeder loss: 1.1 dB.

From these parameters we can derive the maximum currently allowable e.i.r.p density:

➔ 2dBW – 1.1 + 46.6 – 10 Log (5 MHz)
➔ 40.6 dBW/MHz

Implementation of narrow channels in the L6 GHz band should therefore also consider this e.i.r.p. spectral density value.

Table 42 below contains allowable e.i.r.p levels for each type of carrier bandwidth.

Example of calculation:
For 2 MHz bandwidth:
e.i.r.p. density per MHz + 10 Log (2 MHz)
40.6 + 3 = 43.6 dBW.

Table 42: Resulting e.i.r.p in the band 5925-6425 MHz

Bandwidth (MHz)	2	1	0.5	0.25	0.025
e.i.r.p (dBW)	43.6	40.6	37.6	34.6	24.6

According Recommendation ITU-R F.758 [23], fixed service parameters for 6425 – 7125 MHz are defined as following:

Minimum bandwidth: 5 MHz (CEPT/ERC/REC 14-02 [5] sets 3.5 MHz bandwidth channels)
Maximum Tx power: 4 dBW
Maximum antenna gain: 47.4 dB
Minimum feeder loss: 0 dB.

From these parameters we can derive the maximum usable e.i.r.p density from a regulatory point of view:

➔ 4dBW + 47.4 – 10 Log (3.5 MHz)
➔ 45.96 dBW/MHz

Implementation of narrow channels in the U6 GHz band should therefore also consider this e.i.r.p. spectral density value.

Table 43 below contains allowable e.i.r.p levels for each type of carrier bandwidth.

Example of calculation:
For 2 MHz bandwidth:
(Tx + Gant) + 10 Log (2 MHz) = 45.96 +3 = 48.96 dBW/MHz
Maximum e.i.r.p for a 2 MHz bandwidth channel: 48.96 dBW

Table 43: Resulting e.i.r.p in the band 6425-7125 MHz

Bandwidth (MHz)	2	1	0.5	0.25	0.025
Max e.i.r.p (dBW)	48.96	45.96	42.96	39.96	29.96

Application

The table below shows some particular scenarios to confirm the feasibility of implementing narrow FS channels in the L6 and U6 GHz bands.

Table 44: Example of scenarios to check the feasibility of implementing narrow FS channels in the L6 and U6 GHz bands

Scenario	a	b	c	d	e	f	
FS Bandwidth (MHz)	2	2	0.5	0.25	0.25	0.25	0.025
Satellite receiving noise temp. (K)	891	700	891	891	700	700	700
Aggregate FS e.i.r.p for ΔTsat/T=6% (dBW/Hz)	-46.82	-47.56	-46.82	-46.82	-47.56	-47.56	-47.56
Satellite antenna gain (dBi)	35	34.7	35	35	34.7	34.7	34.7
Max aggregate FS e.i.r.p in one channel (dBW/Bandwidth)	16.18	15.44	10.18	7.15	6.44	6.44	-3.56
FS Location	48N 2E	48N 2E	48N 2E	48N 2E	48N 2E	48N 2E	48N 2E
FS elevation (°)	2	0	2	2	0	0	0
FS antenna gain (dBi)	46	45	43	45	45	45	40
FS Tx power (dBW)	2(1)	-3	-1	-5	-5	-5	-10
FS e.i.r.p (dBW)	48 (2)	42(2)	42(2)	40(2)	40(2)	40(2)	30(2)
Satellite longitude	7E	66E	7E	7E	66E	66E	66E
Fixed service off axis/Satellite (°)	32	8.45	32	32	8.45	8.45	8.45
Off axis attenuation (dB)	-53	-39	-50.89	-53	-39	-39	-33.43
Number of FS links in one channel	207	28	127	164	5	5.5	1.53
Number of FS links over 15 MHz	1552	210	3810	9840	332	330	918

(1) Typical transmitter highest power (ETSI TR 102 243 [21])
(2) Recommendation ITU-R F.758 [23] reports an e.i.r.p range from 15.8 to 48.8 dBW. One administration (France) reports an average of 32 dBW.

<u>Example of calculation:</u>
<u>*Scenario a*</u> :
FS location : 48N 2E - FS elevation : 2° - Pointing satellite longitude
Satellite longitude : 7E – Elevation off axis with FS : 32°
$e.i.r.p._{FS} = 10 \cdot \log(0.06) - 29.1 - 35 + 10 \cdot log(891) \ = -46.82 \ dB(WHz^{-1})$
$e.i.r.p._{FSchannel} = e.i.r.p._{FS} + 10 \cdot \log(B) = -46.82 + 10 \cdot \log(2000\,000) = 16.18 \ dBW/MHz$

$e.i.r.p._{Device\ channel}$ is the e.i.r.p. density range in dBW/channel of one single FS PP device in the direction of the satellite.
$e.i.r.p._{Device\ channel}$ = 48 dBW – 53 dBi – 2 dB = - 7 dBW/2MHz
(-53 dBi = off axis antenna attenuation at 32° – ref ITU-R F.1245-2 [26])
Number of active devices: $10\log(N) = e.i.r.p._{FSchannel} - e.i.r.p._{Device\ channel}$
Number of active devices: 16.18 dBW + 7 = 23.18 or 207 fixed service devices over 2 MHz.

It must be noted that there is a very low probability that numerous fixed service stations are simultaneously pointing the same low elevation satellite whose footprint spans over Europe, on the same channel.

4.3.4.3 Conclusions

To ensure compatibility between FS with narrow channels and FSS in the 6 GHz band, and in addition of RR Article 21 provisions and e.i.r.p. spectral density values mentioned above, the implementation of narrow channels should also consider the two following conditions:

- Use of the lowest e.i.r.p levels when the fixed service is pointing further East/West positions of GSO;
- Insofar as possible, use of ATPC for FS links.

4.4 COMPATIBILITY STUDIES FOR L6 AND U6 BANDS

4.4.1 Impact of wide bandwidth channels on narrow channels in the 6 GHz band.

4.4.1.1 Scenarios to be considered.

Scenario a).

The following layout is assumed as the consistent scenario:

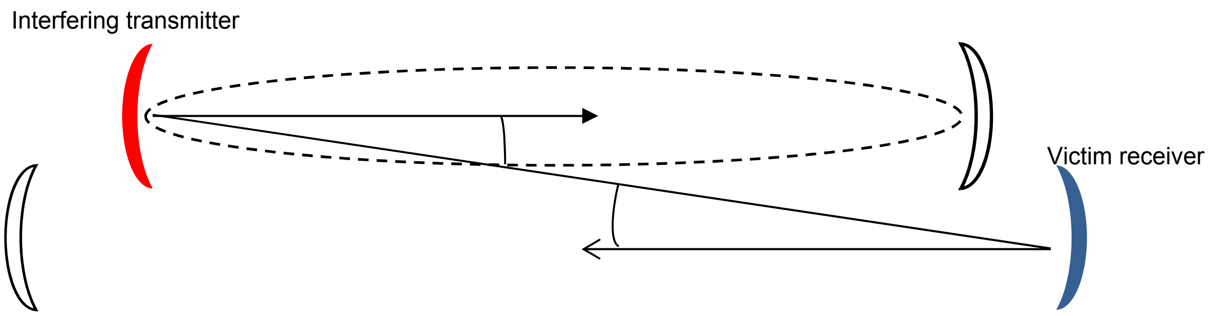


Figure 39: relevant scenario to assess coordination between fixed service links

Recommendation ITU-R F.1095 [39] points out that for calculating the coordination distance, the antenna discrimination of transmitting and receiving antenna must be integrated in calculation.

<u>Scenario b)</u>

The following layout is assumed as the worst case scenario:

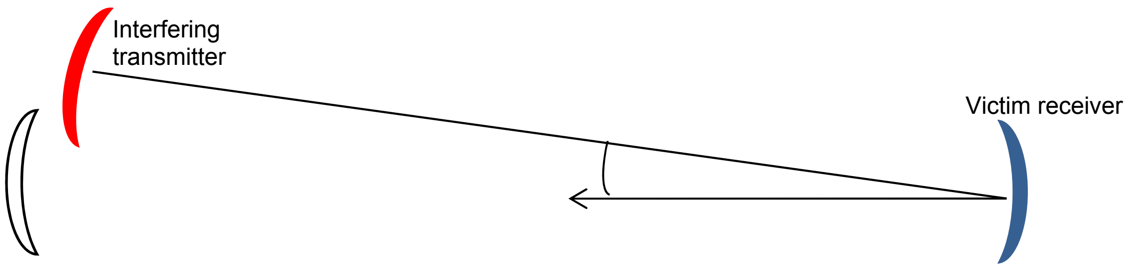


Figure 40: worst case scenario to assess coordination between fixed service links

Interfering transmitter is always pointing at victim receiver.

4.4.1.2 Compatibility studies.

L6 band – 29.65 bandwidth channels.

We will consider the 29.65 MHz bandwidth upper channel of the lower part of the band:
f0 = f8 as defined in Rec 14-01 = 6152.75 MHz

The first 0.5 MHz bandwidth channel is operated at:
5925 MHz + 5.376 MHz+ (8x29.65 MHz) + 2.92 MHz+ 0.25 MHz = 6170.74 MHz

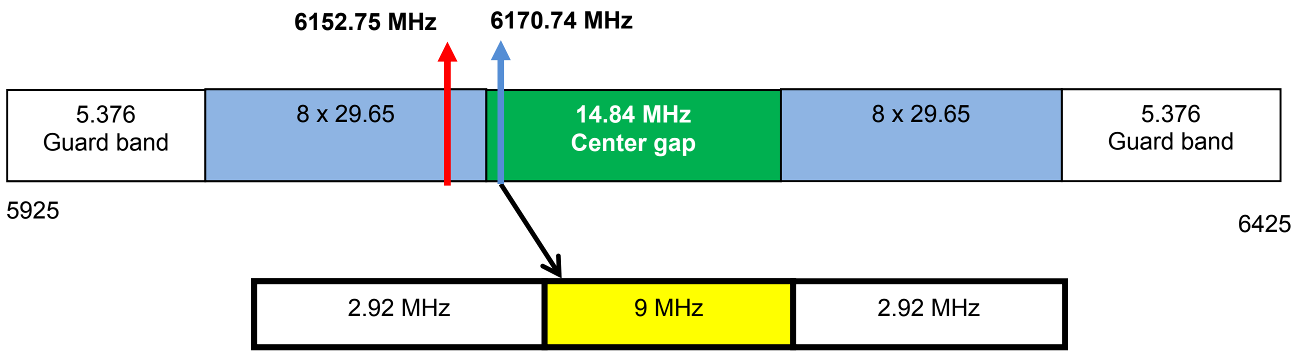


Figure 41: example of channels implementation in L6 band

29.65 MHz spectrum mask:

From ETSI EN 302 217 [18] (table B4), spectrum mask for 28 to 30 MHz channels bandwidth operating between 3 and 11 GHz is defined as following :

Table 45: parameters of spectrum mask for a 29.65 MHz bandwidth channel

	f0	f1	f2	f3
Frequency (MHz)	6152.75	6163.95	6175.15	6180.75
Frequency offset (MHz)	0	11.2	22.4	28
Attenuation (dB)	0	1	-32	-37

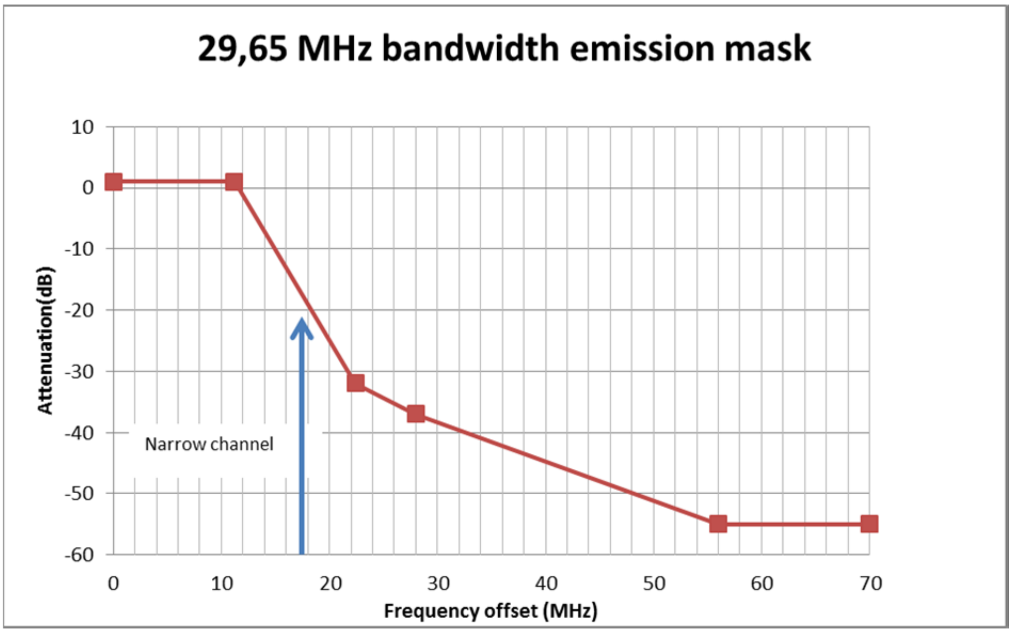


Figure 42: 29.65 MHz bandwidth spectrum emission mask

From spectrum mask, we can derive the attenuation at 6170.74 MHz (f0 + 17.99 MHz) : - 19 dB

29.65 MHz bandwidth channel Tx power: 27 dBm
Tx power spectral density = 27 dBm – 2 -19 – 10 Log (29.65) = -8.72 dBm/MHz

Scenario a):

With: MCL = -8.72 dBm/MHz + $Gant_{vict}$ [f(off axis angle)]+ $Gant_{int}$ [f(off axis angle)] + 115 dBm/MHz (I/N=-6dB)
d = $10^{[MCL-32.44-20\log(f)]/20}$

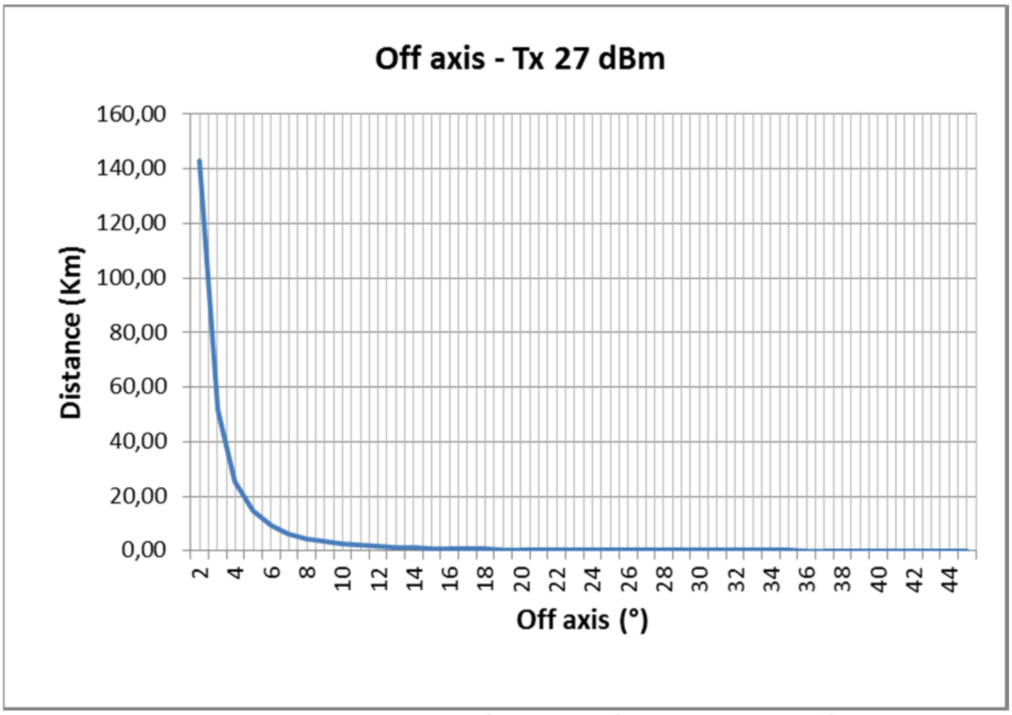


Figure 43: Distance between IT and VR as a function of victim and interfering antenna angle (antenna patterns derived from ITU-R F.1245 [26])

Scenario b)

with: MCL = -8.72 dBm/MHz + $Gant_{int}$ (45 dBi) + $Gant_{vict}$ [f(off axis angle)] + 115 (dBm/MHz) (I/N=-6dB)
d = $10^{[MCL-32.44-20\log(f)]/20}$

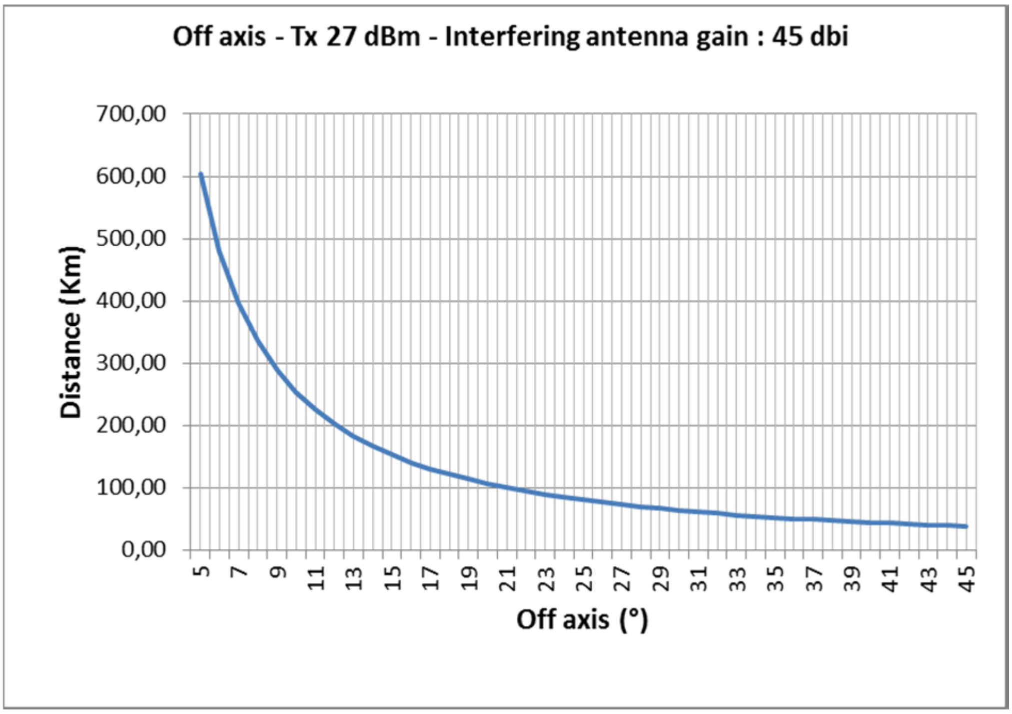


Figure 44: Distance between IT and VR as a function of victim and interfering antenna angle (antenna patterns derived from ITU-R F.1245 [26])

For that worst (and rare) case scenario, a strong and careful coordination is required, as usually, in fixed service engineering.

U6 band – 40 MHz bandwidth channels

We will consider the 40 MHz bandwidth upper channel of the lower part of the band:
f0 = f8 as defined in CEPT/ERC/REC 14-02 [5] = 6740 MHz

The first 0.5 MHz bandwidth channel is operated at:
6425 MHz + 15 MHz + (8x40MHz) + 2.5 MHz+ 0.25 MHz = 6762.75 MHz

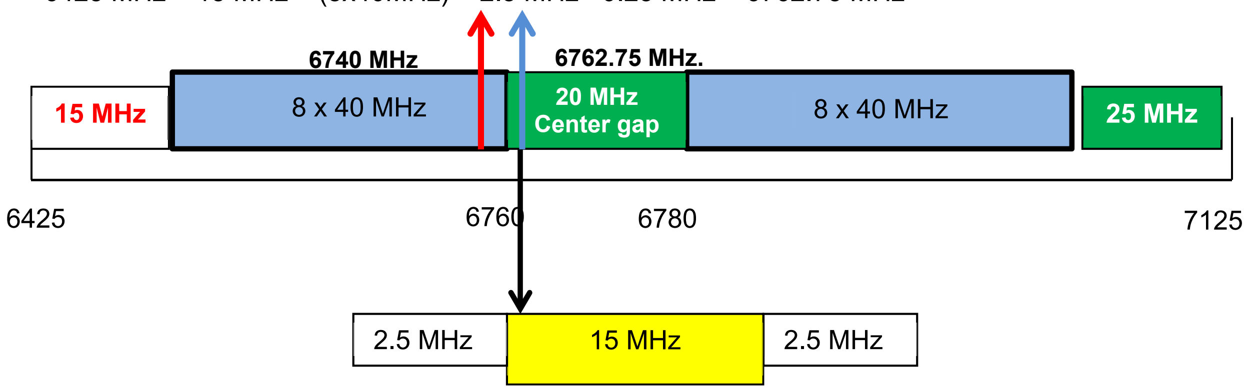


Figure 45: example of channels implementation in U6 band

40 MHz channel spectrum mask:

From ETSI EN 302 217 [18] (table C4), spectrum mask for 40 MHz channels bandwidth operating between 3 and 11 GHz is defined as following:

Table 46: parameters of spectrum mask for a 40 MHz bandwidth channel

	f0	f1	f2	f3	F4
Frequency (MHz)	6740	6757	6759.5	6764	6794
Frequency offset (MHz)	0	+17	+19.5	24	54
Attenuation (dB)	0	+1	-10	-35	-40

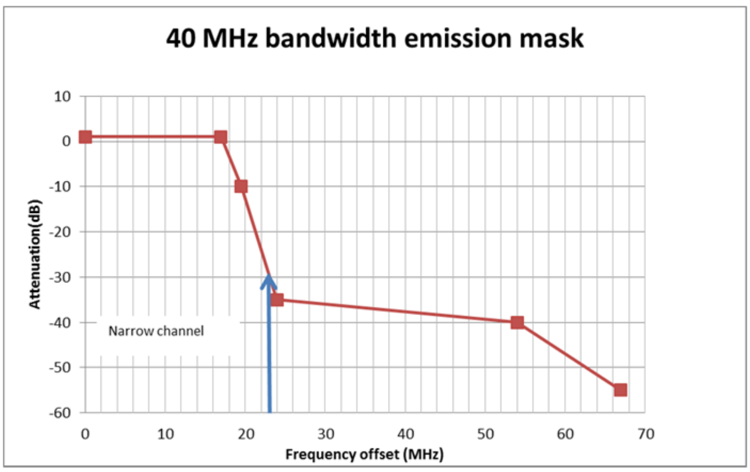


Figure 46: 40 MHz bandwidth spectrum emission mask

From spectrum mask, we can derive the attenuation at 6762.75 MHz (f0 + 22.75 MHz): -28 dB.

40 MHz bandwidth channel Tx power: 27 dBm
Tx power spectral density = 27 dBm – 2 - 28 – 10 Log (40 MHz) = - 19 dBm/MHz

Scenario a)
With: MCL = -19 dBm/MHz + $Gant_{int}$ [f(off axis angle)]+ $Gant_{vict}$ [f(off axis angle)] + 115 (dBm/MHz) (I/N=-6dB)
$d = 10^{[MCL-32.44-20\log(f)]/20}$

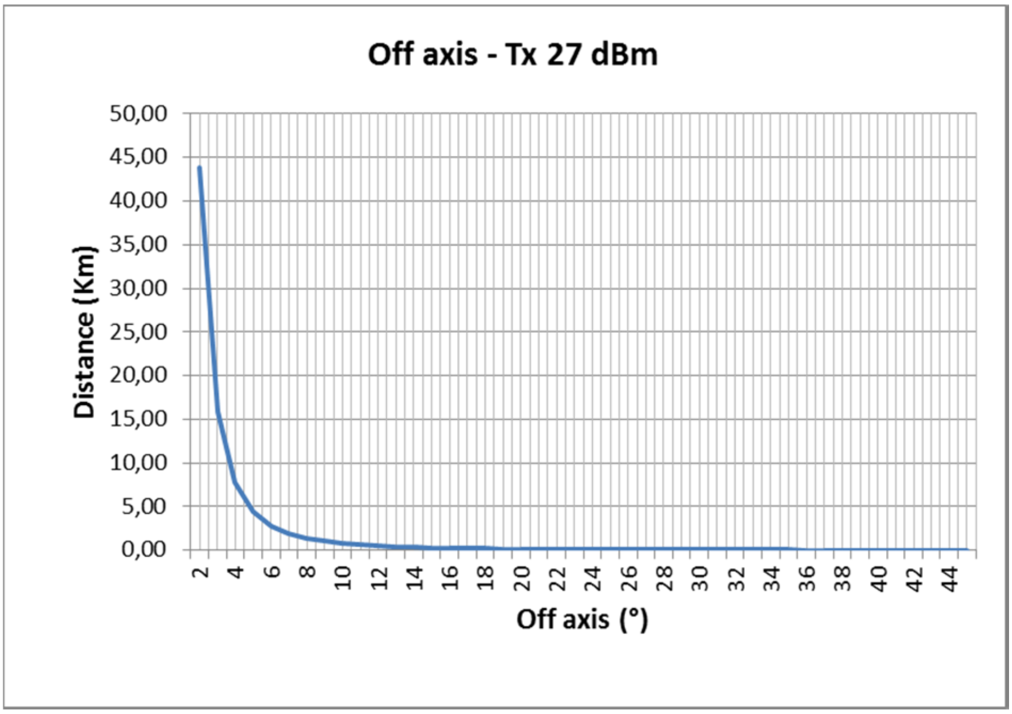


Figure 47: Distance between IT and VR as a function of victim and interfering antenna angle (antenna patterns derived from ITU-R F.1245 [26])

Scenario b)

with: MCL = -19 dBm/MHz + $Gant_{int}$ (45 dBi) + $Gant_{vict}$ [f(off axis angle)] + 115 (dBm/MHz) (I/N=-6dB)
$d = 10^{[MCL-32.44-20\log(f)]/20}$

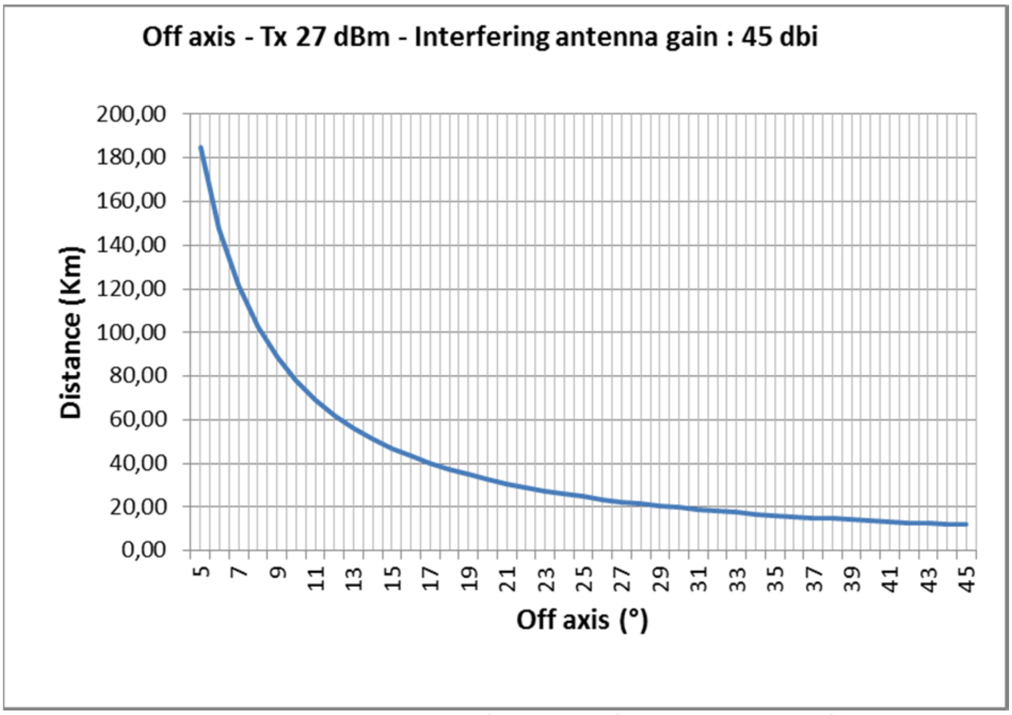


Figure 48: Distance between IT and VR as a function of victim and interfering antenna angle (antenna patterns derived from ITU-R F.1245 [26])

For that worst (and rare) case scenario, a strong and careful coordination is required, as usually, in fixed service engineering.

U6 band – 3.5 MHz bandwidth channels.

We will consider the 3.5 MHz bandwidth upper channel of the lower part of the band:
f0 = f44 as defined in CEPT/ERC/REC 14-02 [5] = 6772.25 MHz

The first 0.5 MHz bandwidth channel is operated at:
6772.25 MHz + 1.75 + 2.5 MHz+ 0.25 MHz = 6776.75 MHz

3.5 MHz channel spectrum mask:
From ETSI EN 302 217 [18] (table B4), spectrum mask for 3.5 MHz channels bandwidth operating between 3 and 11 GHz is defined as following :

Table 47: parameters of spectrum mask for a 3.5 MHz bandwidth channel

	f0	f1	f2	f3	F4
Frequency (MHz)	6772.25	6773.65	6775.05	6775.75	6779.25
Frequency offset (MHz)	0	+ 1.4	+ 2.8	+ 3.5	+ 7
Attenuation (dB)	0	+1	- 32	- 37	- 55

From spectrum mask, we can derive the attenuation at 6776.75 MHz (f0 + 4.5 MHz): >- 37 dB

3.5 MHz bandwidth channel Tx power: 27 dBm
Tx power spectral density = 27 dBm – 2 - 37 – 10 Log (3.5 MHz) = < -17.44 dBm/MHz.

As the same results than those for 40 MHz channels (-19 dBm/MHz) are expected, no calculation have been carried out.

4.4.2 Impact on wide bandwidth channels receiver

Figure 11, referred to as "option 1", presents a possible implementation of such channels with incumbent 40 MHz bandwidth channels.

The studies carried out so far, have highlighted acceptable conditions to achieve compatibility taking in account the impact of narrow channels out of band emissions as interferer.
The present study is a review of compatibility with regard to 40 MHz receiver selectivity.

4.4.2.1 Implementation of channels.

Table C.7 from document ETSI EN 302 217-2-2 [18] defines co-channel and adjacent channel interference sensitivity for 40 MHz bandwidth receiver.

Table 48: Co-channel and adjacent channel interference sensitivity for 40 MHz bandwidth receiver (extract of table C.7 of ETSI EN 302 217-2-2 [18])

Spectral efficiency		Minimum RIC rate (Mbits/s)	C/I for BER≤ 10^{-6} RSL degradation of 1 dB	
Reference index	Class		Co-channel interference	First adjacent channel interference
6	5LB	STM-1 or 137	33	-4

From this table, it can be deducted that for 40 MHz bandwidth receiver, ACS 1= 37dB.

Thus, the spectral occupancy may be depicted as shown below:

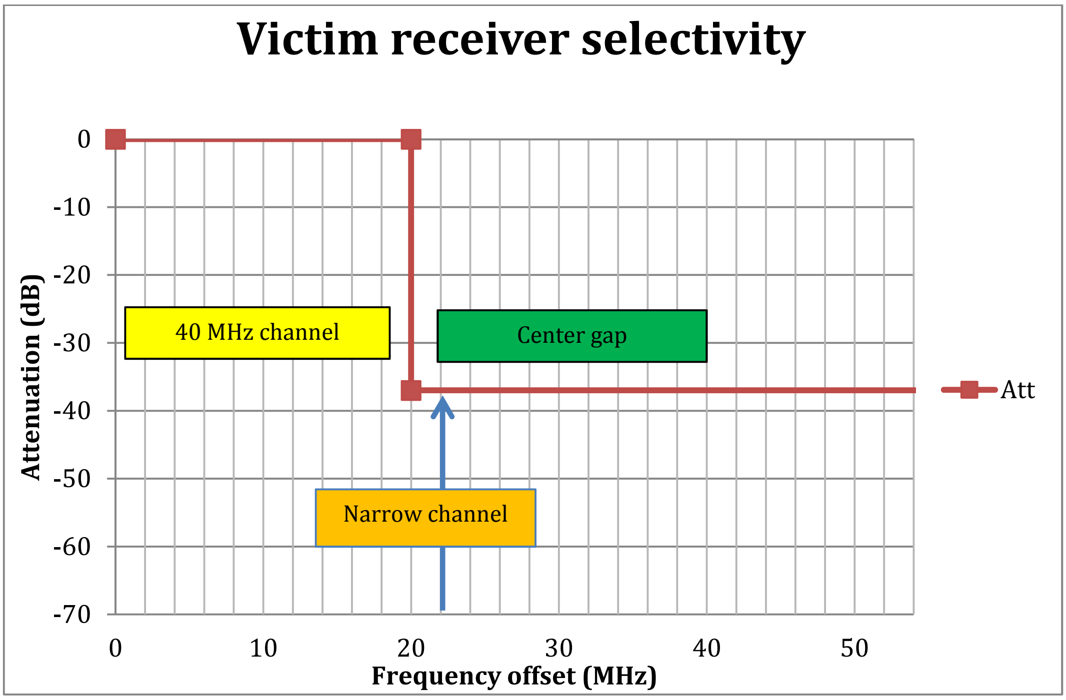


Figure 49: 40 MHz bandwidth channel receiver selectivity

with
f_0 = 6740 MHz
f_0 + 20 = 6760 MHz (start of centre gap)
f_0 + 40 = 6780 MHz (end of centre gap)

3. Compatibility study.

Considering a narrow channel Tx power of -9 dBm/MHz
[27dBm - 2(FS loss) – 10 Log (0.5 MHz) – 37 (receiver selectivity)]

Considering a -25.75 dBm/MHz level for narrow channel out of band emissions on 40 MHz channel (from para 4.3.2)

Total received interfering level: -25.75 dBm/MHz + (– 9 dBm/MHz)(Blocking) = -8.93 dBm/MHz (Addition in linear)

With: MCL = -8.93dBm/MHz + $Gant_{int}$ [f(off axis angle)]+ $Gant_{vict}$ [f(off axis angle)] -2 (FS Loss) + 115 (I/N=-6dB)

$d = 10^{[MCL-32.44-20\log(f)]/20]}$

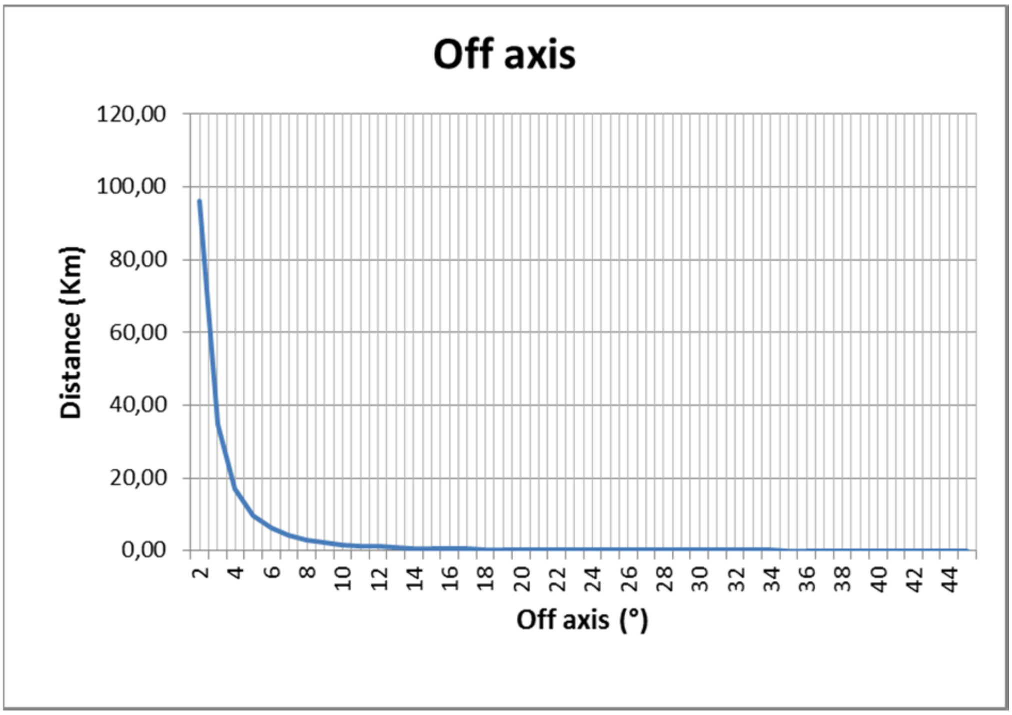


Figure 50: Distance between IT and VR as a function of victim and interfering antenna angle (antenna patterns derived from ITU-R F.1245 [26])

Considering that similar results are expected for the L6 band and 29.65 MHz channels, no studies have been carried out for this band.

4.5 CONCLUSION ON U6 STUDIES

With regard to the results of compatibility and sharing studies herein, introduction of very narrow channels in f the 6 GHz band may be planned in acceptable technical conditions.

This study demonstrates that there is potential feasibility to operate narrow channels in the 6 GHz band. According to the studied options, up to 24 MHz could be used (with regard with 25 MHz currently used in 1375-1400 / 1427-1452 MHz).

For administrations who implement only one channelization in each band (e.g. 29.65 MHz in L6 and 40 MHz in U6), a channelization as described in Figure 15 appears as the most appropriate one, with the advantage of not interfering with the incumbent and future services below 5925 MHz.

5 HOP LENGTH ASSESSMENT

The next figures are zooms from figures of French public consultation on FS (ARCEP, April 2012). On the left part, the 1.5 GHz FS links are given in red. On the right part, the 6 GHz FS links are presented in blue. What can be seen from this figure is that generally, there is no correlation between the directions of the two kinds of links: therefore, the probability that the coexistence case would be the worst (antenna gain of the interferer in front of the antenna gain of the receiver) is very low. It means that, from this point of view, the coexistence between the two kinds of applications could be easily done.

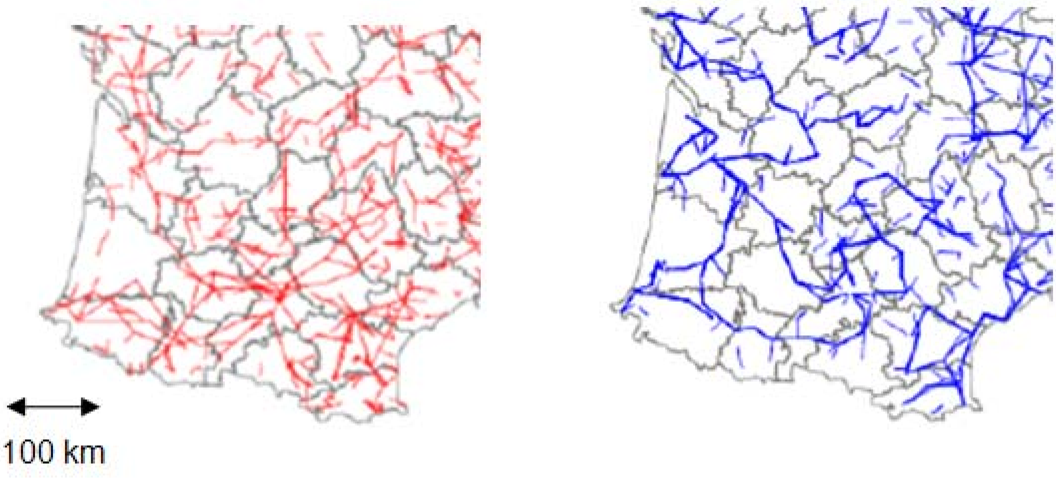


Figure 51: 1.5 GHz FS links in red on the left and 6 GHz FS links in blue on the right. French public consultation on FS (ARCEP, April 2012)

Generally the distances in CEPT countries could be up to 80 km with an average distance of 28 km (ECC Report 173 [1]).

The following parameters are proposed for these links in the 6 GHz band:

- Pout=23 dBm
- Antenna gain=36 dBi (Antenna diameter=1.2 m).

The choice of an antenna having a 1.2 m diameter is done because for low capacity links a bigger antenna would be too expensive. Therefore

- e.i.r.p.=23+36=59 dBm
- RSL=-91 dBm.

With these proposed parameters, we can deduce the maximum path loss between the transmitter and the receiver by a simple budget link:

RSL= e.i.r.p.+receiving antenna gain-Maximum Path Loss

Maximum Path Loss= e.i.r.p.+receiving antenna gain-RSL

Maximum Path Loss=59+36+91

Maximum Path Loss=186 dB

Using a classical propagation model like P.530, the hop length can be deduced for the 6 GHz band and the result is an Hop length=50 km.

Therefore, up to 50 km LoS link in climatic zone of moderate severity (i.e. Po about 1.2) is feasible with these parameters. Therefore, it is believed that the proposed parameters are appropriate parameters for low capacity links in the 6 GHz band.

Figure 52 is based on the ETSI normative EN 302 217-2-2 [18]. It gives the emission mask for a CS of 0.25 MHz. The transmit power is 27 dBm and two modulations are considered (4QAM and 16 QAM). The spurious emissions are also given.

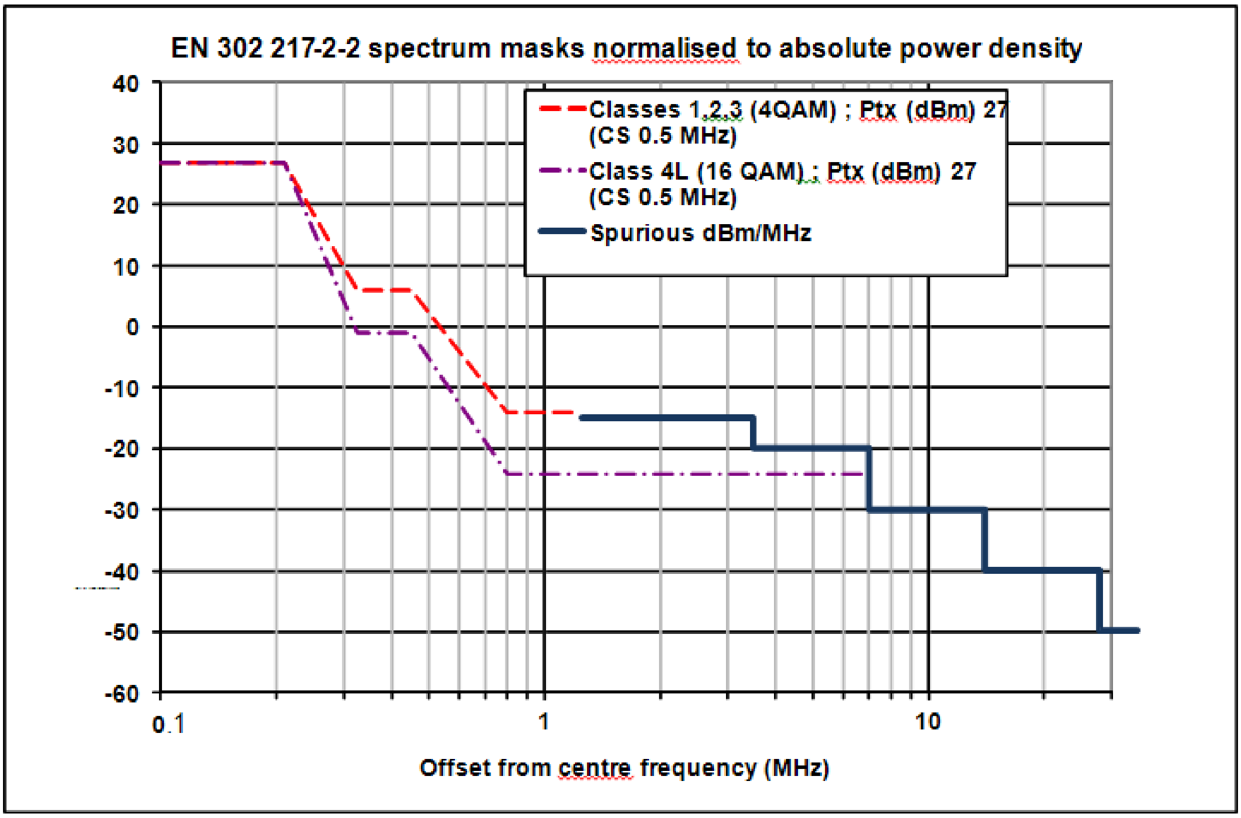


Figure 52: EN 302 217-2 spectrum masks normalised to absolute power density with a transmit power of 27 dBm

Figure 53 is the same as the previous one except for the transmit power which is 23 dBm as the proposed power for the narrow channel spacings in the 6 GHz band. This figure shows that the emission mask can give even lower powers than the spurious emissions. This is particularly interesting with respect to coexistence studies.

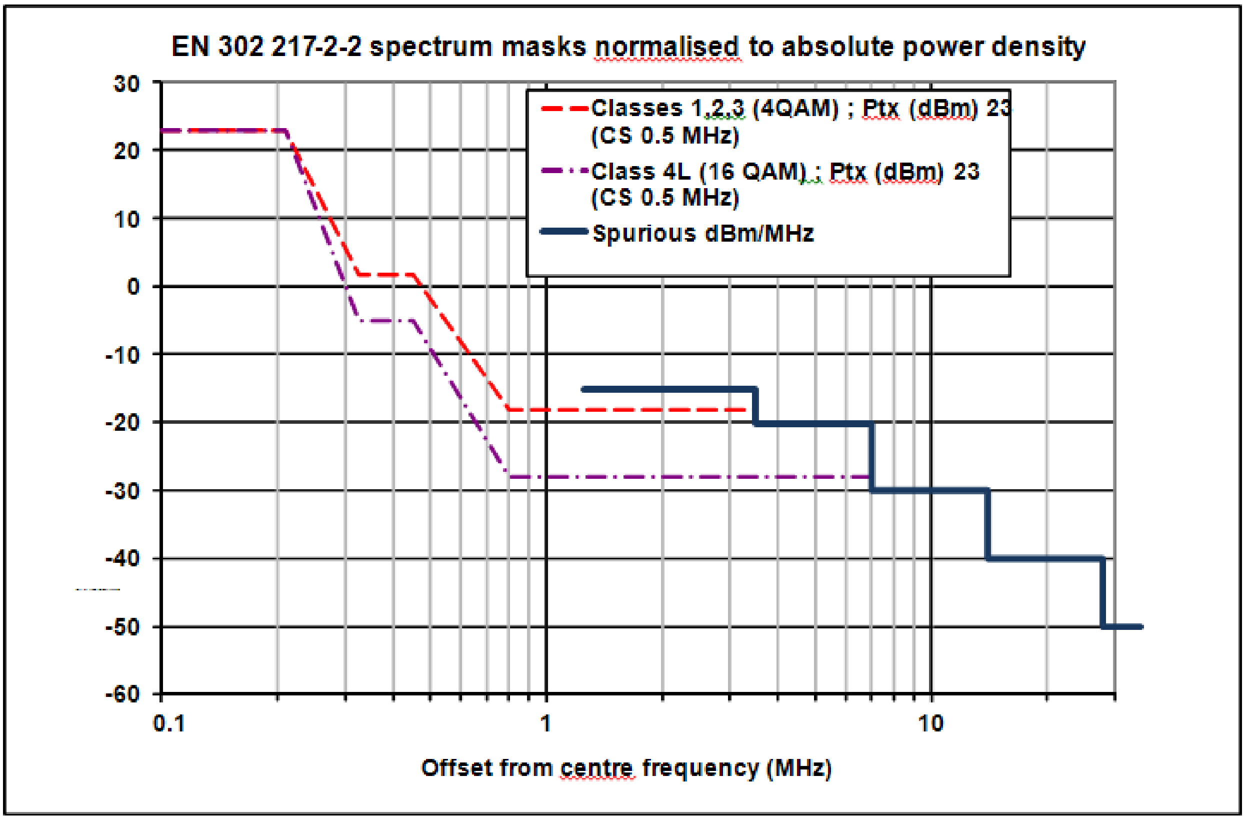


Figure 53: EN 302 217-2 spectrum masks normalised to absolute power density with a transmit power of 23 dBm

Therefore the coexistence between narrow channel spacings and wide channel spacings of the "classical" FWS band plan would be made easier using the proposed parameters of this contribution for the narrow channel spacings (especially considering interferences from narrow channel spacings to wide channel spacings). This is because by decreasing the output powers the out of band emission decrease even below spurious emissions according to the current spurious regulation. Furthermore, the diameter of the chosen antenna induces an antenna gain of 36 dBi which also decreases the interferences compared to a 45 dBi antenna gain.

The calculations below gives an example of the results of coupling loss calculations between interfering narrow channel spacings and wide channel spacing of the regular band plan using the parameters (output power, antenna gain) proposed just above in this part 6. The guard band considered between narrow CS and wide CS is 5 MHz just as for the U6 proposed band plan. The results of these calculations show that for an azimuth angle above or equal to 48 degrees between interferer and victim, the coordination distance is of the order of 1 km, which means a lower coordination distance than for the parameters previously used in part 5 of this document.

All calculations were done for 500 kHz narrow channel spacing interferer with output power = 23 dBm, antenna gain = 36 dBi and feeder loss = 2dB.

The calculations for narrow band emission with 16QAM (class 4) are presented in Table 49 where the OOB emission level was -28 dBm/MHz for emission with Pout = 23 dBm.

Table 49: Summary of the results OOB MCL for FS PP, Guard band = 5MHz

Parameters	Value						
Channel spacing (MHz)	30				40		
Modulation scheme	4QAM	64QAM	128OAM (STM-1)	512QAM 6HA (ACAP)	64QAM	128OAM	512QAM 6HA (ACAP)
SEL (dBm/MHz)	-28	-28	-28	-28	-28	-28	-28
Wide Antenna Gain (dBi)	45	45	45	45	45	45	45
Sensitivity (dBm)	-81	-68	-67	-58.5	-69	-63.5	-57.5
Co channel interference (dB):	23	34	37	43	33	37	43
I/N (dB)	-6	-6	-6	-6	-6	-6	-6
C/N (dB)	-17	-28	-31	-37	-27	-31	-37
N (dBm)	-97	-95	-97	-94.5	-95	-93.5	-93.5
MCL (dB)	166.8	164.8	166.8	164.3	166.0	164.5	164.5

Table 50: Summary of the results for FS 30MHz victim wide channel spacings worst case: 4QAM (based on ITU-R P.452-14 [34], 0.01% of time, 6770 MHz)

	ITU-R F.699 [25]	ITU-R F.1245 [26]
Minimum distance required when antennas are pointing each other	274.5 km	274.5 km
Minimum distance required when antenna azimuth is 0.5°	249.4 km	249.4 km
Minimum distance required when antenna azimuth is 10°	32.5 km	18.7 km
Minimum distance between IT and VR/antenna azimuth	1.91 km / ≥48°	1.17 km / ≥48°

Table 51: Summary of the results for FS 40MHz victim wide channel spacingsworst case: 64 QAM (based on ITU-R P.452-14 [34], 0.01% of time, 6770 MHz)

	ITU-R F.699 [25]	ITU-R F.1245 [26]
Minimum distance required when antennas are pointing each other	268.5 km	268.5 km
Minimum distance required when antenna azimuth is 0.5°	243.7 km	243.7 km
Minimum distance required when antenna azimuth is 10°	29.3 km	16.5 km
Minimum distance between IT and VR/antenna azimuth	1.73 km / ≥48°	1.07 km / ≥48°

6 INFORMATION ON EQUIPMENT

During this study, no information have been presented on the feasibility of FS equipment to facilitate this narrow channels on the 6 and 10 GHz bands as well as the availability of the equipment currently on the market.

However, one administration who currently implement a large number of links operated in the 1375/1400 – 1427/1452 MHz band, indicated a steady increase of the need for implementing narrow channels.

7 CONCLUSIONS

The aim of this report is to assess the feasibility of introducing narrow channel spacings for FS (25 kHz to 2 MHz), similar to those used in 1375-1400 / 1427-1452 MHz in some existing plans, in guard bands and center gaps of FS channel arrangement between 3 GHz and 15 GHz in terms of the compatibility and sharing considerations with others services as well as within the FS. These narrow channel FS links are used for fixed wireless services for a variety of applications including broadcasting, fixed networks, Oil & Gas, public safety and utilities, often for long hop narrowband communications. The largest users are public safety and utilities sectors. In developing this report it should be noted that the feasibility of using the bands within the range 3 to 15 GHz, for the applications that are currently used in the band 1375-1400 / 1427-1452 MHz (in terms of hop length and link design), was not part of this work.

During this study, no information have been presented on the feasibility of FS equipment to facilitate these narrow channels on the 6 and 10 GHz bands as well as the availability of the equipment currently on the market supporting these channels. However, one administration who currently implement a large number of links operated in the 1375/1400 – 1427/1452 MHz band, indicated a steady increase of the need for implementing narrow channels.

The feasibility of narrow channels from compatibility/sharing point of view with others services and within FS for the following bands was carried out:

- Compatibility studies carried out for the 10 GHz band have shown that implementation of narrow channels in guard band and/or center gap would adversely impact the incumbent services, especially those below 10.5 GHz. However, from 10.5 to 10.6 GHz and with additional channels arrangements to those currently presented in CEPT/ERC/REC 12-05, the 10 GHz band may be considered.
- The compatibility studies carried out for the 6 GHz band indicate that feasibility of small channel is possible in guard bands and/or center gap. Although the 6 GHz band is already allocated to fixed services as a primary allocation, several scenarios have been considered to take into account the impact of the increase of spectral power density with respect to other services like FSS. It must be noted that worst cases scenarios have pointed out the need of coordination between new FS using these small channels and other incumbent FS uses, as usually done in fixed service planning.

In summary, this report presents different options for those administrations wishing to implement narrow channels which could be considered at national level taking into account the above considerations.

ANNEX 1: POSSIBLE CHANNEL ARRANGEMENT IN THE 10 GHz BAND

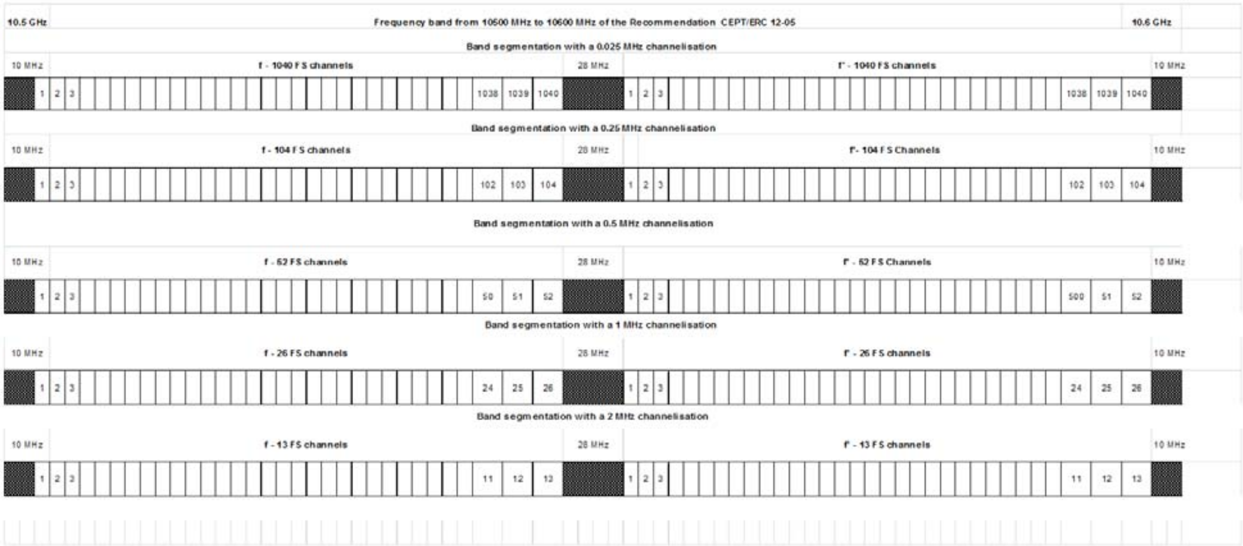


Figure 54: Possible channel arrangements with 0.025 MHz, 0.25 MHz, 0.5 MHz, 1 MHz and slots in 10.5-1.6 GHz

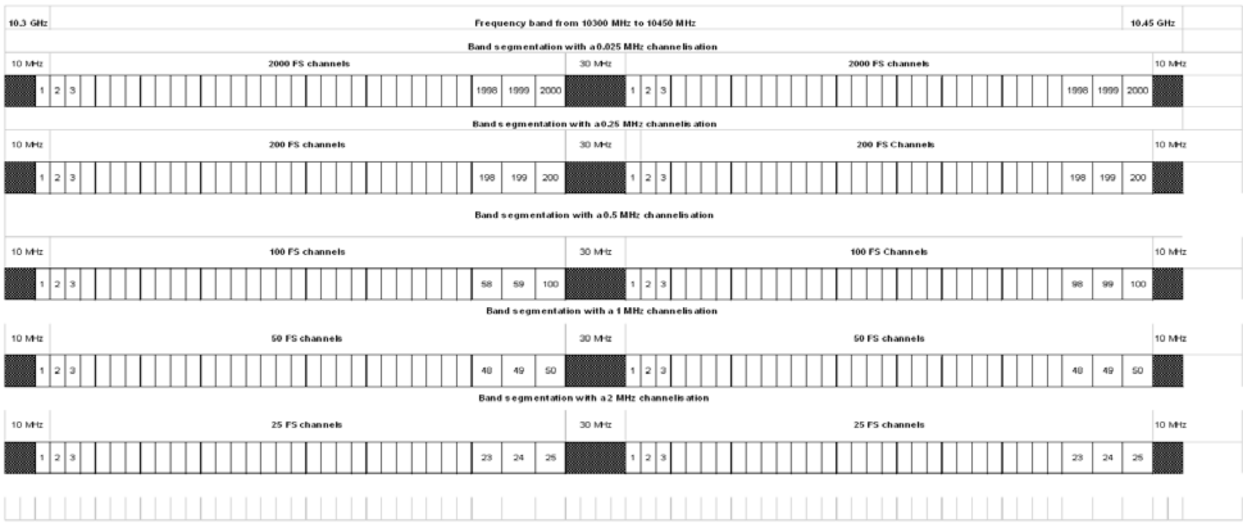


Figure 55: Channel arrangement proposal for 150 MHz centre gap of 10-10.68 GHz band (10300-10450 MHz centre gap)

ANNEX 2: SYSTEM PARAMETERS FOR POINT-TO-POINT FS SYSTEMS IN ALLOCATED BANDS BETWEEN 3 AND 10 GHz

Table 52: FS P-P parameters from Recommendation ITU-R F.758-5 [23]

Parameters	Value	
Frequency range (GHz)	10.5-10.68	10.5-10.68
Reference ITU-R Recommendation	F.747 [31]	F.747 [31]
Modulation	QPSK(3)	128-TCM
Channel spacing and receiver noise bandwidth (MHz)	1.25, 2.5, 3.5, 7	1.25, 2.5, 3.5, 7
Maximum Tx output power range (dBW)	−2	−3
Maximum Tx output power density range (dBW/MHz)(1)	−10	−7.0
Minimum feeder/multiplexer loss range (dB)	0	0
Maximum antenna gain range (dBi)	49	51
Maximum e.i.r.p. range (dBW)	47	48
Maximum e.i.r.p. density range (dBW/MHz)(1)	39	44
Receiver noise figure (dB)	3	4
Receiver noise power density typical (=NRX) (dBW/MHz)	−141	−140
Normalized Rx input level for 1 × 10–6 BER (dBW/MHz)	−127.5	−116.4
Nominal long-term interference power density (dBW/MHz)(2)	−141 + I/N	−140 + I/N

ANNEX 3: CURRENT STATE OF THE ART IN CEPT COUNTRIES FOR THE 10 GHz BAND

A3.1 CURRENT SITUATION IN GERMANY

10 GHz general situation

Currently, in Germany there are no public fixed links in the 10 GHz Band. Since this frequency band is used for military applications in Germany, only limited information can be provided.

First - sub band 10.00 – 10.40 GHz

In this sub band there are no civil applications / services because this band is exclusively designated for the military purpose. In the band, some radar-systems are operated in Germany which is covered by the Recommendation ITU-R M.1796-1 [29] (the recommendation is currently in revision in Working Group 5B). These systems are A4, G4, S2 and G14 systems.

Second - sub band 10.40 – 10.68 GHz

In Germany, the sub band 10.40 - 10.68 GHz is allocated to the following radio services:

Table 53: 10.4 - 10.68 GHz allocation

Frequency	Application
10400 MHz - 10450 MHz	Amateur
10400 MHz - 10450 MHz	FIXED
10400 MHz - 10450 MHz	MOBILE
10450 MHz - 10.5 GHz	Amateur
10450 MHz - 10.5 GHz	Amateur-Satellite
10450 MHz - 10.5 GHz	FIXED
10450 MHz - 10.5 GHz	MOBILE
10.5 GHz - 10.6 GHz	FIXED
10.6 GHz - 10.68 GHz	FIXED
10.6 GHz - 10.68 GHz	Earth Exploration-Satellite
10.6 GHz - 10.68 GHz	Radio Astronomy

The fixed and the mobile service are designated to electronic news gathering (temporary short P-P link video-audio links / ITU definition news gathering links).

Only occasional temporary point-to-point links should be allowed in the frequency band 10.60 - 10.68 GHz. Studies concluded that even limited deployment of cordless cameras and portable video links in the band 10.6 - 10.68 GHz could result in interference to the EESS (passive) (see ECC Report 017 [10] and CEPT/ERC/REC 25-10 [6]).

A3.2 CURRENT SITUATION IN THE CZECH REPUBLIC

10.301 - 10.42 GHz: fixed wireless point-to-point links (low/medium/high capacity)

10.42 - 10.476 GHz: SAP/SAB applications

10.476 - 10.588 GHz: fixed wireless point-to-point links (low/medium/high capacity)

10.301 - 10.42 GHz and 10.476 - 10.588 GHz

- Reference Recommendation ITU-R: No relevant ITU-R Rec;
- Mostly used channel bandwidths: 3.5 / 7.0 / 14.0 / 28.0 MHz;
- Most common used antennas: RPE class 2 (diameter 0.65 m / gain 34 dBi);
- No strict duplex is established, i.e. both TDD or FDD systems are possible, however there is a majority of FDD systems;
- Frequency coordination and individual authorization are not applied. Any kind of light licensing is not applied yet.

Channel arrangement is as follows:

Table 54: Channel arrangement

Center frequencies [GHz]	Maximum occupied bandwidth [MHz]
10.308	14
10.322	28
10.336	14
10.350	28
10.364	14
10.378	28
10.392	14
10.406	28
10.490	28
10.504	14
10.518	28
10.532	14
10.546	28
10.560	14
10.574	28

Additional channels whose centre frequencies are derived from frequencies listed in the Table 1 can be used for transmission of signal which does not require fully occupied bandwidth. Centre frequencies are as follows:

f = fn ± 7 MHz for maximum occupied bandwidth 14 MHz,

or

f = fn ± 3.5 MHz for maximum occupied bandwidth 7 MHz

where:

f is rated centre frequency of additional channels [MHz] and fn is rated centre frequency of channel [MHz] listed in Table 1, whereas the channel with rated centre frequency 10.301 MHz shall not be used;

10.42 - 10.476 GHz

Temporary point to point video links;

A3.3 CURRENT SITUATION IN THE GREECE

Currently, in Greece there are deployed 113 fixed links in the 10 GHz Band (10.00-10.68 GHz) with the following characteristics.

Table 55: Fixed links characteristics in Greece

Frequency band (MHz)	Links (total)	Links vs bandwidth		Links vs Modulation states		Links vs Duplex		Links vs Technlogy	
		1-25 MHz	25-60 MHz	2,4,8	16,32,64	Uni-directional	Bi-directional (Symmetric)	Analog	Digital
10000-10680	113	28	85	23	5	112	1	85	28

First - sub band 10.00 - 10.40 GHz

In Greece, the sub band 10.00 - 10.40 GHz is allocated to the following radio services:

Table 56: 10.4 - 10.68 GHz allocation

Frequency	Application
10000 MHz - 10150 MHz	FIXED
10000 MHz - 10150 MHz	MOBILE
10000 MHz - 10150 MHz	RADIOLOCATION
10000 MHz - 10150 MHz	Amateur
10150 MHz - 10300 MHz	FIXED
10150 MHz - 10300 MHz	MOBILE
10150 MHz - 10300 MHz	RADIOLOCATION
10150 MHz - 10300 MHz	Amateur
10300 MHz - 10400 MHz	FIXED
10300 MHz - 10400 MHz	MOBILE
10300 MHz - 10400 MHz	RADIOLOCATION
10300 MHz - 10400 MHz	Amateur

Second - sub band 10.40 – 10.68 GHz

In Greece, the sub band 10.40 - 10.68 GHz is allocated to the following radio services:

Table 57: 10.4 - 10.68 GHz allocation

Frequency	Application
10400 MHz - 10450 MHz	MOBILE
10450 MHz - 10500 MHz	FIXED
10450 MHz - 10500 MHz	RADIOLOCATION
10450 MHz - 10500 MHz	Amateur
10450 MHz - 10500 MHz	Amateur-Satellite
10500 MHz - 10550 MHz	FIXED

Frequency	Application
10500 MHz - 10550 MHz	MOBILE
10500 MHz - 10550 MHz	Radiolocation
10550 MHz - 10600 MHz	FIXED
10550 MHz - 10600 MHz	MOBILE except aeronautical mobile
10550 MHz - 10600 MHz	Radiolocation
10600 MHz - 10680 MHz	EARTH EXPLORATION-SATELLITE (passive)
10600 MHz - 10680 MHz	FIXED
10600 MHz - 10680 MHz	MOBILE except aeronautical mobile
10600 MHz - 10680 MHz	RADIO ASTRONOMY
10600 MHz - 10680 MHz	SPACE RESEARCH (passive)
10600 MHz - 10680 MHz	Radiolocation

A3.4 CURRENT SITUATION IN ITALY

The frequency band 10 - 10.68 GHz is used in Italy for fixed links of the broadcasting service, with channel bandwidth of 3.5 MHz, 7 MHz 14 and 28 MHz.

The central band from 10.3 to 10.5 GHz can be used for bidirectional and/or mono directional fixed links following the extension of ECC channel plan described in Recommendation ITU-R F.747-1 [31] Annex 4. Used channel bandwidths are: 3.5, 7, 14 and 28 MHz. Figure 56 better describes the situation.

10.00 - 10.68 GHz: SAP/SAB applications in the whole range in accordance with CEPT/ERC/REC 12-05 Recommends 4.

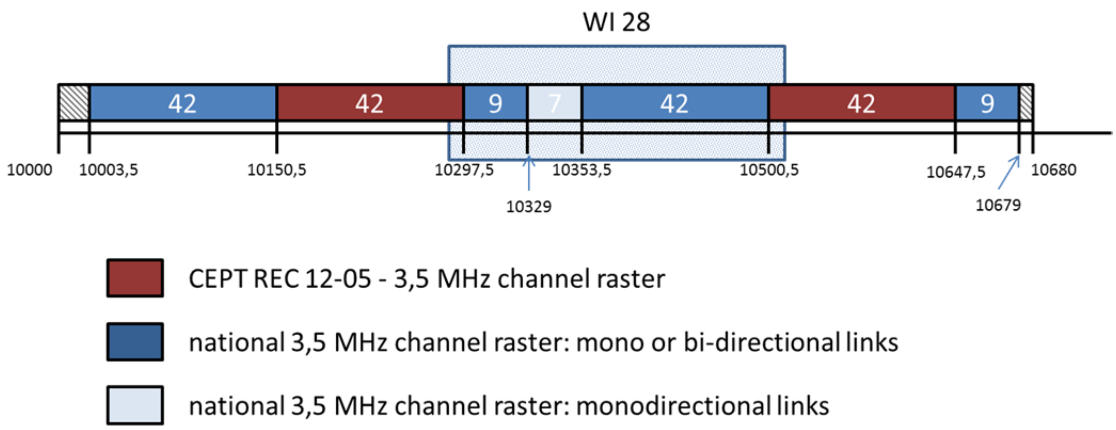


Figure 56: Channel arrangement in Italy

A3.5 CURRENT SITUATION IN FRANCE

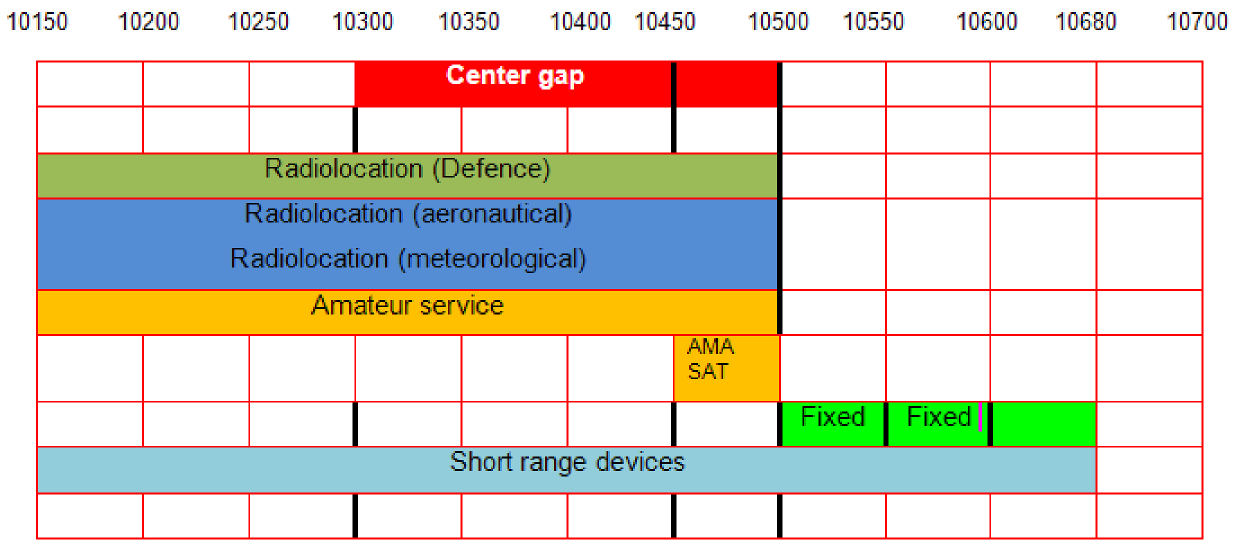


Figure 57: Channel arrangement in France

A3.6 CURRENT SITUATION IN SWITZERLAND

The current situation in Switzerland for P to P links is as follows and illustrated in Figure 58:

- 10.150 - 10.650 GHz : 3.5; 7; 14 MHz / ACCP / CCDP (CEPT/ERC/REC 12-05 [3]) Duplex = 350 MHz
- 3.5 MHz channelling may be used in particularly justified cases only. Number of links per channel spacing : 3.5MHz = 4; 7 MHz = 19; 14 MHz = 34; 28MHz = 0
- Old links: 10322.0 – 10500.5 MHz with Duplex = 65 MHz. Number of links per channel spacing : 1.25MHz = 5; 5MHz = 3

As a general comment, the ACM up to 2048-QAM could be possible in the future. The corresponding C/I should be considered in the study. Very little interest in Switzerland for small channel spacing: 0.025 .. 3.5 MHz.

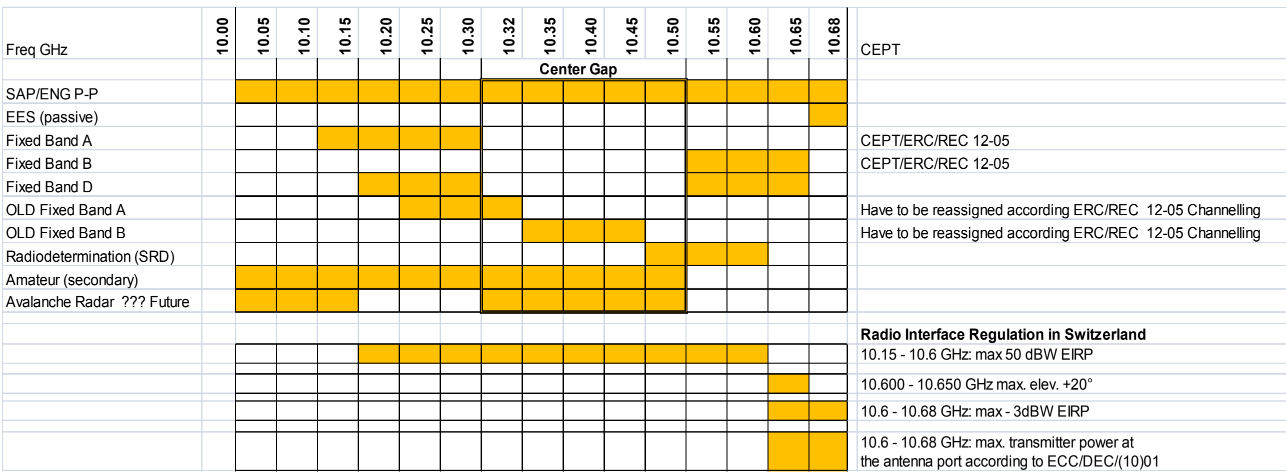


Figure 58: Channel arrangement in Switzerland

ANNEX 4: LIST OF REFERENCE

[1] ECC Decision (06)04: ECC Decision of 24 March 2006 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz.
[2] ECC Decision (11)02: ECC Decision of 11 March 2011 on industrial Level Probing Radars (LPR) operating in frequency bands 6 - 8.5 GHz, 24.05 - 26.5 GHz, 57 - 64 GHz and 75 - 85 GHz.
[3] CEPT ERC Recommendation 12-05: Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10.0 - 10.68 GHz.
[4] ERC Recommendation T/R 13-01: Preferred channel arrangements for fixed service systems operating in the frequency range 1-2.3 GHz.
[5] CEPT ERC Recommendation 14-02 E: Radio-frequency channel arrangements for high, medium and low capacity digital Fixed Service systems operating in the band 6425 - 7125 MHz.
[6] CEPT ERC Recommendation 25-10: Frequency ranges for the use of temporary terrestrial audio and video SAP/SAB links (incl. ENG/OB).
[7] ECC Report 173: Fixed Service in Europe, current use and future trends post 2011.
[8] ECC Report 002: SAP/SAB (Incl. ENG/OB) spectrum use and future requirements.
[9] ECC Report 100: Compatibility studies in the band 3400- 3800 MHz between Broadband Wireless Access (BWA) systems and other services.
[10] ECC Report 017: Sharing between EESS (Passive) and video SAP/SAB links in the band 10.6-10.68 GHz
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[25] Recommendation ITU-R F.699: Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz.
[26] Recommendation ITU-R F.1245: Mathematical model of average and related radiation patterns for line-of-sight point-to-point fixed wireless system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz.
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[30] Recommendation ITU-R SM.329: Unwanted emissions in the spurious domain.
[31] Recommendation ITU-R F.747: Radio-frequency channel arrangements for fixed wireless system operating in the 10.0-10.68 GHz band
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