CEPT ECC
Electronic Communications Committee

ECC Report 365

Fixed Links in CEPT;
Technical characteristics and statistical review

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0 EXECUTIVE SUMMARY

Due to the increasing demand for spectrum for various services and applications, frequency bands traditionally used by the Fixed Service come to the focus for potential sharing. In order to be able to carry out accurate sharing and compatibility studies, current and representative parameters of the FS are required. With the intention to gather precise and representative parameters to be used in these studies, CEPT launched a questionnaire to CEPT administrations.

The questionnaire contained the following parts:

- Request for data on FS system parameters similar to the parameters available in Recommendation ITU-R F.758 [1];
- Request for statistical FS data similar to Recommendation ITU-R F.2086 [2];
- Request for “typical FS links” based on min/max and mode Net Fade Margin.

Once several answers were received, technical discussions took place on how to appropriately proceed for obtaining parameters at CEPT level. It was noted that due to the unexpected differences in the understanding of the “Net Fade Margin” and also the limited availability of this parameter in the database of some administrations, the data gathered from questionnaire on “typical links” was impossible to compare or to combine into a set of representative links for CEPT. However, the raw data provides information about current values for the (net) fade margin in certain frequency ranges.

This Report mainly focuses on the following aspects:

- Summarising the basic background of the various parameters, especially with respect to the different fade margins;
- Providing a weighted summary of the data on system parameters from CEPT administrations;
- Describing how the statistical parameters and the system parameters were obtained;
- Explaining why the typical links could not be generated at CEPT level;
- Comparing the produced data with the appropriate Recommendation ITU-R F.2086 [2] and Recommendation ITU-R F.758 [1].

Care must be taken when considering the parameters produced in this report, noting that:

- the derived parameters are based solely on the data provided by the administrations who answered the questionnaire. It is noted that for certain frequency bands, the number of FS links represented may be relatively small;
- the raw sets data that were provided by the CEPT administrations that responded to the questionnaire date back to 2020/2021 and may be outdated in some cases;
- the analysis done to generate the statistical and system parameters was performed through a univariate analysis, which is likely to be less accurate than a multivariate analysis but easier to perform; Consequently, the consistency between the parameters that are linked (ex: *e.i.r.p.* is linked with Tx output power density and antenna gain) was not checked. Therefore, those statistical and representative data should not be directly used for performing sharing and compatibility studies.

When undertaking sharing and compatibility studies, the data provided in this report might be used as an addition to the most recent versions available of the appropriate ITU-R Recommendations. The responsible ECC groups and CEPT administrations remain encouraged to provide characteristics for sharing and compatibility studies as up to date as possible.

TABLE OF CONTENTS

0 Executive summary 2

1 Introduction 5

2 Questionnaire FOR CEPT ADMINISTRATIONS 6
2.1 Statistical data 7
2.1.1 Expected data in the questionnaire 7
2.1.2 Antenna Heights, link length and elevation angles 8
2.1.3 Modulation Format 8
2.1.4 Net Fade Margin 9
2.2 System parameters 10
2.2.1 Expected data in the questionnaire 10
2.2.2 Processing of the different types of characteristics 11
2.2.3 Necessity of a weighting matrix for statistics 11
2.2.4 Synthesis of links considered 15
2.3 Typical links 16
2.3.1 Expected Data in the questionnaire 16
2.3.2 On the typical links provided 17

3 Comparison of the produced statistic with existing ITU-R Recommendation 18
3.1 Comparison of statistical data with recommendation ITU-R F.2086 [2] 18
3.2 Comparison of system parameters with recommendation ITU-R F.758 24

4 Conclusion 27

ANNEX 1: Summary of Data for system parameter 28

ANNEX 2: LIst of References 51

Abbreviation	Explanation
CEPT	European Conference of Postal and Telecommunications Administrations
ECC	Electronic Communications Committee
ITU	International Telecommunication Union
RSL	Receiver Signal level
FFM	Flat Fade Margin
DFM	Dispersive Fade Margin
NFM	Net Fade Margin
ATPC	Adaptive Transmit Power Control
APO	Availability Performance Objective
EPO	Error Performance Objective
PtP	Point-to-Point
Pmp	Point-to-Multipoint

1 INTRODUCTION

This Report is based on the collection of technical parameters from CEPT countries on their registered fixed links, the compilation of those parameters and the production of a set of representative technical Fixed Service parameters, for each frequency band allocated to the Fixed Service.

The produced statistics are based on a snapshot of the deployed links at the time the questionnaire was made. It was understood that for sharing and compatibility studies it is necessary to use the most up to date available values, and that administrations should always have the possibility to provide the characteristics of their actual systems.

The parameters were separated into different categories:

- Statistical parameters, focusing on the Net Fade Margin (NFM), the modulation scheme, Antenna height, Elevation Angle and link length. The Net Fade Margins were provided by each administration as NFM min (representing less than 5% of the values), NFM max (representing more than 95% of the values), the average and the "mode" values. The "mode" value was understood to be the most representative value;
- System parameters, providing data similar to the ones indicated in Recommendation ITU-R F.758 [1] (Modulation Format, Channel Spacing and receiver Noise, 3 dB Bandwidth, Tx Output power, maximum Tx output power density, *e.i.r.p.*, *e.i.r.p.* density range, feeder/ multiplexer loss, antenna gain, receiver noise figure, receiver noise power density typical, normalised Rx input level for BER of 1e-6, Nominal long-term interference power density, ATPC range);
- Typical links, with the objective to have the RF characteristics as given in the system parameters for three typical links among those falling in the category of NFN_{min}, NFM_{max} and NFM mode as described in statistical parameters.

One of the objectives of the data collection was to provide parameters that can be required for sharing and compatibility studies but which are not part of Recommendation ITU-R F.758 [1]. The link lengths or the elevation of the fixed service stations may be required depending on the analysed scenario. Another example is the NFM that may be required depending on the protection criterion considered in the study.

Another objective was to address a difficulty with Recommendation ITU-R F.758 and the wide ranges for some parameters. When it comes to sharing and compatibility studies, it is necessary to ensure that coherent values for the various parameters are selected in order to perform the studies with stations that would be representative of the stations actually deployed.

2 QUESTIONNAIRE FOR CEPT ADMINISTRATIONS

The questionnaire was initiated and finalised in 2021. The categories to fill by the administrations were the following:

- Point-to-Point systems:
  - Statistical parameters for PtP;
  - System parameters for PtP FS systems;
  - Representative “typical links”.
- Point-to-Multipoint systems:
  - Statistical parameters for PtP;
  - System parameters for PtP FS systems;
  - Representative “typical links”.
- The questionnaire was open to any band for which an allocation in Article 5 of the Radio Regulations to the Fixed Service exists.

14 administrations replied to this questionnaire.

The following table summarises that information:

Table 1: Number of links per frequency band for CEPT administrations – based on first responses to the questionnaire of 2021

		AUT	CZE	FIN	FRA	GER	HNG	HOL	HRV	IT	SRB	SUI	SVK	SVN	SWE
PtP statistical	Unit	3606	41162	553	102659	127385	32430	2386	5046	48815	6467	4008	10332	13	24942
60-70	MHz	0	0	0	0	0	0	0	0	0	0	0	0	0	
150-167	MHz	0	0	0	0	0	0	0	0	0	0	0	0	0	
394-450	MHz	0	0	0	0	0	0	0	0	0	0	0	0	0	
1350-1530	MHz	0	0	0	1985	0	0	0	0	0	0	0	0	0	
1700-2300	MHz	0	0	0	3	0	0	0	0	0	0	0	0	0	
3400-3600	MHz	0	0	0	0	0	0	0	0	0	0	0	0	0	
3800-4200	MHz	0	0	0	0	71	6	0	62	0	0	8	0	0	
4400-5000	MHz	0	0	0	0	0	0	0	0	0	0	0	0	0	
5975-6425	MHz	0	139	0	8761	769	77	0	48	820	119	126	49	0	38
6425-7125	MHz	0	342	25		2463	0	0	235		60	106		0	1036
7125-7425	MHz	0	27	0		609	0	0	172	2019	142	22	79	0	
7425-7725	MHz	0	0	0		2844	289	0			95			13	680
7725-8275	MHz	0	0	0		0	0	0	127	0	128	0	0	0	2007
7900-8275	MHz	0	0	0		0	0	0		0	0	0	0	0	
8275-8500	MHz	0	0	0		0	0	0		0	12	0	0	0	
10-10.65	GHz	0	0	0	0	0	18	0	0	0	0	73	51	0	0
10.7-11.7	GHz	0	3514	0	8584	0	384	0	179	4156	389	124	651	0	0
12.75-13.25	GHz	122	1152	0	6881	9874	2200	0	580	6423	823	488	600	0	934
14.5-15.35	GHz	69	544	0	13	3359	187	0	0	6043	406	32	233	0	3435
17.7-19.7	GHz	344	9078	310	31245	24297	3486	198	1099	11433	1030	686	2341	0	6907
22.0-23.6	GHz	372	2947	0	11731	18224	3835	780	1676	6779	1668	529	1430	0	1539
24.5-26.5	GHz	508	3864	0	8050	13836	0	0	0	1324	840	39	920	0	2870
27.9-29.5	GHz	430	19	17		2430	0	0	0	2200	0	336	350	0	0
31.8-33.4	GHz	379	2402	0	7861	11265	0	202	0	129	0	263	1028	0	1988

		AUT	CZE	FIN	FRA	GER	HNG	HOL	HRV	IT	SRB	SUI	SVK	SVN	SWE
PtP statistical	Unit	3606	41162	553	102659	127385	32430	2386	5046	48815	6467	4008	10332	13	24942
37.0-39.5	GHz	785	7070	0	10836	28405	18728	961	678	5269	755	430	2600	0	2993
40.5-43.5	GHz	62	434	0		3193	0	0	0	784	0	300	0	0	0
51.4-52.6	GHz	0	0	0	0	0	0	0	0	0	0	3	0	0	0
59-64	GHz	0	0	0	0	0	76	0	0	0	0	0	0	0	0
71-86	GHz	535	9630	201	6707	5746	3144	245	190	1436	0	443	0	0	515

It is to be noted that for several frequency ranges, some administrations) provided information with different granularity. An opportunity was then given in January 2023 to administrations to provide updated data.

It is also worth mentioning that the range 10000-10650 MHz was indicated when the RR indicates an attribution to Fixed Service up to 10680 MHz, and that two administrations out of the three that provided data in this band considered a 10000-10680 MHz range.

2.1 STATISTICAL DATA

The statistical data was focusing on the Net Fade Margin (NFM), the modulation scheme, Antenna height, Elevation Angle and link length. The synthesis of the data provided can be found in Attachment 2:Statistical data output.

2.1.1 Expected data in the questionnaire[1]

The requested data from CEPT administrations on “Statistical parameters for PtP” for all links deployed for each of the frequency bands were the following ones:

Frequency range/band xy	
Reached for.	NFM value
NFM min (less than 5%)	
NFM max (more than 95%)	
NFM mode	
NFM average	

It is assumed that the NFM is calculated using Recommendation ITU-R P.530 [3] for required availability at BER 10-6 or otherwise (with the relevant explanation).

[1] Annex 17 of Doc. SE(21)112

Frequency range/band xy	
Modulation scheme	
Max QAM	
Min QAM	
Mode QAM	

Frequency range/band xy		Percentiles			Median	Standard deviation
	Number of records	5:95	10:90	25:75		
Antenna height (m)						
Elevation angle (°)						
Link length (km)						

2.1.2 Antenna Heights, link length and elevation angles

For those two parameters, it was quite straightforward to produce the statistics at CEPT level, with a weighted-average of the percentile (5%, 10%, 25%, 75%, 90% and 95%) values provided by the CEPT administrations:

Table 2: Example of Antenna Height, Elevation Angle and link length - Range 3800-4200 MHz

3800-4200 MHz		Percentiles						Median	Standard deviation
Parameter	Number of records	5	10	25	75	90	95		
Antenna height (m)	278	18.22	31.11	41.15	67.14	102.78	121.30	55.56	28.64
Elevation angle (°)	278	-1.24	-0.70	-0.48	0.07	0.33	0.94	-0.18	0.55
Link length (km)	139	21.250	23.234	37.003	72.053	93.477	95.750	53.835	26.085

It can be seen in the example above that 278 records were gathered for the Antenna heights and the elevation angles. For those two parameters the Number of records correspond to the quantity of stations, where in the case of the link length, the Number of records correspond to the quantity of links.

2.1.3 Modulation Format

The answers from administrations were provided in different formats: some indicated only the modulation scheme by giving the number of points in the constellation (4, 16, 64,…) while others provided the number of points associated to QAM (for quadrature amplitude modulation). Finally, other administrations indicated on top of the modulation scheme a qualifier ("Strong", "Light") providing indication on the coding rate that was associated to the modulation scheme. That last information could not be considered in the overall statistic, not

only because it was not systematically provided by all administrations, but also because those qualifiers were not associated to specific coding rates or coding techniques.

Table 3: Example of Modulation Scheme information - Range 3800-4200 MHz

3800-4200 MHz	
Modulation Scheme	
Max. QAM	128
Min. QAM	64
Mode QAM	128

2.1.4 Net Fade Margin

The planning methods define on a link-by-link basis, the required Flat Fade Margin (FFM, sometimes also referred to as Thermal Fade Margin, TFM) necessary for respecting the required Availability Performance Objective (APO) and Error Performance Objective (EPO) for that link. The FFM is computed based on the propagation statistics effects given in Recommendation ITU-R P.530 [3]. The FFM is also represented by the difference between the "nominal" Receiver Signal Level (RSL, often referred to as "clear sky" RSL, calculated from the link budget, according to Recommendation ITU-R P.525,annex 1, section 2.2) and the RSL corresponding to the BER=10^{-6} threshold of the FS link.

Adaptive Transmit Power Control (ATPC) is a common feature for links in the Fixed Service; it aims to reduce interference from other links in the Fixed Service in the same area, so enabling the possible increase of link density/frequency reuse of the network.

When propagation permits (i.e. most of the time) the Transmit output power is reduced up to the selected $ATPC_{RANGE}$ (dB) and, consequently, also the "clear sky condition" RSL is reduced of the same amount; the transmit output power and, consequently, the full FFM are restored to their nominal planned value only when the RSL drops below the ATPC activation threshold (i.e. for around the remaining % of the time). These concepts are graphically shown in Table 3.

When properly designed, ATPC does not have any impact on APO and EPO effects due to propagation considered in the link planning. However, it has significant impact when considering the effects of high-level external interference presence, because the full FFM is normally not available when the interference level increases beyond the Net Fade Margin (NFM)[2]. NFM is defined in Recommendation ITU-R F.1108 [4] as:

NFM = FFM - $ATPC_{RANGE}$ (all values in dB)

[2] Please note that in multipath and signature literature sometimes the term "Net Fade Margin" was used meaning NFM = min(DFM; FFM); to be used in link planning for dominant multipath situations (see e.g. Recommendation ITU-R F.1093 [5]).

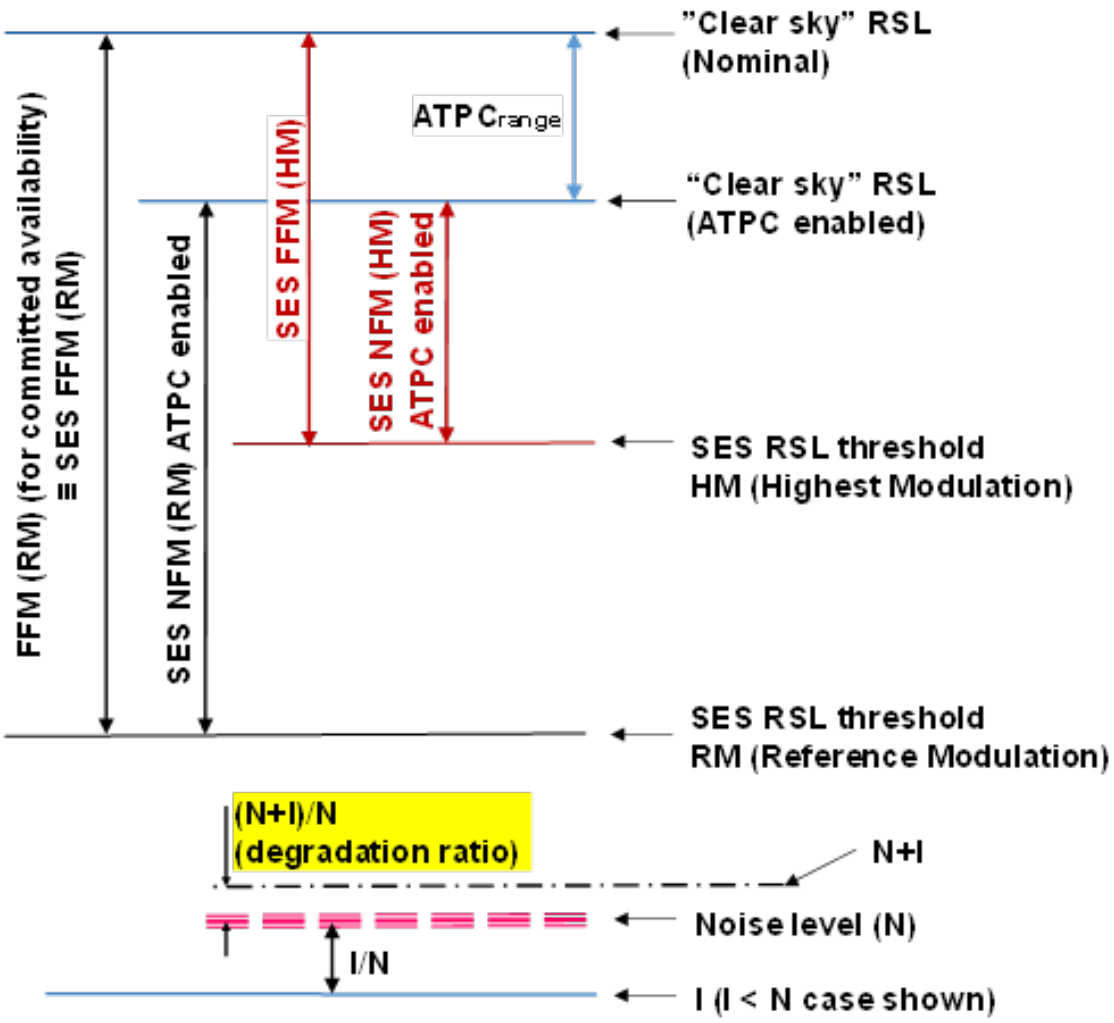


Figure 1: RSLs, FFMs and NFMs concepts in modern, ACM and ATPC enabled, FS systems

This parameter was likely to be one of the most difficult, even if it was indicated in the questionnaire that the Net Fade Margin was to be "calculated using Recommendation ITU-R P.530 [3] for required availability at BER 10^(-6)". For some administrations, this information is directly available since it is part of the registration process, but for others it was necessary to compute it, and then to compute the associated percentiles for NFM min, NFM max, NFM average and NFM mode.

In Figure 1, it can be seen that there are different RSL thresholds and different NFMs according to the modulation under consideration. The NFM for the highest modulation (i.e. the most sensitive one, also providing the best spectral efficiency) can be significantly lower than the one for the lowest modulation (i.e. the most robust, offering a lower spectral efficiency). As a consequence, the notion of NFM is intrinsically linked to the notion of reference modulation. Without a common understanding between administrations, it was unfortunately not possible to produce statistics on the NFM.

2.2 SYSTEM PARAMETERS

2.2.1 Expected data in the questionnaire

The requested data from CEPT administrations[3] on the system parameters were the following ones:

[3] See questionnaire in Doc. SE(21)112, annex 17

Frequency range/band	xy		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format			
Channel spacing and receiver noise bandwidth (MHz)			
3 dB bandwidth (MHz)			
Tx output power (dBW)			
Maximum Tx output power density (dBW/MHz)			
e.i.r.p. (dBW)			
e.i.r.p. density range (dBW/MHz)			
Feeder/multiplexer loss (dB)			
Antenna gain (dBi)			
Receiver noise figure (dB)			
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)			
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)			

2.2.2 Processing of the different types of characteristics

The 14 parameters for which statistics are computed are divided into three subcategories:

- Modulation Format: a straightforward average is not appropriate without modulation consideration, since the output value would need to be a modulation format, between 4-QAM and 4096-QAM;
- Tx Output Power (dBW), Maximum Tx Output power density (dBW/MHz), *e.i.r.p.* (dBW), *e.i.r.p.* density range (dBW/MHz), Feeder/multiplexer loss (dB), Antenna Gain (dBi), Receiver noise figure (dB), Receiver noise power density typical (dBW/MHz), Nominal Rx input level for 1e-6 BER (dBW/MHz), Nominal long-term interference power density (dBW/MHz) and ATPC range (dB) are values provided in a logarithmic format: a pre-treatment in which the values are converted into linear is necessary;
- Channel Spacing and receiver noise bandwidth: those two parameters are provided in MHz, which is a ”natural” unit. No pre-treatment of those parameters is therefore required.

It is to be noted that, the consistency between the parameters that are linked (ex: *e.i.r.p.* is linked with Tx output power density and antenna gain) was not checked.

2.2.3 Necessity of a weighting matrix for statistics

The quantity of links per frequency band alone, for each administration, is not sufficient to compute the system parameters.

Due to differences between the answer received in the questionnaire, the identification of common parameters for which administrations have provided values is also needed.

Table 4: German Data 3.8-4.2 GHz

	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	64	128	128
Channel spacing and receiver noise bandwidth (MHz)	29.0	29.0	29.0
3 dB bandwidth (MHz)	29.0	29.0	29.0
Tx output power (dBW)	-13.0	3.0	1.0
Maximum Tx output power density (dBW/MHz)	-27.6	-11.6	-13.6
e.i.r.p. (dBW)	18.8	39.8	35.3
e.i.r.p. density range (dBW/MHz)	4.2	25.2	20.7
Feeder/multiplexer loss (dB)	0.4	5.5	3.0
Antenna gain (dBi)	31.5	38.7	35.4
Receiver noise figure (dB)	4.4	4.4	4.4
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.6	-139.6	-139.6
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-114.8	-110.0	-111.4
Nominal long-term interference power density (dBW/MHz)(2)	-145.6	-145.6	-145.6
ATPC range (dB)	3.0	20.0	20.0

Table 5: Hungary Data 3.8-4.2 GHz

	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format			
Channel spacing and receiver noise bandwidth (MHz)	29	29	29
3 dB bandwidth (MHz)			
Tx output power (dBW)	2	2	2
Maximum Tx output power density (dBW/MHz)	-12.6	-12.6	-12.6
e.i.r.p. (dBW)	36.8	39.5	39
e.i.r.p. density range (dBW/MHz)	22.2	24.9	24

	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Feeder/multiplexer loss (dB)	3.3	3.8	3.8
Antenna gain (dBi)	38.8	41.3	41
Receiver noise figure (dB)			
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)			
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)			

Table 6: Croatian Data 3.8-4.2 GHz

	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	128	128	128
Channel spacing and receiver noise bandwidth (MHz)	29	29	29
3 dB bandwidth (MHz)	29	29	29
Tx output power (dBW)	0	0	0
Maximum Tx output power density (dBW/MHz)			
e.i.r.p. (dBW)	31.2	39.2	36.17
e.i.r.p. density range (dBW/MHz)			
Feeder/multiplexer loss (dB)	2.7	4.1	3.17
Antenna gain (dBi)	34.8	42.7	39.35
Receiver noise figure (dB)	4.5	4.5	3.5
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-104	-104	-104
Nominal long-term interference power density (dBW/MHz)(2)	N/A	N/A	N/A
ATPC range (dB)	N/A	N/A	N/A

Table 7 : Swiss Data 3.6-4.2 GHz

	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	128	128	128
Channel spacing and receiver noise bandwidth (MHz)	29	29	29
3 dB bandwidth (MHz)	29	29	29
Tx output power (dBW)	0	0	0
Maximum Tx output power density (dBW/MHz)			
e.i.r.p. (dBW)	31.2	39.2	36.17
e.i.r.p. density range (dBW/MHz)			
Feeder/multiplexer loss (dB)	2.7	4.1	3.17
Antenna gain (dBi)	34.8	42.7	39.35
Receiver noise figure (dB)	4.5	4.5	3.5
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-104	-104	-104
Nominal long-term interference power density (dBW/MHz)(2)	N/A	N/A	N/A
ATPC range (dB)	N/A	N/A	N/A

In Table 4, Table 5, Table 6 and Table 7 are given examples of representative information from different administrations for the frequency range 3.8-4.2 GHz. 71 links were indicated by Germany, 6 links were indicated by Hungary, 62 by Croatia and 8 for Switzerland in that portion of spectrum. But for each parameter, the situation can be different:

- information for the ”Receiver Noise figure (dB)” is only given for Switzerland, Croatia and Germany;
- information for ”ATPC range” is only given for Switzerland and Germany;
- information for ”Nominal long-term interference power density” is only given for Germany.

From those tables and the quantity of links for each administration in each band, matrixes indicating, for all parameters, the quantity of links for all administrations for which information is provided were computed:

Table 8: Quantity of links considered for the computation - example matrix for 3.8-4.2 GHz

	Overall Minimum	Overall maximum	Overall Mode
Modulation Format	141	141	141
Channel spacing and receiver noise bandwidth (MHz)	147	147	147
3 dB bandwidth (MHz)	133	133	133

	Overall Minimum	Overall maximum	Overall Mode
Tx output power (dBW)	147	147	147
Maximum Tx output power density (dBW/MHz)	85	85	85
e.i.r.p. (dBW)	147	147	147
e.i.r.p. density range (dBW/MHz)	85	85	85
Feeder/multiplexer loss (dB)	147	147	147
Antenna gain (dBi)	147	147	147
Receiver noise figure (dB)	141	141	141
Receiver noise power density typical (=NRX) (dBW/MHz)	79	79	79
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	141	141	141
Nominal long-term interference power density (dBW/MHz)(2)	71	71	71
ATPC range (dB)	79	79	79

Then, for all frequency bands, based on:

- the quantity of links of that administration;
- the effective availability of each parameter for that administration;
- the matrixes of quantity of links computed at the previous step.

The weights that will be associated to each parameter of each administration in each frequency band were computed, as shown in the example below for 3.8-4.2 GHz: 71 links are indicated by Germany, 6 links are indicated by Hungary, 62 by Croatia and 8 for Switzerland:

- Information for the ”Receiver Noise figure (dB)” is available for Switzerland (8 links), Croatia (62) and Germany (71) for a total 141 links:
  - Weight for Swiss value is 8/141 = 5.67%;
  - Weight for Croatian value is 62/141 = 43.97%;
  - Weight for German value is 71/141 = 50.35%.
- Information for ”ATPC range” is only given for Switzerland (8 links) and Germany (71) for a total of 79 links:
  - Weight for Swiss value is 8/79 = 10.13%;
  - Weight for German value is 71/79 = 89.87%.
- Information for ”Nominal long-term interference power density” is only given for Germany (71 links)
  - Weight for German value is 100%

Those weights were then used to obtain the weighted average of the provided values (either directly on the values or on their ”natural” value, as appropriate, see section 1.2.1).

Finally, for the modulation format, the QAM modulation scheme with the closest number of points in the constellation scheme (4 QAM, 16 QAM, 32 QAM, 64 QAM, 128 QAM, 256 QAM, 512 QAM, 1024 QAM, 2048 QAM and 4096 QAM) is chosen.

2.2.4 Synthesis of links considered

The synthesis of the quantity of links considered is provided below:

Table 9: Number of links per frequency band for CEPT administrations considered in the computation of system parameters

		AUT	CZE	FIN	FRA		GER	HNG	HOL	HRV	IT	SRB	SUI	SVK	SVN	SWE
Frequency Range	Unit	3606	41162	553	69951	32708	127385	32430	2386	5046	0	6467	4008	10204	13	24942
1350-1530	MHz	0	0	0	1987	0	0	0	0	0	0	0	0	0	0	0
1700-2300	MHz	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
3800-4200	MHz	0	0	0	0	0	71	6	0	62	0	0	8	0	0	0
5925-6425	MHz	0	139	0	1691	111	769	77	0	48	0	119	126	0	0	38
6425-7125	MHz	0	342	25	3385	308	2463	0	0	235	0	60	106	0	0	1036
7125-7425	MHz	0	27	0	0	0	609	0	0	86	0	142	13	0	0	0
7425-7725	MHz	0	0	0	17	0	2844	289	0	86	0	95	9	0	13	680
7725-8275	MHz	0	0	0	1342	278	0	0	0	64	0	128	0	0	0	1004
8275-8500	MHz	0	0	0	1350	279	0	0	0	63	0	12	0	0	0	1003
10-10.65	GHz	0	0	0	0	0	0	18	0	0	0	0	73	51	0	0
10.7-11.7	GHz	0	3514	0	7006	1578	0	384	0	179	0	389	124	651	0	0
12.75-13.25	GHz	122	1152	0	5428	1453	9874	2200	0	580	0	823	488	600	0	934
14.5-15.35	GHz	69	544	0	13	0	3359	187	0	0	0	406	32	233	0	3435
17.7-19.7	GHz	344	9078	310	15814	15431	24297	3486	198	1099	0	1030	686	2341	0	6907
22-23.6	GHz	372	2947	0	9131	2600	18224	3835	780	1676	0	1668	529	1430	0	1539
24.5-26.5	GHz	508	3864	0	7743	307	13836	0	0	0	0	840	39	920	0	2870
27.9-29.5	GHz	430	19	17	0	0	2430	0	0	0	0	0	336	350	0	0
31.8-33.4	GHz	379	2402	0	3139	4722	11265	0	202	0	0	0	263	1028	0	1988
37-39.5	GHz	785	7070	0	9549	1287	28405	18728	961	678	0	755	430	2600	0	2993
40.5-43.5	GHz	62	434	0	0	0	3193	0	0	0	0	0	300	0	0	0
51.4-52.6	GHz	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
59-64	GHz	0	0	0	0	0	0	76	0	0	0	0	0	0	0	0
71-86	GHz	535	9630	201	2353	4354	5746	3144	245	190	0	0	443	0	0	515

In yellow are highlighted the links that could unfortunately not be considered in the statistics.

The synthesis of the data provided can be found in Annex 1.

2.3 TYPICAL LINKS

2.3.1 Expected Data in the questionnaire

The requested data from CEPT administrations[4] on “Representative typical links” were the following ones:

[4] See questionnaire in Annex 17 of Doc. SE(21)112

Frequency range/band	XY GHz					
Representative links				Further links to be considered		
Examples	Link 1 (NFM min)	Link 2 (NFM max)	Link (NFM „mode“)	Link 1	Link 2	Link 3
Modulation (QAM)						
Channel bandwidth (MHz)						
Tx output power (dBW)						
e.i.r.p. (dBW)						
Feeder/multiplexer loss (dB)						
Antenna gain (dBi) (Tx/Rx)						
Receiver noise figure (dB)						
Receiver threshold for 10-6						
ATPC range (dB)						
Net fade margin for BER 10-6						
Rain zone or P0 according to Recommendation ITU-R P.530 [3]						
Antenna height (Tx/Rx)						
Link length						
Antenna elevation (Tx/Rx)						

2.3.2 On the typical links provided

Some administrations provided typical links corresponding to the different values of NFM. On top of the difficulties encountered also for the system parameters, with which some parameters are shared, the main issue was related to the notion of NFM itself. As explained in section 2.1.4, without a common definition of the reference modulation, and therefore of the associated RSL and NFM, it was impossible to statistically process at CEPT level the data gathered by the different administrations on the typical links.

3 COMPARISON OF THE PRODUCED STATISTIC WITH EXISTING ITU-R RECOMMENDATION

3.1 COMPARISON OF STATISTICAL DATA WITH RECOMMENDATION ITU-R F.2086 [2]

The statistical data was focusing on the Net Fade Margin (NFM), the modulation scheme, Antenna height, Elevation Angle and link length.

In the absence of existing reference in ITU-R Recommendations, no comparison could be made for the values of NFM that were obtained for this Report.

Per frequency range, antenna heights, elevation angles and link lengths were compared with the values indicated in Recommendation ITU-R F.2086 for administrations not part of CEPT. It is to be noted that the last revision of that Recommendation was issued in 2015 and that the values may not be up to date.

The following results are obtained for elevation angles:

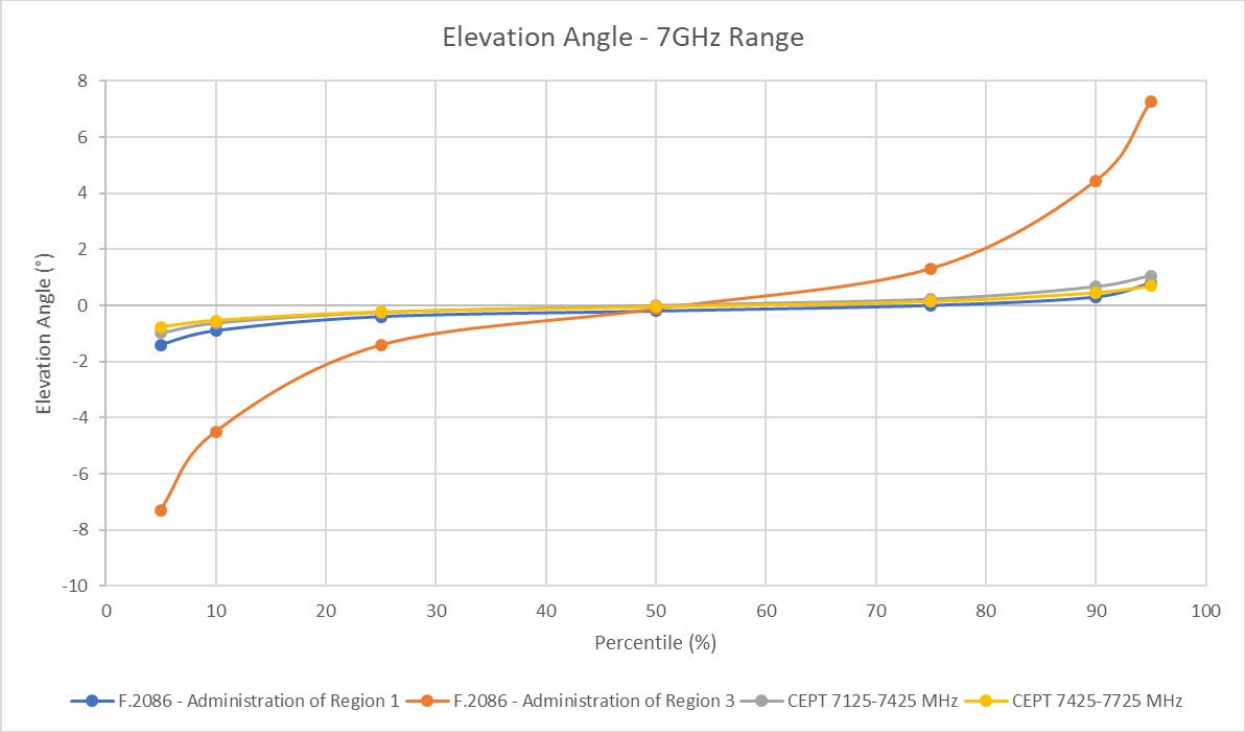


Figure 1: Elevation angle - 7 GHz range

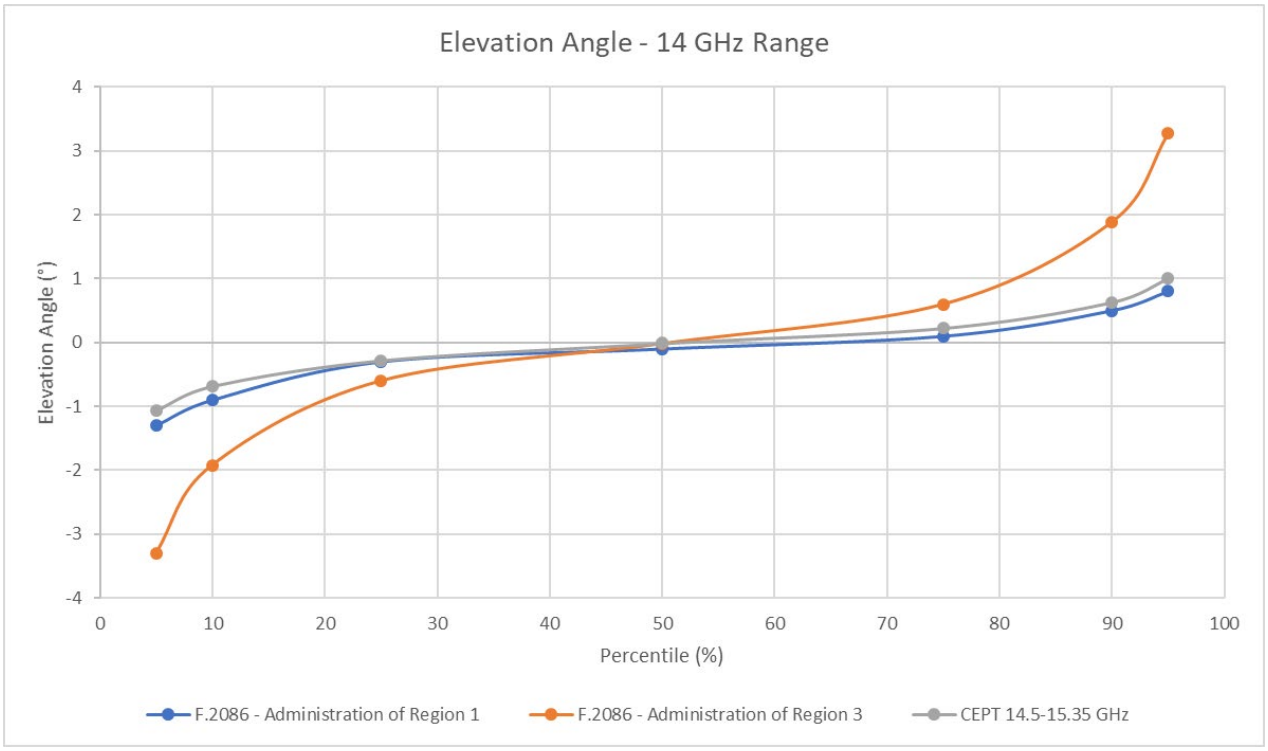


Figure 2: Elevation angle - 14 GHz range

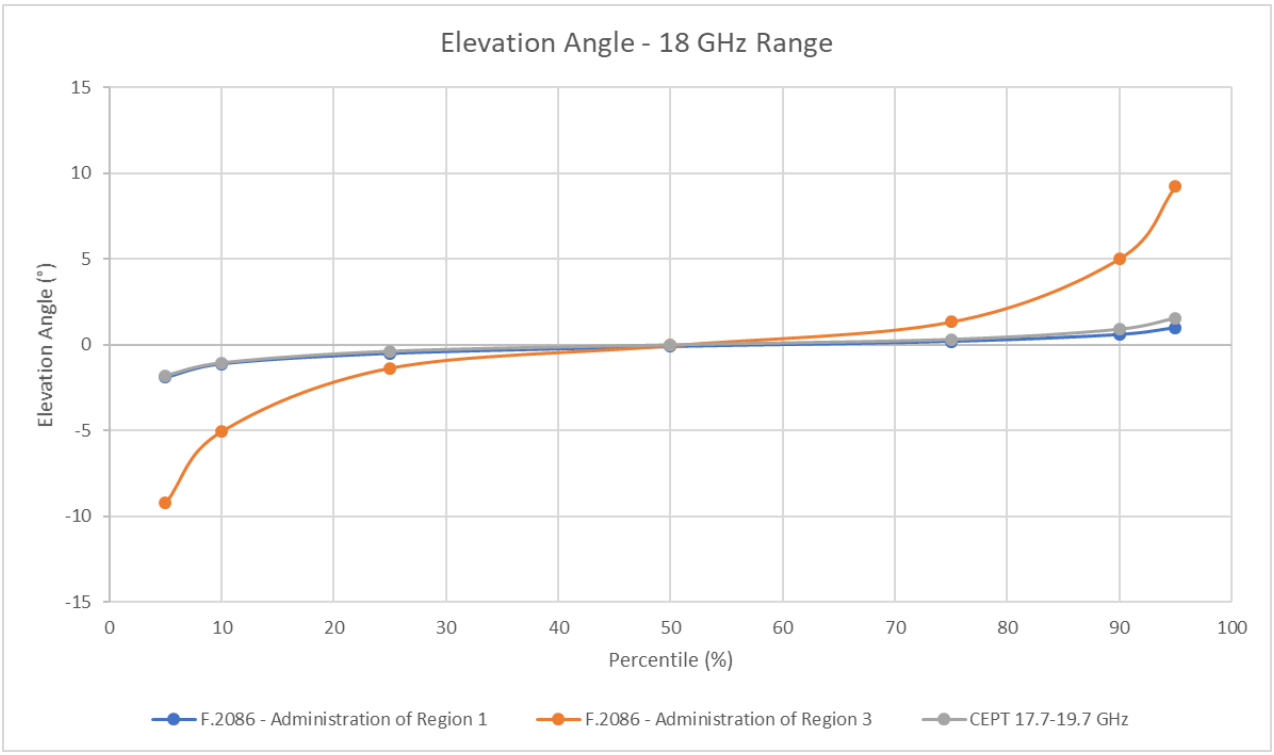


Figure 3: Elevation angle - 18 GHz range

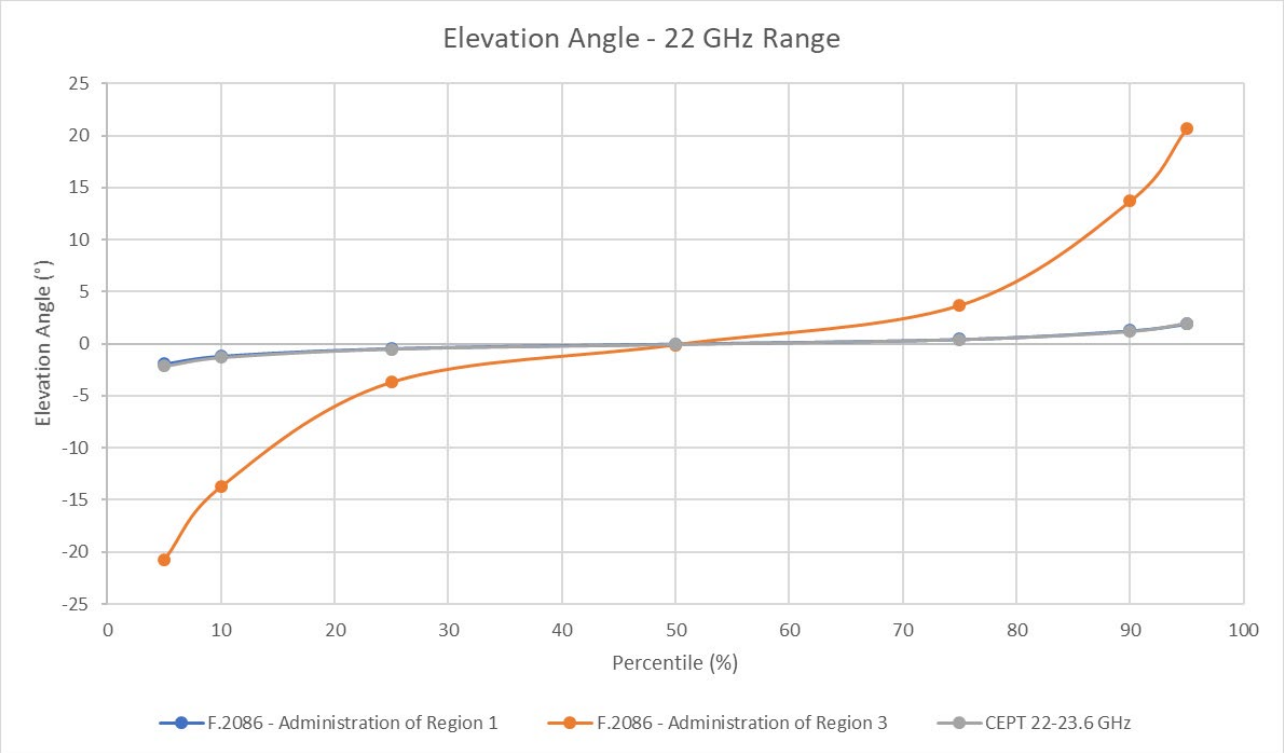


Figure 4: Elevation angle - 22 GHz range

The following results are obtained for link lengths:

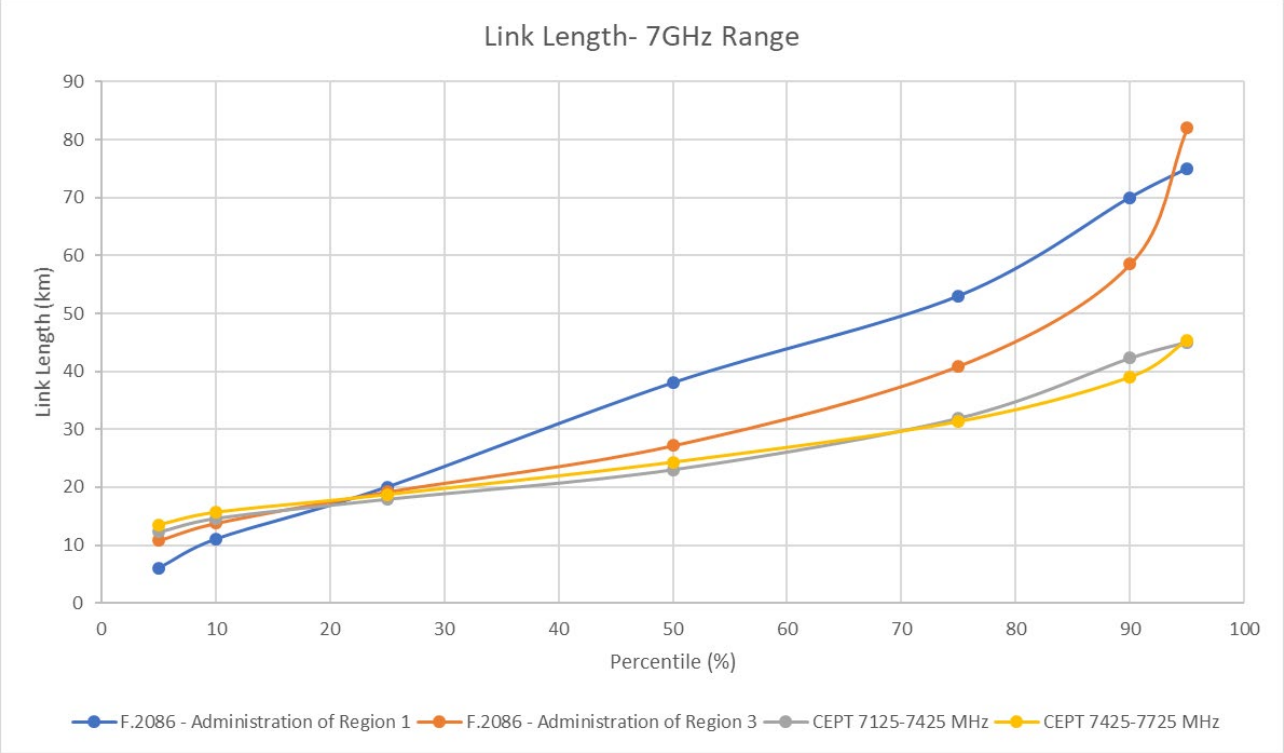


Figure 5: Link length - 7 GHz range

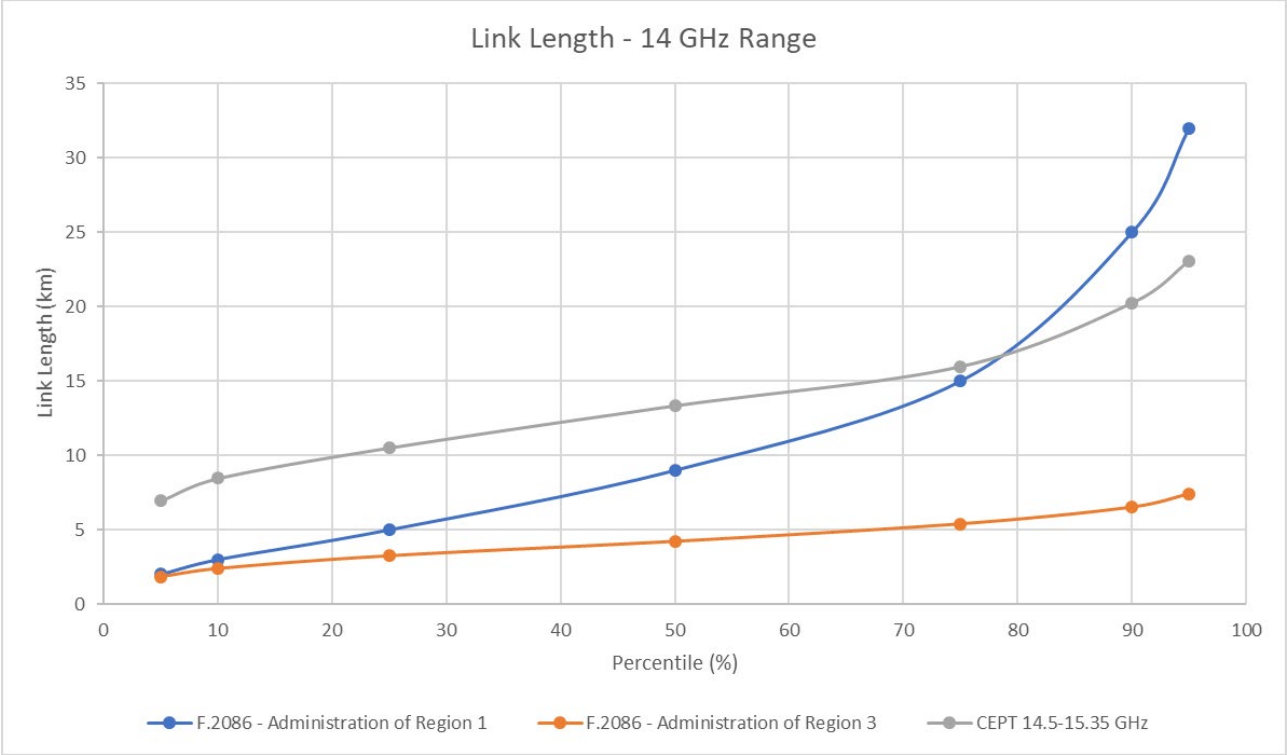


Figure 6: Link length - 14 GHz range

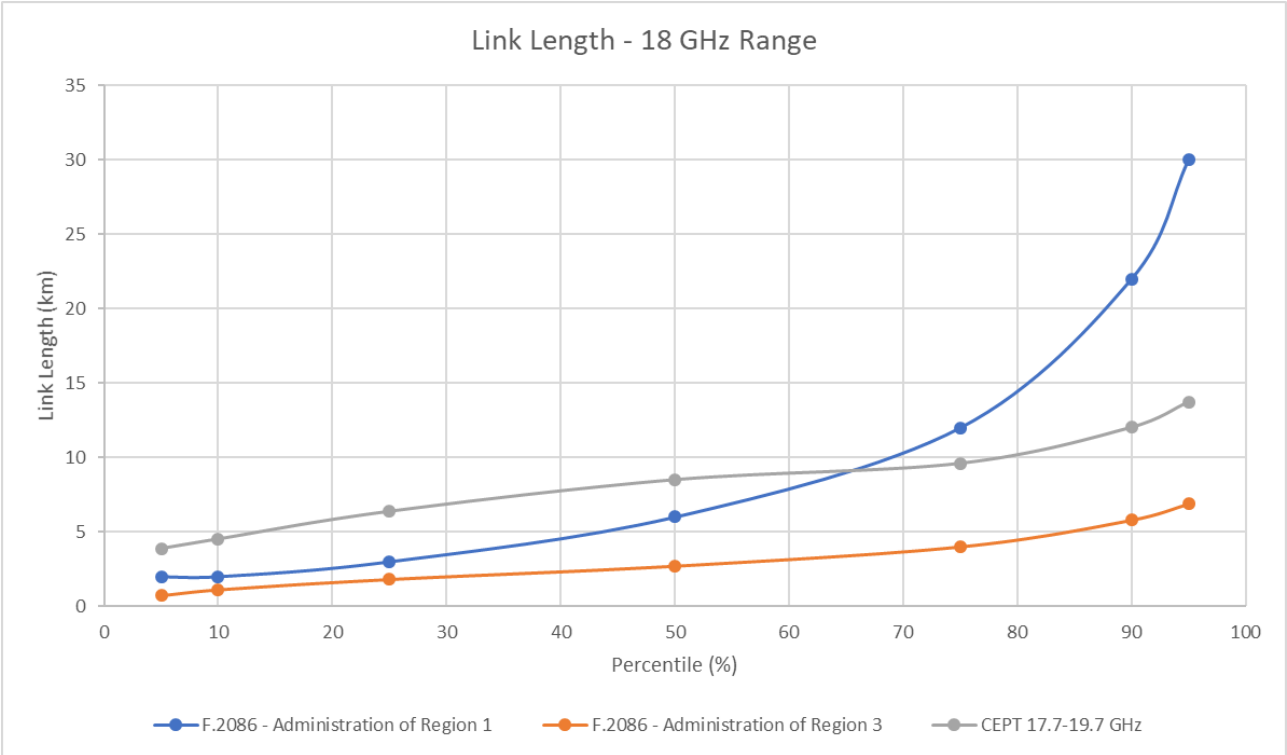


Figure 7: Link length - 18 GHz range

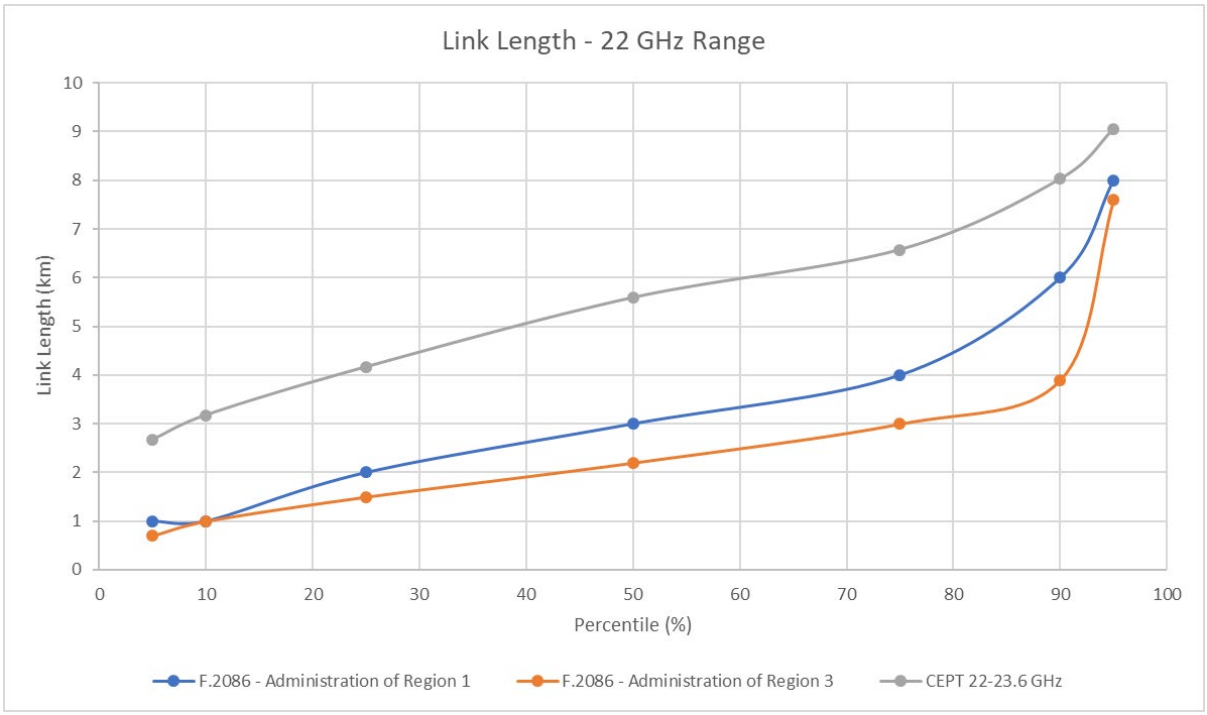


Figure 8: Link length - 22 GHz range

Finally, the following results are obtained for antenna heights:

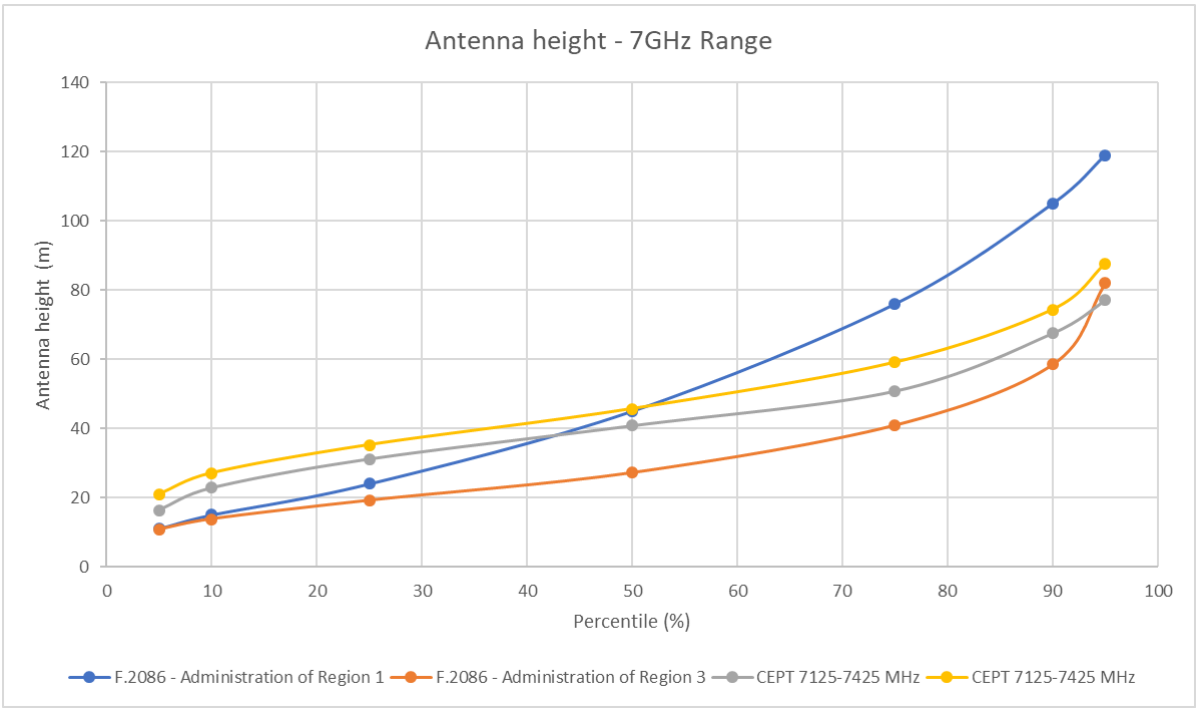


Figure 9: Antenna height - 7 GHz range

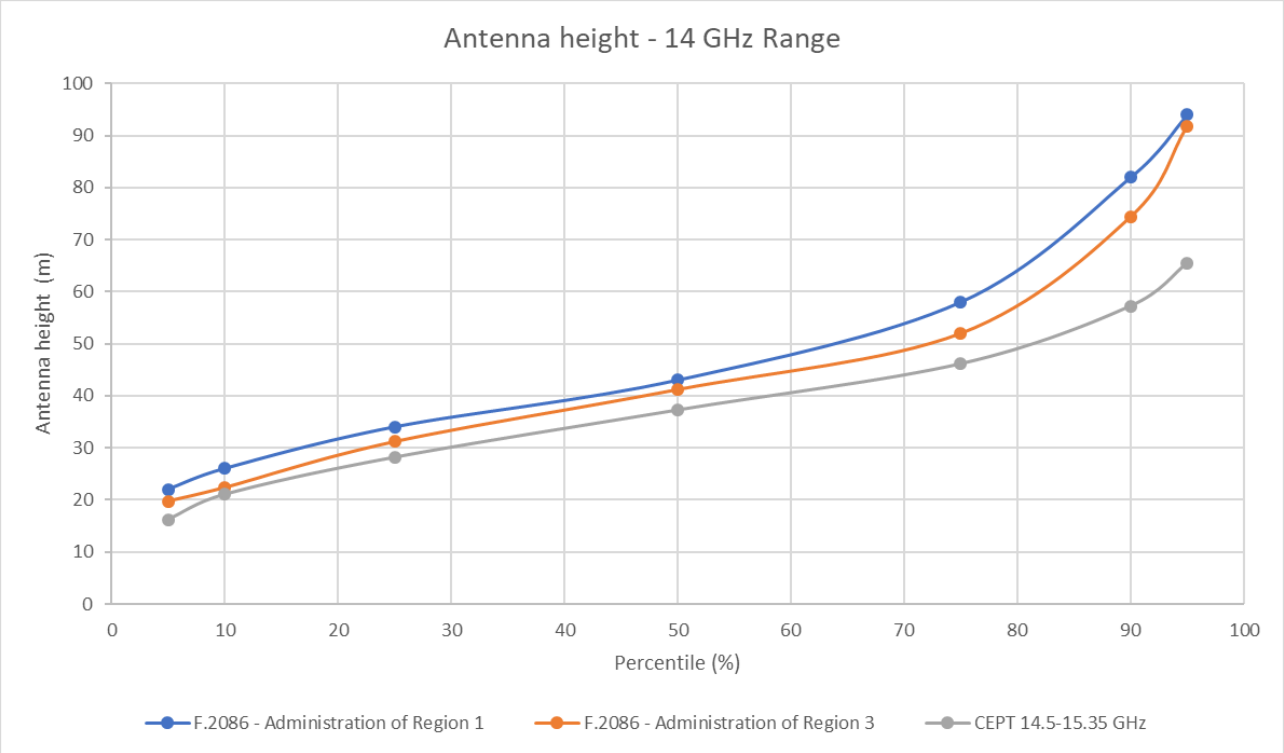


Figure 10: Antenna height - 14 GHz range

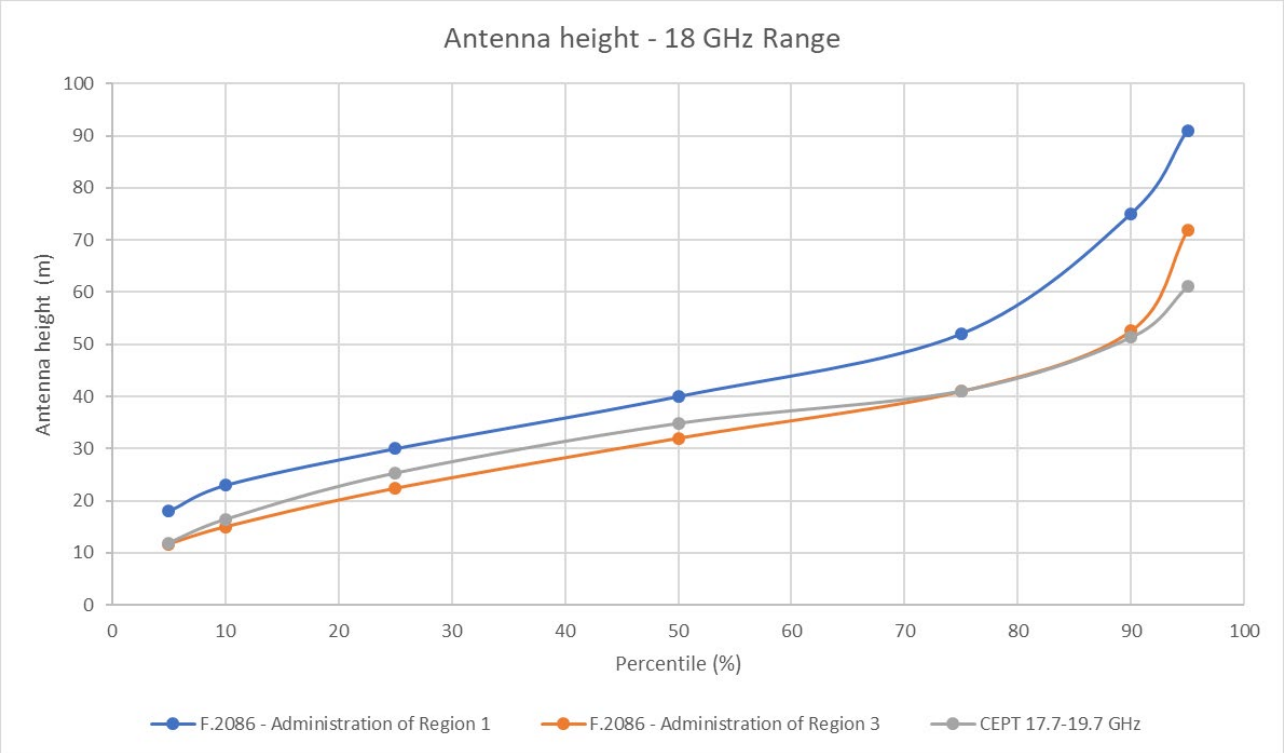


Figure 11: Antenna height - 18 GHz range

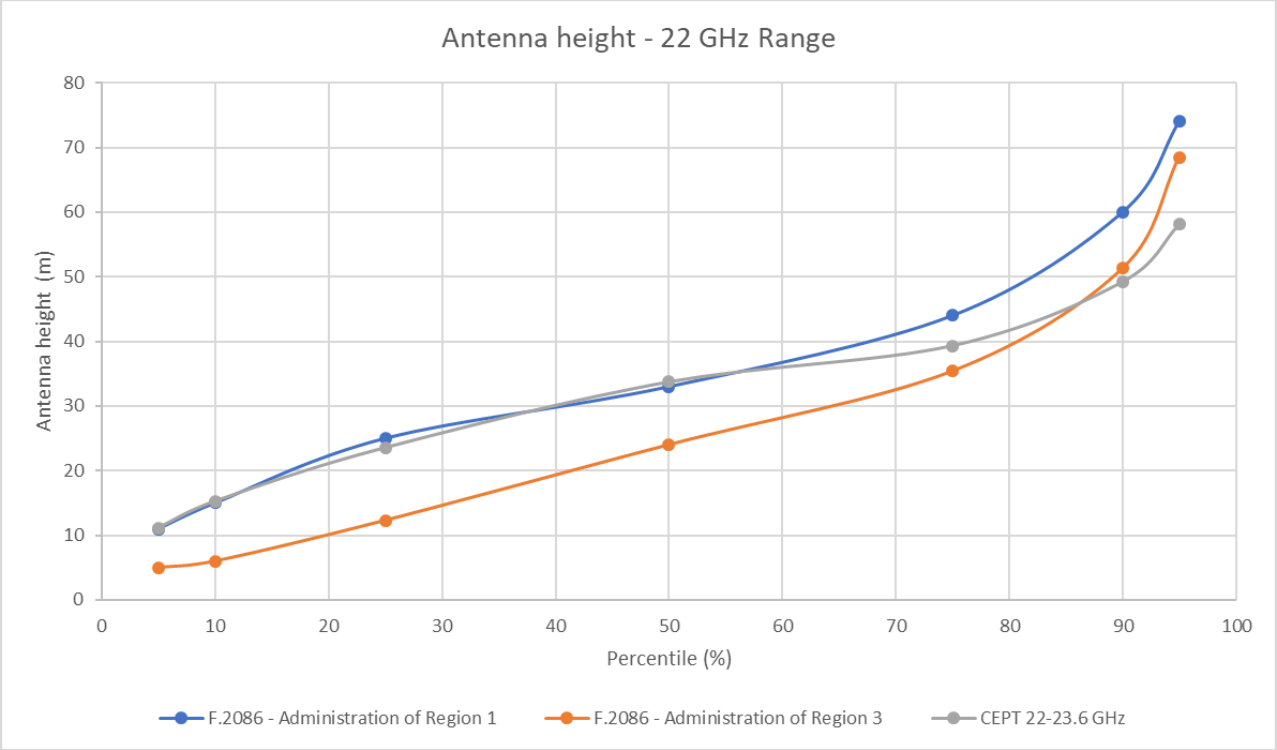


Figure 12: Antenna height - 22 GHz range

3.2 COMPARISON OF SYSTEM PARAMETERS WITH RECOMMENDATION ITU-R F.758

Per frequency range, some parameters (Receiver Noise Figure, *e.i.r.p.*, Feeder Losses and Antenna Gain) of the links that were obtained (considering all links) are compared to the values of the data indicated in Recommendation ITU-R F.758 [1].

The frequency ranges in abscissa are the ones for which data has been gathered, respectively

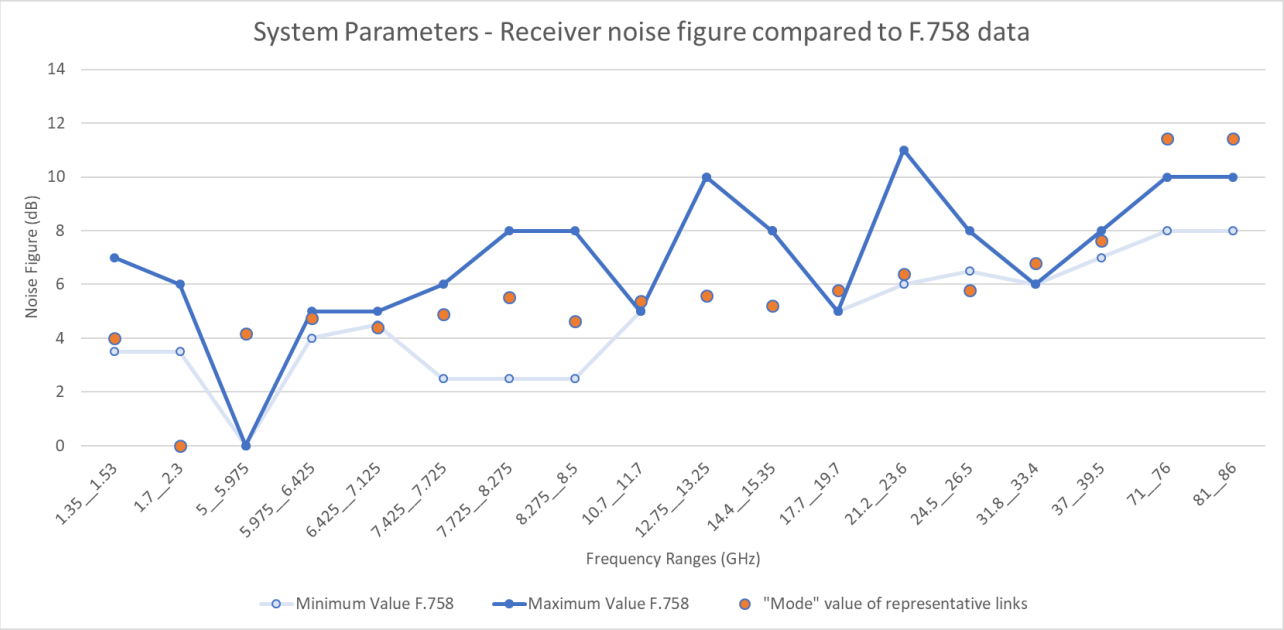


Figure 13: Noise Figure from system parameters of CEPT links vs. Recommendation ITU-R F.758

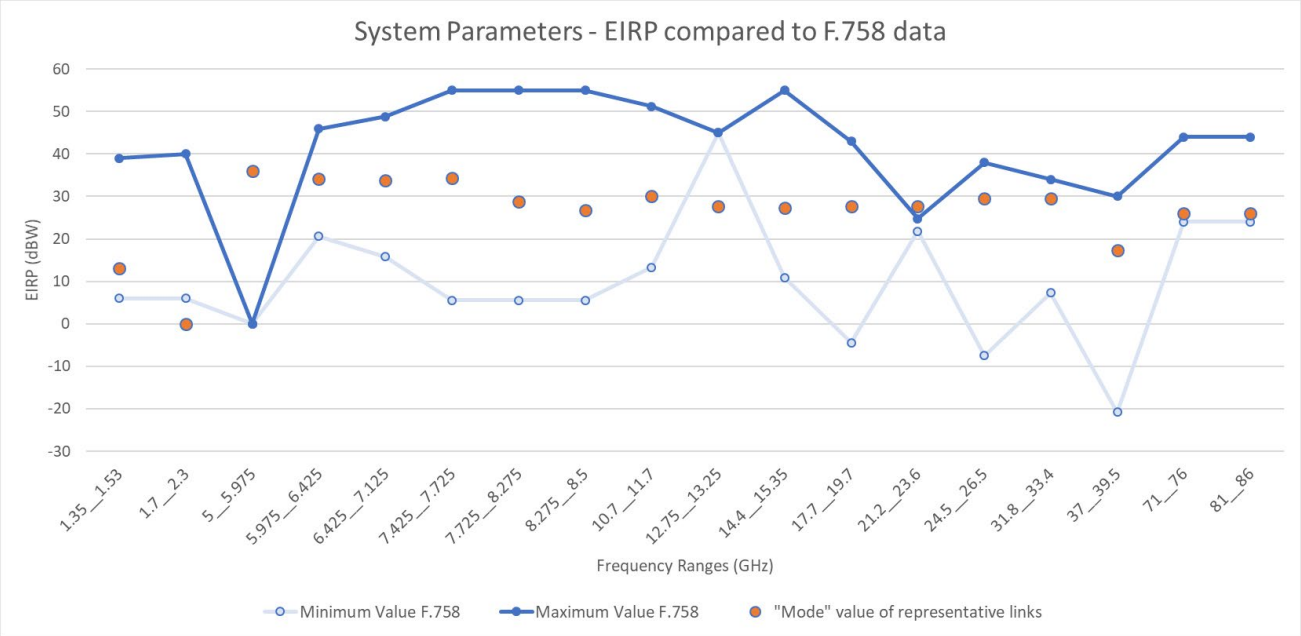


Figure 14: *e.i.r.p.* from system parameters of CEPT links vs. Recommendation ITU-R F.758

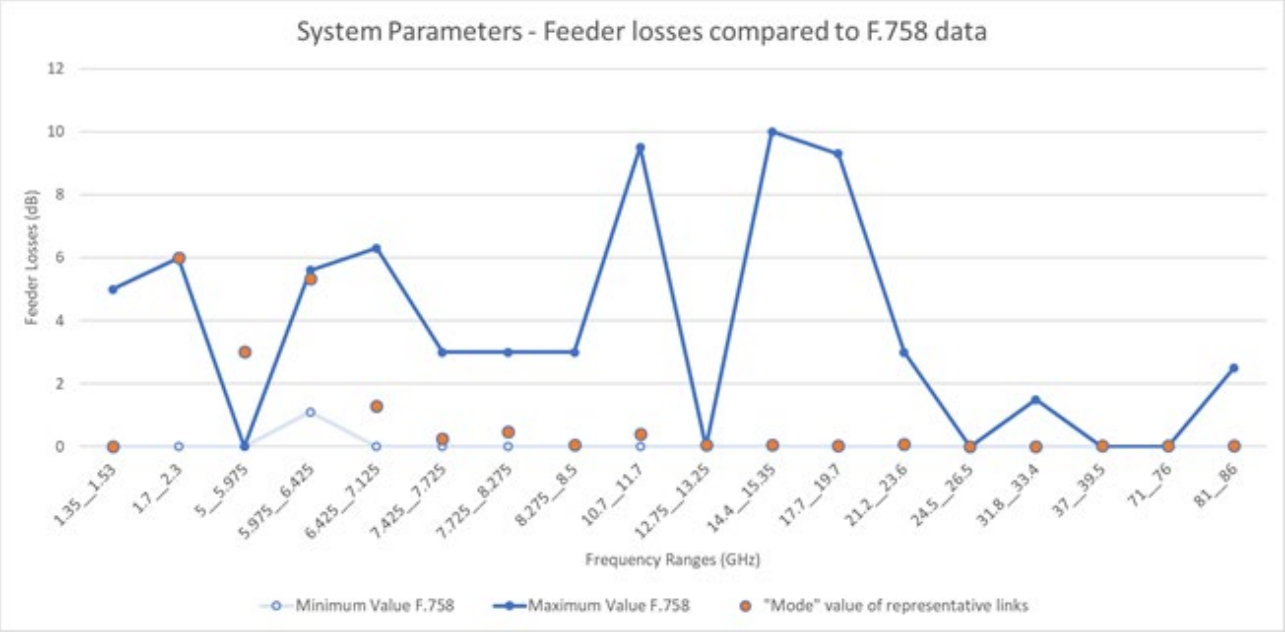


Figure 15: Feeder Losses from system parameters of CEPT links vs. Recommendation ITU-R F.758

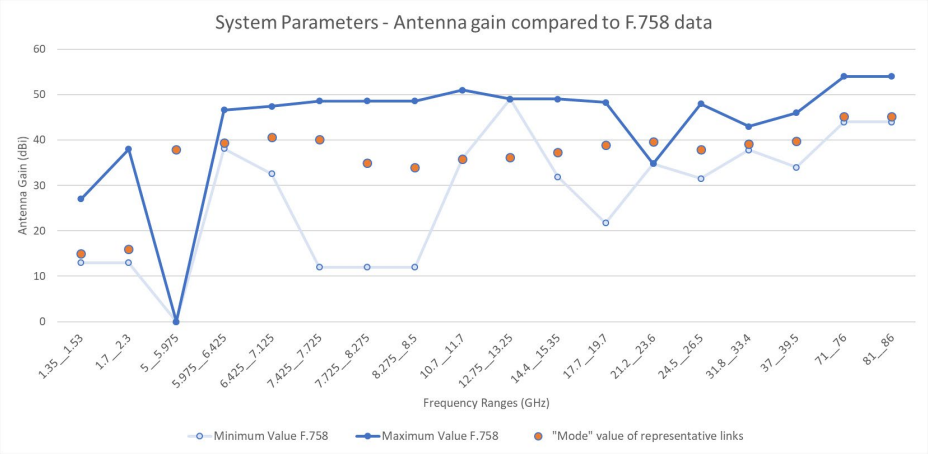


Figure 16: Antenna Gain from system parameters of CEPT links vs. Recommendation ITU-R F.758

The result of the comparison between the 5% percentile values, the 95% percentile values, and ”mode” values is given in the table below:

Table 10: Percentage of the system parameters of CEPT links comprised in the ranges of Recommendation ITU-R F.758

	5% Percentile - CEPT	95% Percentile - CEPT	Mode - CEPT
Receiver Noise Figure (dB)	35%	39%	48%
e.i.r.p (dBW)	70%	78%	74%
Feeder loss (dB)	78%	13%	78%
Antenna Gain (dBi)	65%	74%	83%

A significant part of the parameters of the ”mode” system parameters data are within the ranges provided in Recommendation ITU-R F.758 [1], which seems to indicate the appropriateness of the univariate analysis approach.

Attachment 1: Raw data as provided by administrations and attachment 2: Statistical data output can be found here.

4 CONCLUSION

Due to the increasing demand for spectrum for various services and applications, frequency bands traditionally used by the Fixed Service come to the focus for potential sharing. In order to be able to carry out accurate sharing and compatibility studies, current and representative parameters of the FS are required. With the intention to gather precise and representative parameters to be used in these studies, CEPT launched a questionnaire to CEPT administrations.

The questionnaire contained the following parts:

- Request for data on FS system parameters similar to the parameters available in Recommendation ITU-R F.758 [1];
- Request for statistical FS data similar to Recommendation ITU-R F.2086 [2];
- Request for “typical FS links” based on min/max and mode Net Fade Margin.

Once several answers were received, technical discussions took place on how to appropriately proceed for obtaining parameters at CEPT level. It was noted that due to the unexpected differences in the understanding of the “Net Fade Margin” and also the limited availability of this parameter in the database of some administrations, the data gathered from questionnaire on “typical links” was impossible to compare or to combine into a set of representative links for CEPT. However, the raw data provides information about current values for the (net) fade margin in certain frequency ranges.

This Report mainly focuses on the following aspects:

- Summarising the basic background of the various parameters, especially with respect to the different fade margins;
- Providing a weighted summary of the data on system parameters from CEPT administrations
- Describing how the statistical parameters and the system parameters were obtained;
- Explaining why the typical links could not be generated at CEPT level;
- Comparing the produced data with the appropriate Recommendation ITU-R F.2086 [2] and Recommendation ITU-R F.758 [1].

Care must be taken when considering the parameters produced in this report, noting that:

- the derived parameters are based solely on the data provided by the administrations who answered the questionnaire. It is noted that for certain frequency bands, the number of FS links represented may be relatively small;
- the raw sets data that were provided by the CEPT administrations that responded to the questionnaire date back to 2020/2021 and may be outdated in some cases;
- the analysis done to generate the statistical and system parameters was performed through a univariate analysis, which is likely to be less accurate than a multivariate analysis but easier to perform; Consequently, the consistency between the parameters that are linked (ex: e.i.r.p. is linked with Tx output power density and antenna gain) was not checked. Therefore, those statistical and representative data should not be directly used for performing sharing and compatibility studies.

When undertaking sharing and compatibility studies, the data provided in this report might be used as an addition to the most recent versions available of the appropriate ITU-R Recommendations. The responsible ECC groups and CEPT administrations remain encouraged to provide characteristics for sharing and compatibility studies as up to date as possible.

ANNEX 1: SUMMARY OF DATA FOR SYSTEM PARAMETER

Based on a weighting detailed in section 2.2.3, the following summary of the data per frequency band can be provided:

Table 11: Summary of the data for frequency band 1350-1530 MHz

Frequency range/band	1350-1530 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format			
Channel spacing and receiver noise bandwidth (MHz)	0.025	0.5	1
3 dB bandwidth (MHz)			
Tx output power (dBW)	-19.2	3.2	-2.0
Maximum Tx output power density (dBW/MHz)	-12.9	12.8	1.0
e.i.r.p. (dBW)	-4.6	20.2	13.0
e.i.r.p. density range (dBW/MHz)	2.0	29.3	16.0
Feeder/multiplexer loss (dB)	0.0	12.0	0.0
Antenna gain (dBi)	13.4	21.0	15.0
Receiver noise figure (dB)	3.0	9.0	4.0
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)			
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)	0.0	0.0	0.0

Table 12: Summary of the data for frequency band 1700-2300 MHz

Frequency range/band	1700-2300 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format			
Channel spacing and receiver noise bandwidth (MHz)	0.1	3.61	0
3 dB bandwidth (MHz)			
Tx output power (dBW)	-16.0	-9.4	-16.0
Maximum Tx output power density (dBW/MHz)	-13.8	-6.0	-6.0
e.i.r.p. (dBW)	0.0	15.1	0.0
e.i.r.p. density range (dBW/MHz)	10.0	10.7	10.0
Feeder/multiplexer loss (dB)	0.6	6.0	6.0
Antenna gain (dBi)	16.0	24.6	16.0
Receiver noise figure (dB)	0.0	8.1	0.0
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)			
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)	0.0	0.0	0.0

Table 13: Summary of the data for frequency band 3800-4200 MHz

Frequency range/band	3800-4200 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 12-08 [7]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	64	128	128
Channel spacing and receiver noise bandwidth (MHz)	29	29	29
3 dB bandwidth (MHz)	29	29	29
Tx output power (dBW)	-2.6	1.7	0.6
Maximum Tx output power density (dBW/MHz)	-21.0	-11.9	-13.7
e.i.r.p. (dBW)	29.9	39.4	35.9
e.i.r.p. density range (dBW/MHz)	14.0	24.9	21.0
Feeder/multiplexer loss (dB)	1.7	4.7	3.0
Antenna gain (dBi)	34.1	40.9	37.9
Receiver noise figure (dB)	4.6	4.6	4.2
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.3	-139.3	-139.3
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-107.1	-106.4	-106.7
Nominal long-term interference power density (dBW/MHz)(2)	-145.6	-145.6	-145.6
ATPC range (dB)	7.0	19.7	19.7

Table 14: Summary of the data for frequency band 5925-6425 MHz

Frequency range/band	5925-6425 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 14-01 [8]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	64	1024	128
Channel spacing and receiver noise bandwidth (MHz)	29.27434253	36.9487941	29.27434253
3 dB bandwidth (MHz)	27.41860465	38.02325581	27.41860465
Tx output power (dBW)	-9.5	0.8	-2.5
Maximum Tx output power density (dBW/MHz)	-24.3	-15.2	-17.5
e.i.r.p. (dBW)	25.6	41.3	34.1
e.i.r.p. density range (dBW/MHz)	10.9	25.4	20.2
Feeder/multiplexer loss (dB)	0.3	12.8	5.3
Antenna gain (dBi)	34.7	43.7	39.3
Receiver noise figure (dB)	2.9	5.3	4.8
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.4	-139.3	-139.3
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-114	-97.6	-108.5
Nominal long-term interference power density (dBW/MHz)(2)	-145.3	-145.3	-145.3
ATPC range (dB)	4.0	16.3	14.9

Table 15: Summary of the data for frequency band 6425-7125 MHz

Frequency range/band	6425-7125 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 14-02 [9]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	64	128	128
Channel spacing and receiver noise bandwidth (MHz)	38.36997487	41.23115578	41.0510397
3 dB bandwidth (MHz)	34.9300227	66.3814983	38.34192626
Tx output power (dBW)	-12.5	1.1	-1.7
Maximum Tx output power density (dBW/MHz)	-28.9	-14.7	-17.6
e.i.r.p. (dBW)	25.0	42.4	33.8
e.i.r.p. density range (dBW/MHz)	9.4	25.4	17.8
Feeder/multiplexer loss (dB)	0.0	13.5	1.3
Antenna gain (dBi)	34.3	44.2	40.6
Receiver noise figure (dB)	3.2	5.5	4.4
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.2	-139.2	-139.2
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-113.3	-93.8	-98.5
Nominal long-term interference power density (dBW/MHz)(2)	-145.0	-145.0	-145.2
ATPC range (dB)	2.0	16.0	6.9

Table 16: Summary of the data for frequency band 7125-7425 MHz

Frequency range/band	7125-7425 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ECC Recommendation (02)06 [10]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	1024	64
Channel spacing and receiver noise bandwidth (MHz)	8.139190422	22.17331813	19.96416192
3 dB bandwidth (MHz)	3.5	14	14
Tx output power (dBW)	-9.7	-0.2	-5.2
Maximum Tx output power density (dBW/MHz)	-23.8	-12.0	-17.9
e.i.r.p. (dBW)	26.2	38.7	29.1
e.i.r.p. density range (dBW/MHz)	11.7	27.2	14.1
Feeder/multiplexer loss (dB)	0.2	9.8	0.1
Antenna gain (dBi)	33.4	43.6	33.6
Receiver noise figure (dB)	4.7	4.8	4.8
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.1	-139.0	-139.1
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.7	-103.4	-110.9
Nominal long-term interference power density (dBW/MHz)(2)	-145.2	-145.2	-145.2
ATPC range (dB)	1.0	24.9	20.0

Table 17: Summary of the data for frequency band 7425-7725 MHz

Frequency range/band	7425-7725 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ECC Recommendation (02)06 [10]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	2048	128
Channel spacing and receiver noise bandwidth (MHz)	6.04562361	53.12571287	24.55721393
3 dB bandwidth (MHz)	6.346621431	54.47441334	28
Tx output power (dBW)	-17.8	1.8	-0.8
Maximum Tx output power density (dBW/MHz)	-32.0	-11.9	-14.9
e.i.r.p. (dBW)	17.9	43.8	34.3
e.i.r.p. density range (dBW/MHz)	3.5	27.7	20.1
Feeder/multiplexer loss (dB)	0.0	11.9	0.2
Antenna gain (dBi)	31.0	46.0	40.2
Receiver noise figure (dB)	4.9	4.9	4.9
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.1	-139.1	-139.1
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-115.7	-100.5	-109.4
Nominal long-term interference power density (dBW/MHz)(2)	-145.1	-145.1	-145.1
ATPC range (dB)	1.1	29.0	14.1

Table 18: Summary of the data for frequency band 7725-8275 MHz

Frequency range/band	7725-8275 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	2048	256
Channel spacing and receiver noise bandwidth (MHz)	6.638068182	38.76931818	38.76931818
3 dB bandwidth (MHz)	6.2	48.8	
Tx output power (dBW)	-12.1	1.6	-2.3
Maximum Tx output power density (dBW/MHz)	-25.5	-8.7	-17.8
e.i.r.p. (dBW)	24.3	44.0	28.8
e.i.r.p. density range (dBW/MHz)	10.2	29.1	16.6
Feeder/multiplexer loss (dB)	0.2	4.5	0.5
Antenna gain (dBi)	32.1	44.1	35.0
Receiver noise figure (dB)	3.2	5.7	5.5
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.0	-139.0	-139.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-117.8	-96.8	-93.0
Nominal long-term interference power density (dBW/MHz)(2)	-145.0		-145.0
ATPC range (dB)	0.3	13.6	10.6

Table 19: Summary of the data for frequency band for 8275-8500 MHz

Frequency range/band	8275-8500 MHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	2048	128
Channel spacing and receiver noise bandwidth (MHz)	5.159925788	38.42077922	38.42077922
3 dB bandwidth (MHz)	6.2	48.8	
Tx output power (dBW)	-16.1	1.7	-2.5
Maximum Tx output power density (dBW/MHz)	-28.9	-8.4	-17.9
e.i.r.p. (dBW)	15.6	44.2	26.7
e.i.r.p. density range (dBW/MHz)	4.3	29.3	16.1
Feeder/multiplexer loss (dB)	0.0	4.5	0.0
Antenna gain (dBi)	30.5	44.1	33.9
Receiver noise figure (dB)	3.1	5.4	4.6
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.0	-139.0	-139.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.9	-102.6	-104.5
Nominal long-term interference power density (dBW/MHz)(2)	-145.0		-145.0
ATPC range (dB)	0.3	13.4	10.6

Table 20: Summary of the data for frequency band 10-10.68 GHz

Frequency range/band	10-10.68 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	32	16
Channel spacing and receiver noise bandwidth (MHz)	3.153846154	16.76923077	3.153846154
3 dB bandwidth (MHz)			
Tx output power (dBW)	-9.9	-0.9	-7.9
Maximum Tx output power density (dBW/MHz)	-21.4	-8.4	-19.9
e.i.r.p. (dBW)	16.2	39.9	21.6
e.i.r.p. density range (dBW/MHz)	5.4	28.4	10.0
Feeder/multiplexer loss (dB)	0.0	18.0	1.5
Antenna gain (dBi)	33.3	43.5	38.8
Receiver noise figure (dB)	3.0	5.3	4.1
Receiver noise power density typical (=NRX) (dBW/MHz)	-140.9	-138.6	-140.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.5	-119.4	-124.5
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)	0.0	18.0	10.0

Table 21: Summary of the data for frequency band 10.7-11.7 GHz

Frequency range/band	10.7-11.7 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	4096	256
Channel spacing and receiver noise bandwidth (MHz)	36.16939565	55.62607919	44.70363203
3 dB bandwidth (MHz)			
Tx output power (dBW)	-16.2	-2.5	-7.8
Maximum Tx output power density (dBW/MHz)	-30.5	-19.7	-22.4
e.i.r.p. (dBW)	19.5	37.2	30.1
e.i.r.p. density range (dBW/MHz)	5.1	20.0	15.3
Feeder/multiplexer loss (dB)	0.1	9.3	0.4
Antenna gain (dBi)	33.3	45.7	35.8
Receiver noise figure (dB)	3.5	6.8	5.4
Receiver noise power density typical (=NRX) (dBW/MHz)	-139.3	-138.5	-139.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-112.6	-87.3	-89.3
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)	0.7	22.6	2.6

Table 22: Summary of the data for frequency band 12.75-13.25 GHz

Frequency range/band	12.75-13.25 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 12-02 [11]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	32	2048	128
Channel spacing and receiver noise bandwidth (MHz)	8.727318847	44.67286717	28.39181534
3 dB bandwidth (MHz)	3.724685418	55.4642117	56
Tx output power (dBW)	-21.1	3.8	-4.7
Maximum Tx output power density (dBW/MHz)	-32.7	-8.7	-18.8
e.i.r.p. (dBW)	14.0	37.8	27.7
e.i.r.p. density range (dBW/MHz)	1.4	25.3	12.1
Feeder/multiplexer loss (dB)	0.0	21.6	0.1
Antenna gain (dBi)	31.2	45.9	36.1
Receiver noise figure (dB)	4.6	6.1	5.6
Receiver noise power density typical (=NRX) (dBW/MHz)	-138.7	-138.6	-138.7
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-114.8	-92.9	-104.3
Nominal long-term interference power density (dBW/MHz)(2)	-144.6	-144.6	-144.6
ATPC range (dB)	0.9	23.4	11.4

Table 23: Summary of the data for frequency band 14.5-15.35 GHz

Frequency range/band	14.5-15.35 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 12-07 [12]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	0	1024	128
Channel spacing and receiver noise bandwidth (MHz)	3.993102199	41.62454699	32.62176854
3 dB bandwidth (MHz)	3.348322049	38.51633795	14
Tx output power (dBW)	-16.6	-1.1	-9.7
Maximum Tx output power density (dBW/MHz)	-25.0	-10.0	-19.2
e.i.r.p. (dBW)	19.0	39.1	27.3
e.i.r.p. density range (dBW/MHz)	10.8	28.0	11.3
Feeder/multiplexer loss (dB)	0.1	16.7	0.1
Antenna gain (dBi)	31.6	43.3	37.3
Receiver noise figure (dB)	5.1	5.4	5.2
Receiver noise power density typical (=NRX) (dBW/MHz)	-138.7	-138.7	-138.7
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-128.3	-102.6	-120.9
Nominal long-term interference power density (dBW/MHz)(2)	-144.7	-144.5	144.7
ATPC range (dB)	0.5	22.9	5.6

Table 24: Summary of the data for frequency band 17.7-19.7 GHz

Frequency range/band	17.7-19.7 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation 12-03 [13]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	2048	128
Channel spacing and receiver noise bandwidth (MHz)	15.54301065	108.1987182	52.41801014
3 dB bandwidth (MHz)	5.265619792	130.8068837	55
Tx output power (dBW)	-19.9	-4.1	-8.9
Maximum Tx output power density (dBW/MHz)	-35.3	-19.8	-27.6
e.i.r.p. (dBW)	17.3	39.0	27.6
e.i.r.p. density range (dBW/MHz)	2.6	23.4	10.8
Feeder/multiplexer loss (dB)	0.1	22.6	0.0
Antenna gain (dBi)	35.3	46.2	38.9
Receiver noise figure (dB)	4.7	6.9	5.8
Receiver noise power density typical (=NRX) (dBW/MHz)	-138.4	-138.3	-138.3
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-122.9	-91.9	-103.7
Nominal long-term interference power density (dBW/MHz)(2)	-144.1	-143.9	-144.3
ATPC range (dB)	4.6	25.3	19.9

Table 25: Summary of the data for frequency band 22-23.6 GHz

Frequency range/band	22-23.6 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	T/R Recommendation 13-02 [14]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	1024	64
Channel spacing and receiver noise bandwidth (MHz)	5.011376305	84.04332097	49.86363223
3 dB bandwidth (MHz)	3.476638162	119.1642969	56
Tx output power (dBW)	-23.9	11.2	-8.1
Maximum Tx output power density (dBW/MHz)	-37.6	-14.5	-27.9
e.i.r.p. (dBW)	12.5	35.8	27.7
e.i.r.p. density range (dBW/MHz)	-2.8	24.2	10.6
Feeder/multiplexer loss (dB)	0.0	25.5	0.1
Antenna gain (dBi)	33.9	45.2	39.6
Receiver noise figure (dB)	5.3	7.0	6.4
Receiver noise power density typical (=NRX) (dBW/MHz)	-137.9	-137.7	-137.9
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.3	-88.8	-101.0
Nominal long-term interference power density (dBW/MHz)(2)	-143.8	-143.7	-143.8
ATPC range (dB)	0.8	27.8	10.3

Table 26: Summary of the data for frequency band 24.5-26.5 GHz

Frequency range/band	24.5-26.5 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	T/R Recommendation 13-02 [14]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	32	2048	64
Channel spacing and receiver noise bandwidth (MHz)	10.72645261	75.79655317	48.79154137
3 dB bandwidth (MHz)	3.448461631	54.76307913	56
Tx output power (dBW)	-27.1	-7.3	-9.9
Maximum Tx output power density (dBW/MHz)	-42.9	-18.4	-29.3
e.i.r.p. (dBW)	8.6	35.8	29.6
e.i.r.p. density range (dBW/MHz)	-6.7	20.9	12.1
Feeder/multiplexer loss (dB)	0,0	30.9	0.0
Antenna gain (dBi)	34.8	46.6	37.9
Receiver noise figure (dB)	5.5	7.5	5.8
Receiver noise power density typical (=NRX) (dBW/MHz)	-137.6	-137.6	-137.6
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.7	-100.6	-113.1
Nominal long-term interference power density (dBW/MHz)(2)	-143.6	-143.4	-143.6
ATPC range (dB)	1.2	22.7	3.9

Table 27: Summary of the data for frequency band 27.9-29.5 GHz

Frequency range/band	27.9-29.5 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	T/R Recommendation 13-02 [14]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	2048	16
Channel spacing and receiver noise bandwidth (MHz)	20.52554745	99.11435523	112
3 dB bandwidth (MHz)	14.25010217	111.5692685	112
Tx output power (dBW)	-28.3	-7.5	-12.0
Maximum Tx output power density (dBW/MHz)	-47.4	-22.5	-32.5
e.i.r.p. (dBW)	9.1	34.2	25.3
e.i.r.p. density range (dBW/MHz)	-10.4	15.8	4.8
Feeder/multiplexer loss (dB)	0.0	21.0	0.0
Antenna gain (dBi)	35.3	42.5	38.0
Receiver noise figure (dB)	6.4	6.4	7.0
Receiver noise power density typical (=NRX) (dBW/MHz)	-137.0	-137.0	-137.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-67.3	-74.2	-119.2
Nominal long-term interference power density (dBW/MHz)(2)	-142.9	-142.9	-143.0
ATPC range (dB)	0.9	11.3	6.0

Table 28: Summary of the data for frequency band 31.8-33.4 GHz

Frequency range/band	31.8-33.4 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ERC Recommendation (01)02 [15]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	2048	128
Channel spacing and receiver noise bandwidth (MHz)	24.05753196	101.2873819	48.59922179
3 dB bandwidth (MHz)	6.879996982	125.8003471	56
Tx output power (dBW)	-20.7	-8.9	-10.5
Maximum Tx output power density (dBW/MHz)	-37.4	-23.6	-31.4
e.i.r.p. (dBW)	20.2	33.6	29.5
e.i.r.p. density range (dBW/MHz)	3.4	18.9	11.3
Feeder/multiplexer loss (dB)	2.1	22.6	0.0
Antenna gain (dBi)	37.1	44.5	39.1
Receiver noise figure (dB)	6.1	7.1	6.8
Receiver noise power density typical (=NRX) (dBW/MHz)	-136.9	-136.8	-136.9
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.0	-101.3	-114.2
Nominal long-term interference power density (dBW/MHz)(2)	-142.9	-142.6	-142.9
ATPC range (dB)	19.4	25.8	22.4

Table 29: Summary of the data for frequency band 37-39.5 GHz

Frequency range/band	37-39.5 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	Recommendation T/R 12-01 [16]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	0	2048	128
Channel spacing and receiver noise bandwidth (MHz)	4.79134143	106.6957424	41.51292303
3 dB bandwidth (MHz)	3.757376266	120.769858	56
Tx output power (dBW)	-32.2	1.1	-15.6
Maximum Tx output power density (dBW/MHz)	-48.4	-5.1	-34.6
e.i.r.p. (dBW)	2.0	32.9	17.3
e.i.r.p. density range (dBW/MHz)	-12.8	20.6	2.0
Feeder/multiplexer loss (dB)	0.3	52.0	0.0
Antenna gain (dBi)	35.2	45.7	39.8
Receiver noise figure (dB)	7.1	9.0	7.6
Receiver noise power density typical (=NRX) (dBW/MHz)	-136.0	-135.9	-136.0
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-124.5	-92.4	-105
Nominal long-term interference power density (dBW/MHz)(2)	-142.2	-142.0	-142.2
ATPC range (dB)	0.9	28.3	7.8

Table 30: Summary of the data for frequency band 40.5-43.5 GHz

Frequency range/band	40.5-43.5 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ECC Recommendation (01)04 [17]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	2048	32
Channel spacing and receiver noise bandwidth (MHz)	26.91200802	106.9180246	50.73903234
3 dB bandwidth (MHz)	28	112	56
Tx output power (dBW)	-29.1	-12.6	-17.5
Maximum Tx output power density (dBW/MHz)	-46.0	-29.3	-43.4
e.i.r.p. (dBW)	0.3	30.3	15.8
e.i.r.p. density range (dBW/MHz)	-17.3	11.4	-3.1
Feeder/multiplexer loss (dB)	0.0	15.7	0.1
Antenna gain (dBi)	38.1	46.0	40.8
Receiver noise figure (dB)	8.1	8.5	8.1
Receiver noise power density typical (=NRX) (dBW/MHz)	-135.8	-135.3	-135.7
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-124.2	-99.1	-113.9
Nominal long-term interference power density (dBW/MHz)(2)	-141.6	-141.6	-141.6
ATPC range (dB)	3.0	17.3	6.5

Table 31: Summary of the data for frequency band 59-64 GHz

Frequency range/band	51.4-52.6 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	16	16
Channel spacing and receiver noise bandwidth (MHz)	14	28	14
3 dB bandwidth (MHz)			
Tx output power (dBW)	-33.0	-27.0	-33.0
Maximum Tx output power density (dBW/MHz)	-47.5	-38.5	-45.0
e.i.r.p. (dBW)	-1.2	14.8	-5.0
e.i.r.p. density range (dBW/MHz)	-15.7	3.3	1-10
Feeder/multiplexer loss (dB)	0.0	10.0	0.0
Antenna gain (dBi)	41.8	41.8	42
Receiver noise figure (dB)	10.0	10.0	10.0
Receiver noise power density typical (=NRX) (dBW/MHz)	-133.9	-133.9	-133.9
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-125.5	-115.5	-115.5
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)	0.0	10.0	0.0

Table 32: Summary of the data for frequency band 59-64 GHz

Frequency range/band	59-64 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement			
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	4	1024	1024
Channel spacing and receiver noise bandwidth (MHz)	1000	1000	1000
3 dB bandwidth (MHz)			
Tx output power (dBW)	-20.0	-5.0	-5.0
Maximum Tx output power density (dBW/MHz)	-50.0	-35.0	-35.0
e.i.r.p. (dBW)	18.0	33.0	33.0
e.i.r.p. density range (dBW/MHz)	-12.0	3.0	3.0
Feeder/multiplexer loss (dB)			
Antenna gain (dBi)	38.0	38.0	38.0
Receiver noise figure (dB)			
Receiver noise power density typical (=NRX) (dBW/MHz)			
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)			
Nominal long-term interference power density (dBW/MHz)(2)			
ATPC range (dB)			

Table 33: Summary of the data for frequency band 71-86 GHz

Frequency range/band	71-86 GHz		
Reference ITU-R Recommendation/CEPT Recommendation for channel arrangement	ECC Recommendation (05)07 [18]		
	Overall minimum	Overall maximum	Overall mode (value(s) which appears the most; (1-2 values)
Modulation format	16	512	32
Channel spacing and receiver noise bandwidth (MHz)	230.2213832	3930.367256	455.3944282
3 dB bandwidth (MHz)	133.3900335	2011.515732	750
Tx output power (dBW)	-25.7	25.5	0.6
Maximum Tx output power density (dBW/MHz)	-49.0	-34.5	-41.9
e.i.r.p. (dBW)	19.2	41.1	26.0
e.i.r.p. density range (dBW/MHz)	-6.2	11.9	3.7
Feeder/multiplexer loss (dB)	0.0	13.7	0.0
Antenna gain (dBi)	40.4	56.4	45.1
Receiver noise figure (dB)	11.3	11.7	11.4
Receiver noise power density typical (=NRX) (dBW/MHz)	-131.5	-131.4	-131.4
Normalised Rx input level for 1 × 10–6 BER (dBW/MHz)	-122.0	-91.1	-101.9
Nominal long-term interference power density (dBW/MHz)(2)	-136.7	-136.4	-137.3
ATPC range (dB)	17.0	34.0	22.8

ANNEX 2: LIST OF REFERENCES

[1] Recommendation ITU-R F.758: "System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference"

[2] Recommendation ITU-R F.2086: "Deployment scenarios for point-to-point systems in the fixed service"

[3] Recommendation ITU-R P.530: "Propagation data and prediction methods required for the design of terrestrial line-of-sight systems"

[4] Recommendation ITU-R P.525-5: "Calculation of free-space attenuation"

[5] Recommendation ITU-R F.1108: "Determination of the criteria to protect fixed service receivers from the emissions of space stations operating in non-geostationary orbits in shared frequency bands"

[6] Recommendation ITU-R F.1093-2: "Effects of multipath propagation on the design and operation of line-of-sight digital fixed wireless systems"

[7] ERC Recommendation 12-08 : “Harmonised radio frequency channel arrangements and block allocations for low, medium and high capacity systems in the band 3600 MHz to 4200 MHz” approved 1997 latest amended May 2024

[8] ERC Recommendation 14-01: “Radio frequency channel arrangements for high capacity analogue and digital radio-relay systems operating in the band 5925 to 6425 MHz” approved May 2015, amended May 2015

[9] ERC Recommendation 14-02: “Radio frequency channel arrangements for high, medium and low capacity digital fixed service systems operating in the band 6425 to 7125 MHz, approved May 1995, latest amended September 2014

[10] ECC Recommendation (02)06: “Preferred channel arrangements for digital Fixed Service Systems operating in the frequency range 7125-8500 MHz”, approved June 2015

[11] Recommendation 12-02: “Harmonised radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the band 12.75 GHz to 13.25 GHz”, approved 1997, revised June 2007

[12] ERC Recommendation 12-07 “Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 14.5-14.62 GHz paired with 15.23-15.35 GHz” approved 1996

[13] ERC Recommendation 12-03: “Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 17.7 GHz to 19.7 GHz”, approved 1996

[14] T/R Recommendation 13-02: “Preferred channel arrangements for fixed service systems in the frequency range 22.0-29.5 GHz”, approved 1993,revised May 2010 and amended May 2019

[15] Recommendation (01)02: “Preferred channel arrangement for fixed service systems operating in the frequency band 31.8-33.4 GHz, approved 2001, revised February 2010 and amended May 2019

[16] Recommendation T/R 12-01: “Preferred channel arrangements for fixed service systems operating in the frequency band 37.0-39.5 GHz, approved 1991,revised February 2010 and amended May 2019

[17] ECC Recommendation (01)04: “Radio frequency channel arrangements for point-to-point (P-P) fixed wireless systems in the frequency band 40.5-43.5 GHz, approved 2001, latest amended January 2025

[18] ECC Recommendation (05)07: “Radio frequency channel arrangements for Fixed Service Systems operating in the bands 71-76 GHz and 81-86 GHz”, approved October 2005, latest amended May 2024