ECC Report 173

Fixed Service in Europe Current use and future trends post 2016

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0 EXECUTIVE SUMMARY

The Fixed Service (FS) is and remains a key service for telecommunication infrastructure development. Since 1997, the CEPT has provided public information to present a picture of the FS deployment in Europe with the intention to use it as a reference and for guidance purposes for administrations, operators and manufacturers.

In 2010, the ECC decided to start the edition of a new report as an updated version of the ECC Report 003 (published in 2002), in order to verify the assumptions of the previous studies and to collect updated information on the number of fixed links for each band in CEPT countries. Therefore, this Report builds on the results of the original ERO Reports on FS trends post-1998 and post-2002 by revising it and updating the information on FS use.

In 2017, a new revision was produced to update the info on effective spectrum use and expectations, also in view of the impact of 5G on FS, including technology trend and licensing regime.

Developments in the technologies show the new trends in the FS sectors: ranging from higher modulation schemes (up to 4096 levels), adaptive modulation schemes to Hybrid/Ethernet technology equipment, better suited for different Quality of Service (QoS) levels and high capacity links.

Fixed Wireless Access (FWA) applications are either stable/decreasing in higher frequency bands or migrating to converged Broadband Wireless Access (BWA) applications networks in bands at around 3500 MHz or below.

The information gathered for developing this Report gives the evidence that the current trends in the FS market place are for an ever increasing provision of high bandwidth capacity for the mobile networks infrastructures. These very high capacity links are able to provide a viable alternative to deploying fibre optic especially in rural areas but equally in high density urban areas where there would be severe disruption regarding fibres such as the ones caused by digging up roads and/or emergency and disaster situations.

As a consequence the Report highlights the strategic importance of some frequency bands for the FS. Some of these bands have already started to show a rapid growth in terms of number of links (13 GHz, 15 GHz, 18 GHz, 23 GHz and 38 GHz), and on which special attention from administrations should be taken; while others (70/80 GHz) start or preparing to take off (32 GHz, 50 GHz and 92 GHz) at time of publication of this revision.

Several administrations are open to the use of higher frequencies including W-band (92-114.25 GHz) and D-band (130-174.8 GHz).

In addition, the potentially interesting issue of Non Line of Sight (NLOS) urban backhauling for the new generation of mobile networks might open for new applications also FS bands below about 6 GHz.

This Report highlights also the fact that the CEPT proactively responds to the industry demand for efficient usage in the new millimetric wave bands with a set of new or revised recommendations. In term, it creates a healthy competitive FS environment with wider harmonisation use of FS. As part of the development strategies, the CEPT, in 2011, revised the recommendation on the usage of the band 7125-8500 MHz with a view to harmonise its use in Europe for countries that are in a position to refarm it, as it is the only FS band lacking harmonisation incentives (in terms of clear CEPT policy and/or channel arrangements).

Regarding the assignment procedures used, the responses show that for Point-to-Point (P-P) links the most used method foresees conventional link by link assignment and centralised coordination. However, assignment/auction of frequency blocks in certain bands becomes also popular; this is particularly true when also Point-to-Multipoint (P-MP) (or, in some cases, even mixed FS and other telecommunication service) are permitted.

For millimetric frequencies different licensing regimes exist. The majority of the administrations apply link-by-link assignment, while a significant percentage (about 20% of the total answers) declares light license or unlicensed regimes.

Possibility to modify licensing regime in the short- or medium- term is also indicated.

Concerning the fees, 22 administrations declare willingness to increase the use of millimetric frequencies by means of fees incentives.

ECO Report 04[1] provides information on the national implementation of the FS channel arrangements covered by ECC/ERC Recommendations, including the related National restrictions. ECO Report 04 in combination with this Report offers a concise overview on FS usage in various frequency bands over Europe for FS related spectrum inventory purposes.

[1] ECO Report 04, Fixed Service in Europe Implementation Status, last update 27 May 2017.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
2G	Second Generation digital cellular network
3G	Third Generation digital cellular network
4G	Fourth Generation digital cellular network
5G	Fifth Generation digital cellular network
AM	Adaptive Modulation
ANFR	Agence Nationale des Fréquences
ARCEP	Autorité de Régulation des Communications Electroniques et des Postes
ATPC	Automatic Transmit Power Control
BCA	Bands and Carrier Aggregation
BEM	Block Edge Mask
BER	Bit Error Rate
BFWA	Broadband Fixed Wireless Access
BNetzA	Bundesnetzagentur/Federal Network Agency
BWA	Broadband Wireless Access
CAGR	Compound Annual Growth Rate
CCDP	Co-Channel Dual-Polarization
CEPT	European Conference of Postal and Telecommunications Administrations
CES	Circuit Emulation
CPE	Customer Premise Equipment
CRS	Cognitive Radio System
CS	Channel Spacing or Channel Separation
DFS	Dynamic Frequency Selection
DSL	Digital Subscriber Line
ECC	Electronic Communications Committee
ECO	European Communications Office
e.i.r.p.	Equivalent (or Effective) isotropically radiated power
ERO	European Radiocommunications Office
ETSI	European Telecommunication Standard Institute
FDD	Frequency Division Duplex
FM	Fade Margin
FS	Fixed Service
FWA	Fixed Wireless Access

FWS	Fixed Wireless System
GSM	Global System for Mobile Communications
GSO	Geostationary Satellite Orbit
HSPA	High-Speed Packet Access
HSPA+	Evolved HSPA
IMT	International Mobile Telecommunications
IMT-2000	International Mobile Telecommunications-2000
IMT-Advanced	International Mobile Telecommunications Advanced: requirements for 4G Standards
IMT-2020	International Mobile Telecommunications-2020
I/N	Interference to Noise ratio
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISM	Industrial Scientific Medial
LAN	Local Area Network
LOS	Line of Sight
LTE	Long Term Evolution
MFCN	Mobile/Fixed Communication Networks
MGWS	Multi Gigabit Wireless Systems
MIMO	Multiple Input Multiple Output
mmW	Millimetric wave
MP-MP	Multipoint-to-Multipoint
MSS	Mobile Satellite System
MW	Microwave
MWA	Mobile Wireless Access
MWS	Multimedia Wireless System
NLOS	Non Line of Sight
NWA	Nomadic Wireless Access
OFCOM	Office Of Communications
OFDM	Orthogonal Frequency-Division Multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
PABX	Private Automatic Branch Exchange
PAMR	Public Access Mobile Radio
PDH	Plesiochronous Digital Hierarchy
PES	Permanent Earth Station
PHY	Physical
P-MP	Point-to-Multipoint

PMR	Professional (or Private) Mobile Radio
P-P	Point-to-Point
PPDR	Public Protection and Disaster Relief
PSTN	Public Switched Telecommunication Network
PW	Pseudo-Wire
QAM	Quadrature Amplitude Modulation
QLOS	Quasi Line of Sight
QoS	Quality of Service
RAS	Radio Astronomy Service
RBER	Residual BER
RPE	Radiation Pattern Envelope
RR	Radio Regulations
SDH	Synchronous Digital Hierarchy
SME	Small Medium Enterprise
SOHO	Small Office Home Office
SRD	Short Range Device
TDD	Time Division Duplex
TDM	Time-Division Multiplexing
TDMA	Time-Division Multiple Access
UHF	Ultra High Frequency (300 MHz-3 GHz)
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
VCO	Voltage-Controlled Oscillator
VHF	Very High Frequency (30-300 MHz)
WiMAX	Worldwide Interoperability for Microwave Access
WRC	World Radiocommunication Conference
XPIC	Cross Polarization Interference Cancellation

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

This activity of collecting info on Fixed Service (FS) use and trend in Europe started in 1997 and several updates were produced over time. This information is highly appreciated by the administrations and industry.

This version is based on results of two questionnaires, the first for frequencies above 50 GHz, the second for frequencies below, developed in 2015 and 2016.

In addition, ECO Report 04 provides the national implementation information for the FS channel arrangements covered by ECC/ERC Recommendations, including the related National restrictions. ECO Report 04 in combination with this Report offers a concise overview on FS usage in various frequency bands over Europe for FS related spectrum inventory purposes.

1.2 OBJECTIVE OF THE STUDY

This study of spectrum requirements for the fixed service had three objectives, namely:

- To provide a comprehensive overview of the development of civil fixed services from 1997 up to 2017;
- To provide a useful reference for administrations, manufacturers and telecom operators on issues surrounding the developments of civil[2] fixed services in Europe;
- To provide a rationale for the general trends with information gathered for the whole CEPT highlighting the basis for these observations.

1.3 METHODOLOGY

The major source of factual data used in the development of this Report, were the questionnaire on FS use and future trends, conducted through CEPT administrations in 2015-2016. In total, 25 administrations and 11 operating/manufacturer companies responded to these questionnaires.

Detailed evaluation of the evolution of FS situation in Europe is done based on the answer of the 23 countries answering both questionnaires (see Table 1), while only comparison trends is accomplished for older versions, due to the absence of database in electronic format for previous questionnaires.

1.4 CONTRIBUTIONS TO THE STUDY

Table 1: Countries replies to the questionnaires

Country Code	Country	1997	2001	2010	2016	Country considered in the comparison
AUT	Austria	X	X	X	X	X
HRV	Croatia	X	X	X	X	X
CZE	Czech Republic	X	X	X	X	X
DNK	Denmark	X	X	X		
FIN	Finland	X	X	X	X	X
F	France	X	X	X	X	X
D	Germany	X	X	X	X	X

[2] Military FSs are not treated in this Report.

Country Code	Country	1997	2001	2010	2016	Country considered in the comparison
HNG	Hungary	X	X	X	X	X
IRL	Ireland	X	X	X	X	X
I	Italy	X	X	X	X	X
LVA	Latvia	X	X	X	X	X
LTU	Lithuania	X	X	X		
LUX	Luxembourg	X	X	X		
NOR	Norway	X	X	X	X	X
POR	Portugal	X	X	X	X	X
SVN	Slovenia	X	X	X	X	X
S	Sweden	X	X	X	X	X
SUI	Switzerland	X	X	X	X	X
G	United Kingdom	X	X	X	X	X
BIH	Bosnia and Herzegovina			X	X	X
CYP	Cyprus			X		
EST	Estonia		X	X	X	X
GRC	Greece			X	X	X
ISL	Iceland	X		X		
HOL	Netherlands			X	X	X
POL	Poland			X		
ROU	Romania			X	X	X
RUS	Russia			X	X	X
SRB	Serbia			X		
SVK	Slovak Republic		X	X	X	X
E	Spain			X		
BEL	Belgium	X	X			
BUL	Bulgaria	X			X	
TUR	Turkey	X	X		X	
MLT	Malta				X	
Total		23	23	31	25	23

The summary of the responses on national FS use in tabular form is given in ANNEX 1: to the Report.

Also 11 operating/manufacturer companies/associations provided their feedbacks: 4RF communications, Wind Telecomunicazioni, OTE, EUTC, Orange, Huawei Technologies, Ericsson, Mobitel EAD, Telenor Bulgaria, Telia and Magyar Telecom.

2 DEFINITIONS (OPTIONAL SECTION)

Term	Definition
CAGR	The **Compound annual growth rate** is a specific term for the smoothed annualized gain over a given time period. It is defined as: $$\mathrm{CAGR}(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$$ where $V(t_0)$: start value $V(t_n)$: finish value $t_n - t_0$: number of years
Terabyte	1 thousand Gigabytes
Petabyte	1 thousand Terabytes
Exabyte	1 thousand Petabytes

3 EUROPEAN FS MARKET AND ITS REGULATION

3.1 GENERAL MARKET TRENDS

Liberalisation of telecommunications has taken place and consolidated on a global basis over the last decades with new operators entering increasingly competitive markets and offering an increasing range of telecommunication services. Many operators are also forming strategic alliances in order to expand their markets beyond primarily national boundaries and to enter new areas.

This new market environment has enabled real competition in telecommunications, which has had an impact not just on the provision of telecommunication services, but also on the supporting infrastructure, whether wireless or cable.

Aside from mobile communications, which are by now well and long established users of radio technologies, many other “traditional” telecom operators started to look more attentively to wireless communications to facilitate speedy implementation, flexibility and economical provision of their networks. This trend, started during the 1990’s, has continued to happen and may be observed both in the provisioning of fixed wireless access for customer connections and in other areas like, for example, in supporting infrastructure for public mobile networks or for other telecommunication networks. This new demand for using radio technologies comes in addition to a considerable fixed radio network infrastructures already for long time in use by incumbent operators, as part of their public switched telephone network (PSTN) , national broadcast distribution (feeder links to regional VHF/UHF transmitters) networks, etc.

The most significant increases of Fixed Service (FS) assignments over the last two decades still came in particular from the area of infrastructure support for public mobile networks, where the reported number of Point to Point (P-P) links shows an annual growth between 1997 and 2016. This demand is expected to increase further with the expected growth in capacity and number of connected nodes (base stations) with the evolution of mobile networks.
Provisioning of infrastructure support through various Point-to-MultiPoint (P-MP) technologies (e.g. universally licensed Fixed Wireless Access (FWA) networks and tailored P-MP backbone networks) is also being considered, or already implemented in some countries as a viable alternative option in the environment with high density of served base stations (e.g. dense urban areas).

The growth in number of FS links is likely to continue for the foreseeable future. In that respect it may be noted, that CEPT has already made several successful moves towards ensuring favourable conditions for such growth, by developing ECC Decisions, Recommendations with relevant channel arrangements and identifying additional bands for high density applications in the FS, including FWA and infrastructure support. The objective of new recommendations and the approach to management of the radio spectrum is to promote innovation and competition in the provision of wireless services. Radio spectrum is a key resource for communication services and its efficient utilisation is critical in the future.

3.2 ROLE OF FIXED SERVICE

Fixed radio links provide a transmission path between two or more fixed points for provision of telecommunication services such as voice, data or video transmission. Typical user sectors for fixed links are telecom operators (mobile network infrastructure, fixed/mobile network backbone links – see Figure 1 as an example of the mobile infrastructure), corporate users (private data networks, connection of remote premises, etc. – see Figure 2) and private users (customer access to PSTN or other networks – see Figure 3). Within each application either P-P or P-MP can be used for each link.

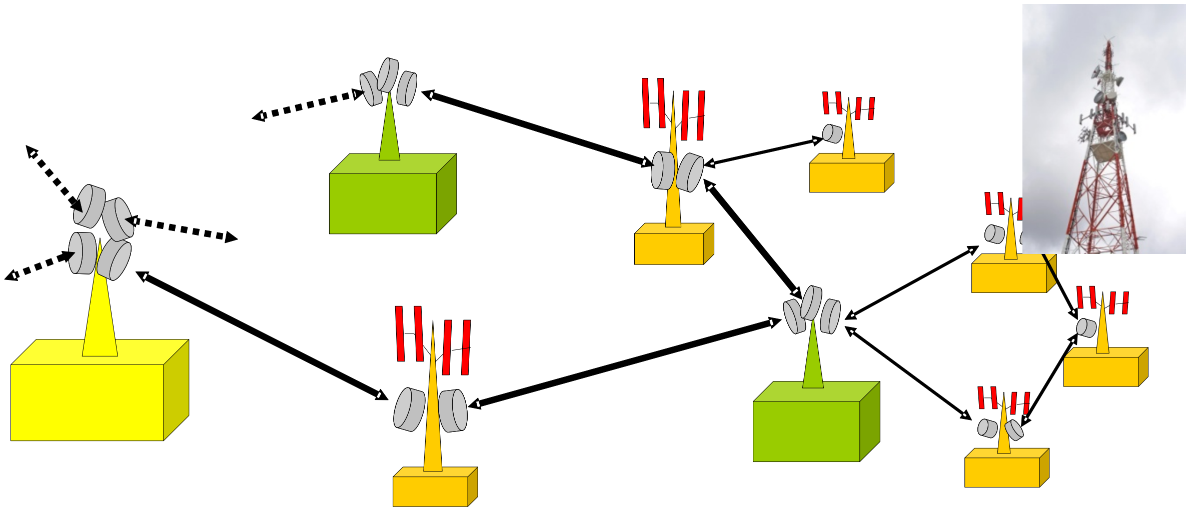

Figure 1: Example of fixed links deployment within the infrastructure of mobile network

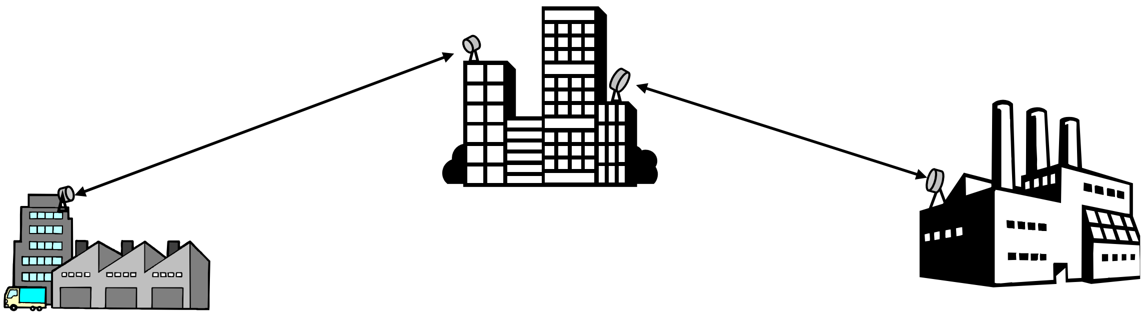

Figure 2: Example of a private radio relay link (e.g. for LAN, PABX inter-connection of premises)

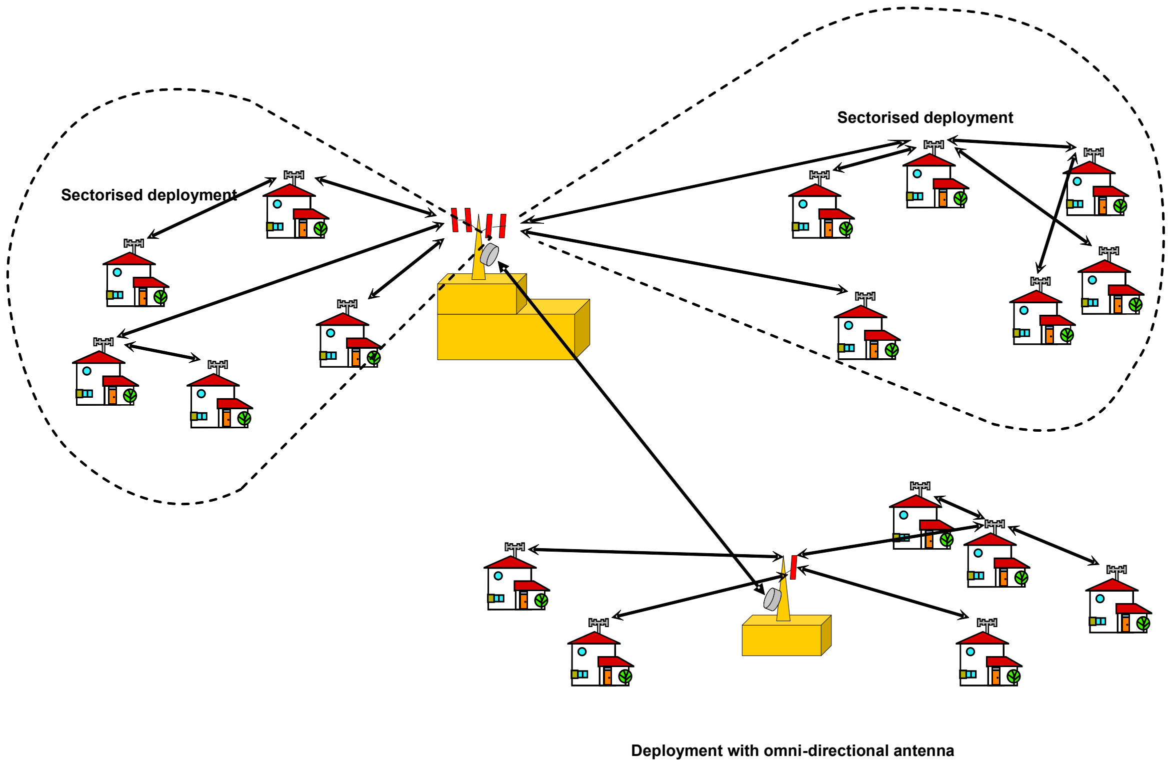

Figure 3: Example of P-MP FWA / BWA network including a P-P infrastructure connection

Fixed radio links, instead of cable and fibre, are often the preferred solution where constraints such as cost, local topography (e.g. mountainous terrain or paths across water) and the need for access to remote rural regions are fundamental considerations. In many such cases, fixed radio links are the only practical solution.

Also in today's competitive environment the ability to further roll out a network rapidly by using radio as transmission media provides an operator with the flexibility to install and scale transmission paths as and when required. This is particularly important as it allows the possibility to reduce and better distribute the required investments, by testing the service and directing revenues as they appear into further development of a network where most use occurs.

It is appropriate to note that being the integral and indispensable part of overall telecommunication infrastructure, fixed service provides a significant contribution to national economies in financial terms.

Furthermore, public mobile service is currently one of the most significant users of spectrum in Europe and all forecasts estimate that it will also be the source of the highest demand for spectrum over the next 10 years. This is primarily due to the expected growth in data traffic over the coming years.

Cisco estimates that data traffic will grow at a Compound Annual Growth Rate (CAGR) of 54% in next future. Trend of growth is indicated in Figure 4.

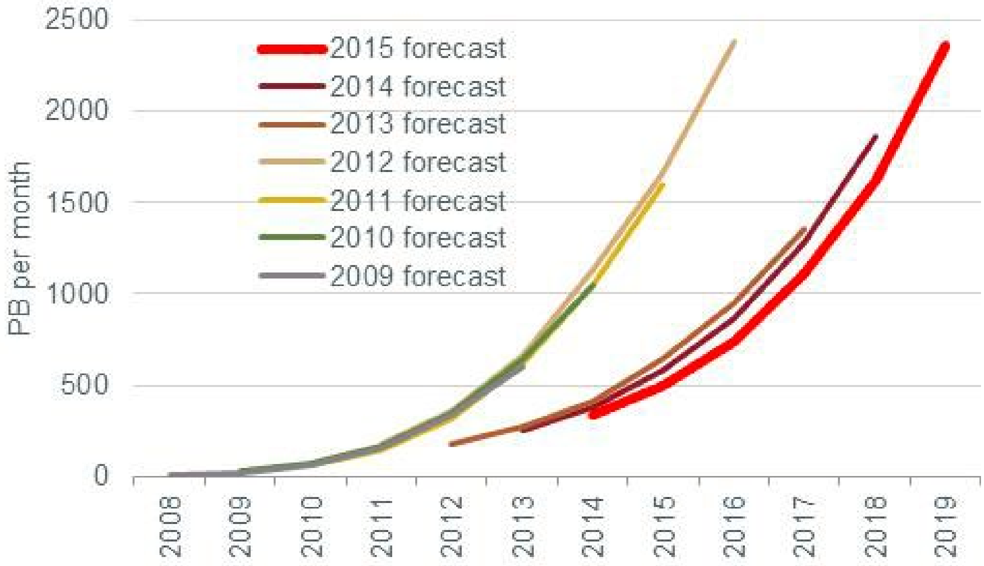

Figure 4: Data traffic forecast (source Cisco)

As a further example, in France about 80% of fixed service link capacity is used by mobile operators In the near future it is expected an important growth of data traffic due to broadband backhaul links supporting terrestrial cellular networks. For instance, the increased smartphone usage with several new applications running is likely to increase network congestion.

3.3 FIXED SERVICE GROWTH

The FS usage figures obtained from 2016 questionnaire, compared with the usage figures obtained in previous studies (see Figure 5), confirms a continuous trend in increase of FS use in Europe (in the order of 85% in 2016, about 75% between in 2010, and 33% in 2001). This corresponds to a CAGR of 8.5% for all period (1997 to 2016).

The trend for the period 1997-2010 was calculated based on data from the 19 administrations answering all the first three questionnaires, while figure for the 2010-2016 period is based on 23 administrations answering both 2010 and 2016 questionnaires.

Figure 5 gives the variation in percentage, relative to previous questionnaire (the first data are from 1997).

In numerical terms, the number of active P-P links declared by respondent administrations increased form the about 160000 links reported in 1997 to about 740000 declared in 2016. The margin of error, due to a non-homogeneous base of respondent administrations in every questionnaire, is estimated to be less than 5%. A detailed comparison of number of links, based on answers from those administrations that answered all questionnaires, was not possible, since data from questionnaires in 1997 and 2001 are not available in an electronic form.

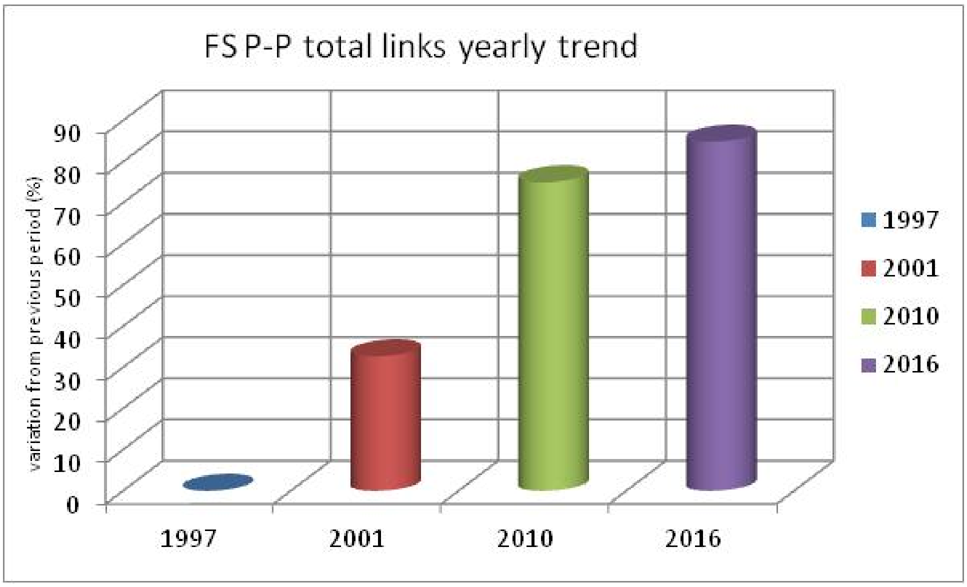

Figure 5: Trend of increase in FS links in Europe for the countries that participated to CEPT questionnaires

The major growth in FS usage was reported in the area of infrastructure support (about 740000 links in 2016, vs. 500000 in 2010, 150000 in 2001 and 73000 in 1997). This trend should be due to the major success of the 3G/4G mobile networks. These networks have developed rapidly over the last few years and the arrival of for IMT-Advanced/ IMT 2000, with the broadband mobile access networks, will imply further increase in FS use for such purpose. The use of unidirectional links has significantly decreased from 2010 (25.5 % to 0.6% of total number of bidirectional links)

Table 2: Total declared number of FS active links

Year	P-P total	P-P(unidirectional)	P-MP Central Stations
2010	494449	126459	21195
2016	742820	4889	34219

3.4 REGULATORY REGIME FOR FS

In addition to data on actual use and future trends of FS in their countries, CEPT administrations were asked to describe the principles used in managing assignments of FS links. From the responses received it appears that all CEPT administrations as a general rule apply central management, i.e. where the administration is the responsible manager of the FS frequency assignments. This central management has not changed for the last two decades. The exceptions are few such as in France, were FS operations within the bands exclusively used by a particular authority or Ministry are subject only to notification procedure (for details see ANNEX 2:).

However, within the framework of centralised management of frequency assignment for the FS, many administrations carry out block assignment of frequencies in selected bands, i.e. where licensees are allocated a block of spectrum within which they deploy and manage links themselves.

3.5 FS ASSIGNMENT METHODS

The assignment methods currently present in the Fixed Service regulatory framework of most CEPT countries may be summarised in the following four categories:

1. **Individual licensing**: this is the conventional link by link coordination (frequency and geographical planning), usually made under administration's responsibility; sometime, the administration delegates this

task to the operators, but it keep control of the national and cross-border interference situation. This is currently assumed to be the most efficient method of spectrum usage for P-P links networks.

2. **Light licensing**: even if the terminology itself is not completely agreed among CEPT administrations (see ECC Report 132), the common understanding, when fixed P-P links are concerned, refers to a link by link coordination, under users responsibility, reflected in the definition given by ECC Report 80 as:
   "A 'light licensing regime" is a combination of licence-exempt use and protection of users of spectrum. This model has a "first come first served" feature where the user notifies the regulator with the position and characteristics of the stations. The database of installed stations containing appropriate technical parameters (location, frequency, power, antenna etc.) is publicly available and should thus be consulted before installing new stations. If the transmitter can be installed without affecting stations already registered (i.e. not exceeding a pre-defined interference criteria), the new station can be recorded in the database. A mechanism remains necessary to enable a new entrant to challenge whether a station already recorded is really used or not. New entrants should be able to find an agreement with existing users in case interference criteria are exceeded."
   From the spectrum usage point of view, this method is, in principle, equivalent to the individual licensing; only the potential risks of "errors" or "misuses" in the coordination process might be higher because of the number of actors involved, some of them also not enough technically prepared.

3. **Block assignment**: the assignment might be made through licensing (renewable, but not permanent) or through public auction (permanent). This is most common when Fixed Wireless Access(FWA) (P-MP) is concerned and the user is usually free to use the block at best to deploy its network; in some cases, there might even be no limitation to the wireless communications methods used in the block (e.g. P-P and/or P-MP, terrestrial and/or satellite or any other innovative technology or architecture). In the most popular bands for this method, ECC recommendations exist, suggesting intra-blocks protections guidelines in terms of guard bands or Block Edge Masks (BEM). For some frequency bands this method is considered the best compromise between efficient spectrum usage and flexibility for the user.

4. **License exempt**: this method offers the most flexible and cheap usage, but does not guarantee any interference protection. It is most popular in specific bands (e.g. 2.4 GHz and 5 GHz) where SRD are allocated, but FS applications may also be accommodated; in addition, it is often used in bands between 57 GHz and 64 GHz less attractive due to the unfavourable propagation attenuation.

From the responses to the questionnaires individual licensing (frequency assignment of each individual link assignment method) continues to be the predominant method in making assignments in the majority of the bands for which information has been provided. This is followed by block assignment, which, while it does not dominate as a method, tends to be applied across most bands. Block assignment is on par with link by link assignment in the 3.4-4.2 GHz range and 24.5-26.5 GHz bands. The reason for this is presumed to be related to the initial P-P links deployment, later on partially switched to possible P-MP applications.

Licence exemption becomes more prominent in bands between 57 GHz and 64 GHz, where oxygen absorption is significant, reducing the risk of interference. Above 64 GHz (i.e. in 64-66 GHz and 71-76/81-86 GHz and 92-95 GHz bands) the favourable propagation conditions justify that in most responses the link by link assignment predominates over the use of licence exemption. However, in some administrations there is also the emergence of a self-coordinated approach, in conjunction of light licensing, to making assignments in these bands.

The decision of an administration for a particular assignment procedure for a particular band or an application can be influenced by a number of factors, which could have different backgrounds such as regulatory, administrative, technology/application or market driven:

- National Regulatory Framework: an administration is bound in its regulatory framework provided by their Telecommunications Act, which gives administrations certain possibilities, or flexibility limits in terms of the frequency assignment. On the other hand, this legal framework could also restrict to certain procedures, which may not always be beneficial under specific circumstances.
- Administrative Factors: the choice for an assignment procedure is also very much influenced by administrative factors. The ability to handle the incoming amount of frequency assignment applications largely depends on the efficiency of the administrative handling, the assignment tool used and the manpower available in a particular administration.

- Propagation factors: the current interest for very high capacity systems in frequency bands higher than 55 GHz, implies that the additional oxygen absorption has to be taken into account. The region between 57 GHz to 64 GHz might be more appropriate for unlicensed (uncoordinated) deployment, while above this range a coordinated (either licensed or light licensed option) deployments might offer a better spectrum usage.
- Technology Drivers: As already reported in the ECC Report 003 in 2002, the decision for or against the individual assignment or block assignment also depends on the technology, employed by a particular application in question. For example, in the case of P-MP systems, an individual assignment of each single link could produce an unnecessary administrative burden for the operator and the Administration. In this case, the individual frequency assignment for the base station or at least information on the base station location could be sufficient for the administration to impose measures to ensure co-existence with neighbouring assignments of the same or different systems (operators).
- Market Forces: Market forces also influence the decision for the assignment method. The time pressure for the introduction of new systems could impose the use of a speedy process for the frequency assignment in order not to hinder the rollout of networks, which are intended to enter the market quickly. Also the expected/desired major utilisation (e.g. for private or public infrastructures) may have a role in selecting the assignment method.

3.6 FREQUENCY BANDS REFARMING

Refarming is a set of administrative, economic and technical measures, aimed at achieving the recovery of a particular frequency band from its existing users for the purpose of re-assignment, either for new uses, or for the introduction of new spectrally efficient technologies. For the FS sector, it means to vacate some of the occupied bands and obtaining new bands for development of new services. The most notable examples of FS surrendering a particular band, are the bands around 2 GHz, which were historically used for FS communications, but which had to be re-located to mobile services since the early 1990’s.

It is an important tool to optimize spectrum efficiency with a better re-arrangement of FS bands, used for different users or services. Examples of such “internal” refarming may be the conversion from P-P to P-MP use (e.g. in the band 3400-3600 MHz), the conversion from military to civil FS use, etc. Therefore FS spectrum management authorities should be well aware of advantages and mechanisms of spectrum refarming as well as of the re-deployment costs (e.g. to relocate current users in new bands or in new channel plan). For this reason, in practice, it has to be kept in mind that in some cases refarming process may be extremely difficult, especially when the concerned band has reached a high level of FS deployment (e.g. the 7/8 GHz bands where many countries might not be in a position to refarm the bands, due to the deployment level already reached).

3.7 SPECTRUM TRADING

Spectrum trading enables the holders of certain wireless licenses to transfer (or, since May 2011, also to lease) their rights to use radio spectrum to another party in accordance with the conditions attached to their authorisations and in accordance with national procedures. This is expressly provided for by the EU framework for electronic communications networks and services. The framework also empowers the EU Commission to adopt appropriate implementing measures to identify frequency bands in which trading must be allowed although this does not extend to frequencies used for broadcasting. This is related to EU countries only and, as of the date of this Report the EU Commission has not adopted any such measures yet.

Nevertheless, national procedures to allow trading of spectrum have been implemented for fixed service spectrum in some CEPT countries.

4 TECHNOLOGY TRENDS

4.1 POINT-TO-POINT LINKS

The technology evolution is obviously continuously driven by the market demand, which implies continuous improvements in the payload management, error performance and spectral efficiency.

4.1.1 Payload management

The major market of P-P links is the mobile networks backhauling. This first of all indicates that higher and higher capacity systems will be mostly required.

A second major change in the market demand is the progressive evolution of the radio traffic nature from TDM (e.g. PDH and SDH mostly used in current mobile networks) to Packet traffic (e.g. IP/Ethernet required by the new generation of mobile networks).

Such passage will be smooth (i.e. mixed old and new network areas need to coexist and interact for long time) using initially Hybrid Microwave (MW), which encapsulates native TDM and packet services into the same radio frame (Figure 6: a)). Newest equipment can already be designed as full packet radio system, which directly manage native packet traffic, while, using techniques like Pseudo-Wire (PW) and Circuit Emulation (CES) are able to merge TDM traffic into Packet traffic on the same common transport frame (Figure 6: b)).

Proper mechanisms will have to be established to guarantee to each transported traffic type, e.g. voice, real-time and data, the right performances, as error ratio and jitter, shall be employed. Packet QoS will be used as flow control technique in particular when Adaptive Modulation (AM) is enabled in order to schedule traffic quote to be added or dropped.

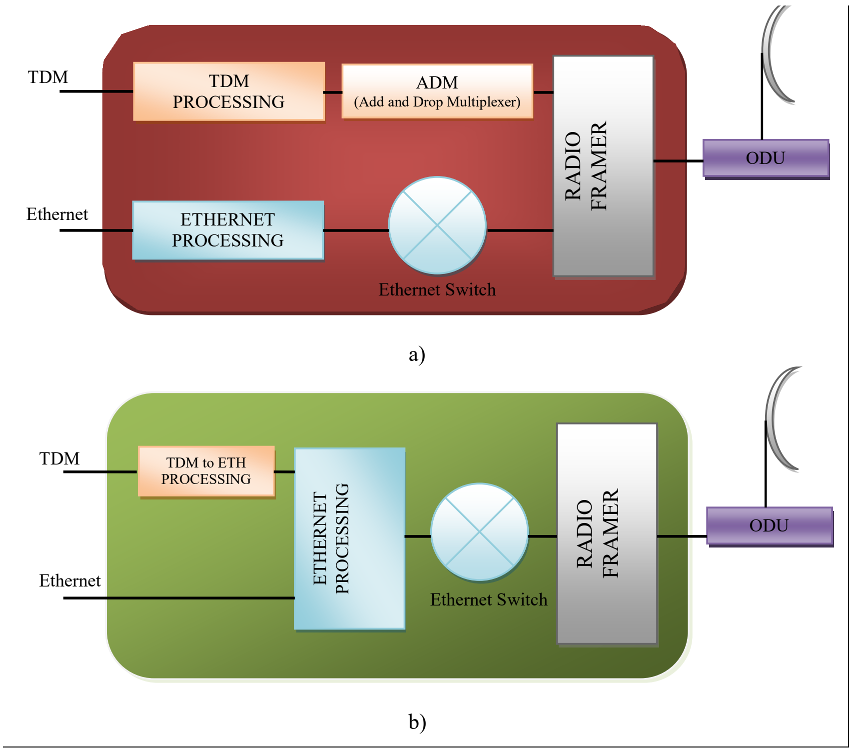

Figure 6: Evolution from Hybrid MW (a) towards Packet MW (b)

4.1.2 Modulation, spectral efficiency and error performance enhancement

4.1.2.1 Modulation and spectral efficiency

Advances in the area of modulation and coding (error correction) technology, new modem chips, and Microwave (MW) components like low phase noise VCO, are having a profound effect on the increase of capacities of P-P links. Today modulation schemes of as high as 128-QAM are used widely for trunk/infrastructure networks and modulation as high as 16-QAM is increasingly used for access links. New equipment can cope with modulation formats up to 1024 -QAM and the introduction in the market of 4096-QAM systems is expected in short time.

The diagram of spectral efficiency vs modulation index is shown in Figure 7.

The flexibility in applying higher modulation orders to achieve higher throughput in a given channel bandwidth may allow operators to solve capacity problems within the conditions of spectrum scarcity in a particular frequency band.

The actual increase in transport capacity with the modulation format follows a growing trend only with the logarithm of the modulation index. Therefore the increase becomes, in percentage, lower and lower as the modulation index increase. Taking also into account the need for more redundant error correction codes, a further enhancement beyond 4096-QAM might no longer justify the technology investment for their development.

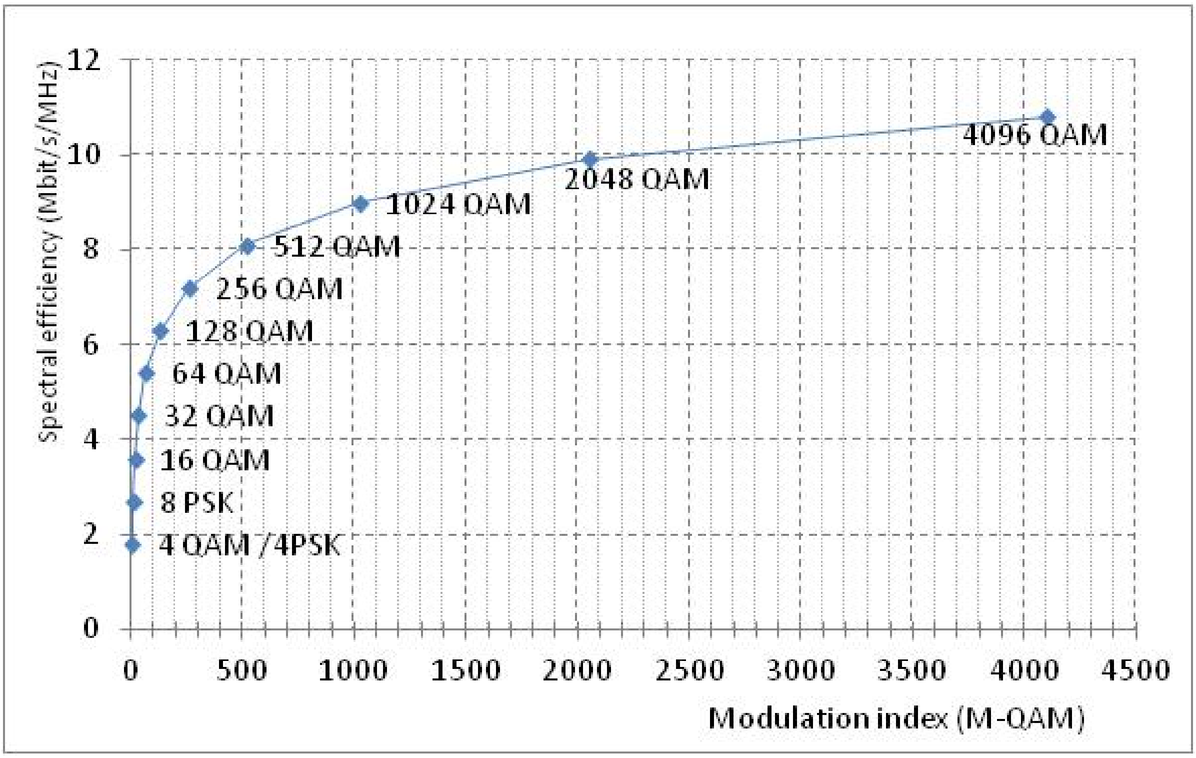

Figure 7: Spectral Efficiency versus Modulation index (example for symbol frequency of around 0.9 CS)

4.1.2.2 Polarisation

The additional use of Cross-Polarization Interference Cancellation (XPIC) to double capacity in Co-Channel Dual-Polarization (CCDP) applications is already a well consolidated technique and should also be more and more utilised. XPIC is already implemented by several administrations, and a trend for increase use is declared. Use of MIMO is in phase of initial consideration.

4.1.2.3 Channel size and new bands

A further possibility for increasing link capacity is the use of systems operating on wider Channel Spacing. The following opportunities are likely to be more and more used:

- band in 6 GHz range: 55 MHz was indicated by Finland, (XPIC, 1 Gbit/s);
- bands below about 13 GHz: 2x28, 2x29.65 and 2x40 MHz CS; these are options recently introduced in relevant ECC and ITU-R recommended channel arrangements, which could be used whenever the coordination with existing networks permits;
- bands in range 15-57 GHz: 56 and, up to 42 GHz, 112 MHz CS[3];
- bands above 57 GHz: e.g. Nx250 MHz CS in 71-76/81-86 GHz.

E-Band equipment (71-86 GHz) with modulation formats up to of 128 QAM is already available. The forthcoming W-band (92-114.25 GHz) and D-band (130-174.8 GHz) result particularly promising in term of capacity (multi Gbit/s radio). Technology evolution, still to be consolidated in higher frequencies above 150 GHz, allows the expectation for commercial availability of equipment, already developed as prototypes for field trials, in next few years.

Low interest is expressed for some high frequency bands such as the 50, the 52 and the 55 GHz even if ECC Recommendations are available since many years.

4.1.2.4 Expectations of changes of the FS applications and technological evolution

A wide consensus was expressed in 2016 on the need for fixed service towards applications that, although formally not so different from today's use (network infrastructure for fixed and mobile, infrastructure for broadcast etc.), can allow capability of ever increasing capacity.

Several available technological options have been indicated to reach this objective including increase channel bandwidth and modulations, XPIC use, increase of modulation order, adaptive modulation, MIMO and use of different network topology.

4.1.2.5 Adaptive modulation

The new services offered to the end-user, over IP based platforms, are going to evolve with different degrees of quality (pay for quality) from the simplest "best effort" to different increasing degrees of guaranteed traffic availabilities. Therefore, the AM algorithm, widely implemented in equipment in all frequency ranges, perfectly fits the quality requirement and allows the use of high modulation schemes even in access links. AM is used to dynamically increase radio throughput by scaling modulation schemes (e.g. 4-QAM → 64-QAM → 256-QAM) according to the current propagation condition (Figure 8).

The modulation scheme can be changed errorless and traffic is added during modulation scaling up or dropped during modulation scaling down according to the assigned priority profile.

More insight on AM can be found in ETSI TR 103 103 on "Fixed Radio Systems; Point-to-point systems; ATPC, RTPC, Adaptive Modulation (mixed-mode) and Bandwidth Adaptive functionalities; Technical background and impact on deployment, link design and coordination".

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[3] In this frequency range the band 40.5 – 42.5 GHz has been opened to P-P systems too.

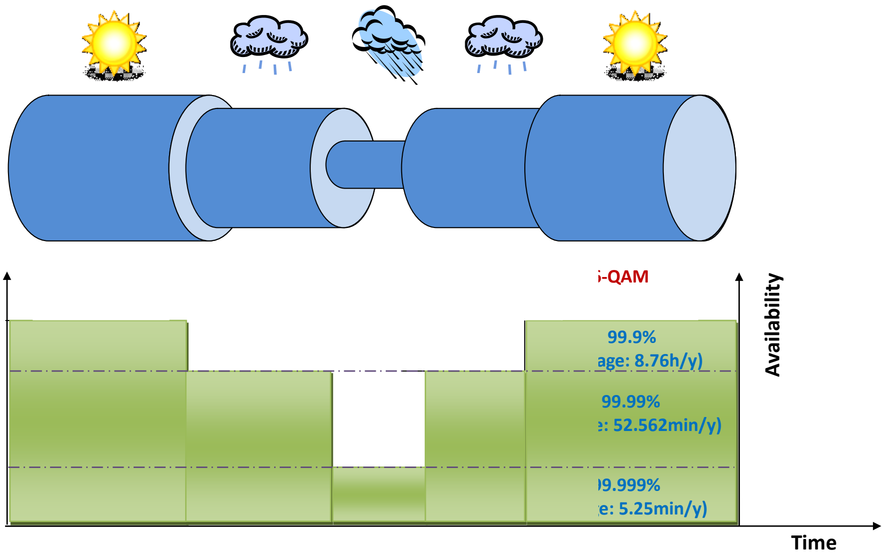

Figure 8: Adaptive Modulation example (availability/outage figures are indicative)

4.1.2.6 Bands and Carrier Aggregation concept

Bands and Carrier Aggregation is a new technology that is taking place in the mobile backhaul arena.

The main idea behind the Bands and Carriers Aggregation (BCA) is to build-on a point-to-point connection, using two or more “carriers” that can even belong to different frequency bands and may have different channel size as well. From the payload perspective, what could be obtained looks like a single carrier connection using a big channel and with plenty of adaptive modulation steps. The result is a payload with different steps in term of capacity/availability, see Figure 11, as per the well know concept of adaptive modulation, but with more capacity and higher number of capacity steps.

The main novelty here is due the fact that with respect to the adaptive modulation, more and different degrees of freedom in link budged are possible. Playing with these degrees of freedom, it is possible to reach different advantages, on top of a huge baseline level of capacity, with respect to a traditional approach, ranging from a more efficient use of the spectrum to a way to decongest some portions of frequency spectrum (removing the boundary to use channels belonging to the same bands).

A general implementation of BCA includes a carrier aggregation engine and different physical radio channels (Figure 9). Most of BCA benefits can be obtained thanks to the engine design which may consider both the required traffic QoS and the conditions and peculiarities of the radio channels chosen.

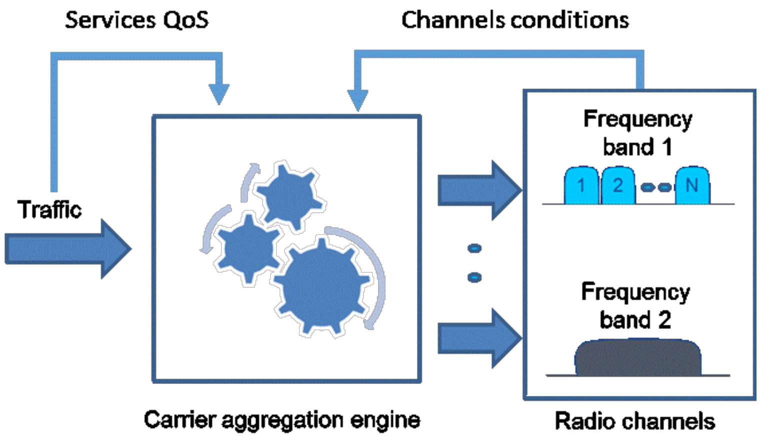

Figure 9: BCA concept

The main use cases applicable to BCA are:

- Channels aggregation in low microwave frequency bands (long-haul application);
- Channels aggregation in medium microwave frequency bands;
- Channels aggregation in traditional microwave frequency bands and W-bands (E-Band).

The last case is the most popular today, considering the wireless transport evolution.

Figure 10 shows an example where a single dual band antenna combines a dual polarisation signal at 18 GHz with one E-Band feed (i.e. composing a 3+0 system). It should be noted that with this approach it could be possible to transmit multi-Gbps capacity over 7 to 10 km.

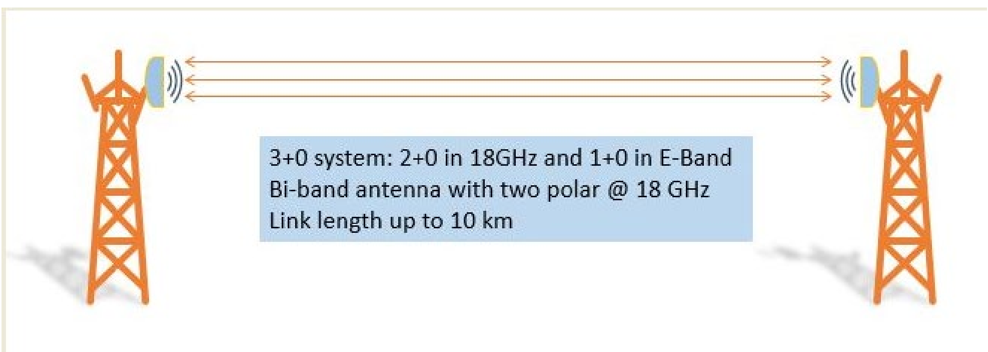

Figure 10: BCA in traditional microwave bands plus E-Band

A typical shape of capacity/availability performance for this case is depicted in Figure 11.

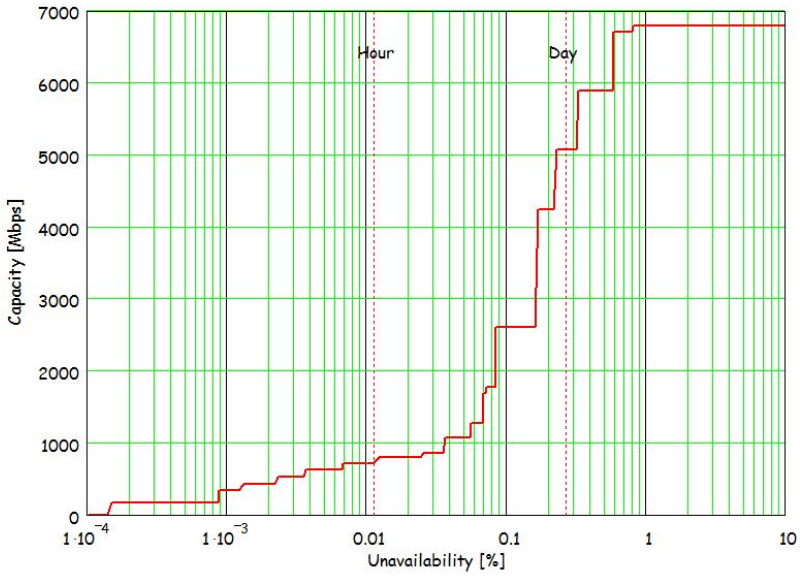

Figure 11: Capacity vs availability with BCA of 18 GHz and E-band

More in general, this specific combination could be used for the following two different uses cases:

- As complement of high traditional microwave bands (like 38 GHz) to increase capacity, addressing spectrum congestion (e.g. 38 GHz + 80 GHz);
- As complement of medium microwave bands (18-23 GHz) to increase capacity and link distance. In such case microwave band would serve most critical services at highest availability, while millimetric wave (mmW) band, working over a huge hop length, would serve data-hungry applications for the majority of time.

It may be worth noting that, the use of BCA technique would possibly impact the automatic link planning tools and procedures, including protection and error performance (availability, long term objectives etc.) for these kind of network element.

4.1.3 Planning

Concerning link planning methods adopted for frequencies above 50 GHz, several respondents note planning is performed according to relevant ITU and ECC Recommendations. In particular the following Recommendations are indicated:

- Rec. ITU-R P.530 (prediction methods) by Slovak Republic, Bulgaria, Hungary, Sweden, Germany, Czech Republic, Austria, Telenor, OTE, Huawei
- Rec. ITU-R P.525 (free space propagation) by Bulgaria, Hungary, Portugal, France, Russia
- Rec. ITU-R P.452 (prediction for interference evaluation) by Sweden, Greece, Czech Republic and Austria

Other complementary Recommendations, e.g. Rec. ITU-R P.837, P. 838 for rain fading, and Rec. ITU-R P.676 on atmospheric gas attenuation are addressed by Hungary, Austria and Russia.

Other ITU Recommendations are also noted by individual respondents:

- Rec. ITU-R P.310 and P.453 (diffraction and refraction), Rec. ITU-R P.2001 (propagation model 30-50 GHz)
- Rec. ITU-R F.746 (Radio frequency arrangements), Rec. ITU-R F.2006 (radio-frequency channel and block arrangements in 71-76 and 81-86 GHz)
- Rec. ITU-T G.821 and G.826 (Error performance)

In some cases the methods have been indicated to be the same as for below 50 GHz (Norway, Switzerland).

Some respondents have not considered planning above 50 GHz due to lack of or limited assignments (Turkey, Malta, Italy, Estonia, Bosnia and Herzegovina).

Some specific tools have been indicated such as LS Telecom CHIR Plus (used up to 80 GHz) and Pathloss 5, in addition to few proprietary tools. Some models above 50 GHz are available in academia, e.g. METIS FP7 project.

Possible needs for improvements of planning methods are noted in relation with some aspects, including propagation (rain effects), equipment (antenna isolation) and methodology (Ray tracing/3D).

The following ETSI documents are noted by individual respondents: ETSI TR 101 854 (interference analysis taking account of digital terrain), ETSI GS mWT 004 V1.1.1 (mWT V-Band street level interference analysis), ETSI EN 302 217 series, including the P-P Harmonised Standard (EN 302 217-2-2).

4.1.3.1 Link quality criteria – error performance and availability

Common view was expressed by many administrations, operators and manufacturers that high availability is expected to still play a significant role in future networks and technologies, including 5G.

Latency is also indicated as important by some respondents.

Recommendations ITU-T Rec. G.826 and ITU-T Y Rec.1563 are used for reference by some respondents.

A widely use parameter for link planning is the availability, based on the 10 consecutive SES criteria, defined many years ago for PDH (ITU-T Rec. G.821, extended later to SDH and Ethernet).

This criteria are used by Norway, Malta, Croatia, France, Germany, Austria (2 operators), OTE, Orange, Telenor, and declared to be still appropriate by 3 administrations (2 on behalf of operators) and 1 operator. The operator notes its simplicity and reliability, and lack of suitable alternatives.

4 administrations and 1 operator don't use these criteria (delay, delay variation, monitoring where indicated), while other respondents considered the matter under stakeholder's responsibility.

An industry group, an administration (on behalf of operators) and a manufacturer believe these criteria may be no longer appropriate, since they were been developed many years ago, and should be reviewed to check suitability to packet based networks. It is noted that the use of availability is not always in line with the ITU-T definition, and therefore standardisation studies could be beneficial to allow a harmonised view.

It was noted that for FWS backhaul link high quality and availability are important and should be taken into account.

4.1.4 Backhaul network evolution and its challenges

As a consequence of the evolution of network needs, a strong pressure exists from FSS/MSS and/or Mobile community on FS frequencies. All the discussions about allocation of spectrum for 5G must consider the equivalent needs for backhaul, currently 3G/4G and in future 5G from rural to dense urban environment (see an example in Figure 12). The allocation of spectrum for 5G cannot be separated by the allocation of sufficient and suitable spectrum to deploy the backhaul network.

With the progressive introduction of more and more broadband services offered by new generation of mobile systems (e.g. IMT-2020), also their backhaul networks need to suitably respond to the change.

The expected growth of needed capacity implies also that, at least in highly populated urban areas, the base stations will use smaller size cell footprint and thus their density will increase. Consequently, FS backhauling link hop should be significantly reduced.

In addition equipment may be installed on light poles at street level and shall not have a large visual impact. This will drive the use of smaller/integral and/or adaptive antennas (see section 4.2.4.1).

An overall trend for smaller size cells is also expected in any geographical area; therefore, the upgrading or new deployment of mobile backhauling networks will, in general, require significantly shorter hops, either on the lower layer (connections between base stations using higher frequency bands e.g. 23 GHz to 42 GHz) and on the higher layer (between larger and more distant exchange stations using lower frequency bands e.g. 15 GHz down to 6 GHz).

4.1.4.1 Correspondent evolution in the coordination

The above expected network evolutions pose additional challenges to the network engineering on both operator and regulator sides due to the significantly lower fade margin needed for the required availability.

The following coordination elements have to be considered:

- The fade margin, usually calculated for the availability objective at BER ≅ 10-6, would result only in a few decibels.
  - It could likely become lower than the safeguard clear sky margin for guaranteeing the Residual BER (RBER) objective, conservatively set in present ETSI standards[4] to be 10 dB;
  - Conventional frequency planning procedure usually fix the maximum transmit e.i.r.p. for matching the fade margin needed for “availability objective” (Recommendation ITU-R F.1703)[5]. In such short hops, this obviously means that, for fulfilling also the other “error performance objectives” (Recommendation ITU-R F.1668), an “extra e.i.r.p. margin” should be assigned in the coordination process.
- Use of adaptive modulation systems for increasing data capacity in clear sky conditions (desired by the operators for obvious economic reasons) and of ATPC for improving the spectrum usage (often considered in the licensing/coordination process).
  - This even more increases the difference between the minimum fade margin for implementing these techniques, and the fade margin calculated for “availability” only.
  - This would imply an even higher “extra e.i.r.p. margin” to be possibly assigned in the coordination process (unless all these hops are designed considering only the topmost modulation format).
  - The “extra e.i.r.p. margin” would imply a higher interference situation; however, it might be tolerable due to larger fade margin if the coordination process includes a C/I impact larger than usual.
- The very low fade margin, in addition to the continuously more demanding low visual impact, implies the use of low antenna gain (small size).
  - Low gain antennas physically imply a lower directivity (ETSI classes 3 and 4 could not be possible).
  - Low directivity antennas imply a reduced nodal frequency reuse rate.
  - The apparent drawbacks of small antennas should be considered in the light of other possible characteristics of the new network scenario (higher links density, “extra margin”, larger C/I tolerance, etc.).

In conclusion, it is expected that further studies would be needed in the field of frequency coordination for very dense networks, where the conventional methods might no longer be appropriate.

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[4] See EN 302 217-2-1

[5] It is usually assumed that other ITU-R “error performance objectives” are automatically met.

Figure 12: Urban area backhauling example

4.1.4.2 Further evolutionary scenario

Four other technological topics are under assessment for possible applications in the FS marketplace:

- Non Line of Sight (NLOS) or Quasi Line of Sight (QLOS) backhauling applications in low frequency bands (typically below, but not limited to, 6 GHz[6]); which may solve the interconnection of mobile pico-cells at street levels. An important part of the challenge is the search for suitable frequency band(s) for such applications; it is well known that frequency resources below 6 GHz are very scarce and most of the “fixed allocations” have already been switched to, or looked for, MWA/BWA use, which imply, in common practice, that the bands are usually auctioned in blocks of relatively small size.
  This has already generated the idea of “in-band backhauling” (i.e. the use of the same auctioned block for both access and backhauling); however, this sometimes conflicts with the national licensing/auctioning rules (e.g. requiring “access only”) or, in any case, imply that the backhaul capacity would reduce the access capability and that, standing the limited block bandwidth, there will be strong limitation to the planning of P-P links (in term of capacity and availability of channels for interference reduction purpose).

  A second option could be the “off-band backhauling” (i.e. the use of a frequency band different from that of the access); possibly, the few bands still in use for conventional coordinated P-P deployment (e.g. 1.5 GHz, 2 GHz and 4 GHz), but not presently expected to support new systems deployment (see band-by-band analysis in ANNEX 1:), might be taken into consideration.
  A third option of using license exempt bands (e.g. 2.4 GHz and 5 GHz), provided that e.i.r.p. limitation currently enforced would permit practical P-P application could be limited by the already extensive use for “urban” applications (RLAN) and highly impacting technical limitations (DFS for primary radars protection); nevertheless, it still deserves careful analysis.
- Multiple Input and Multiple Output (MIMO) systems, which can increase capacity (Spatial Multiplexing) and/or link availability (Space Coding). MIMO use in fixed service is described ECC Rep. 258, including planning guidelines, and in ETSI TR 102 311.

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[6] Recommendation ITU-R P.1411-5 “Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz” contains NLOS propagation model in urban street canyons up to 16 GHz.

- Introduction of more complex “Cognitive Radio System (CRS)” capability[7].
- Asymmetrical traffic point-to-point links as described in ECC Report 211.

4.2 P-MP AND MP-MP NETWORKS

4.2.1 Overview

P-MP networks are usually deployed in a dense manner employing the star configuration for their networking topology. It is necessary to ensure the transmission of high data rates between the base and terminal stations, and, at the same time, minimise the possible intra-system interference between different cells/sectors of the network. Due to the fact that link budgets for P-MP networks, by nature of their design, will be different for differing terminal stations, the appropriate modulation scheme to be employed in a scenario of different terminal stations should be carefully studied. An example of adaptive modulation in P-MP context is given in Figure 13: .

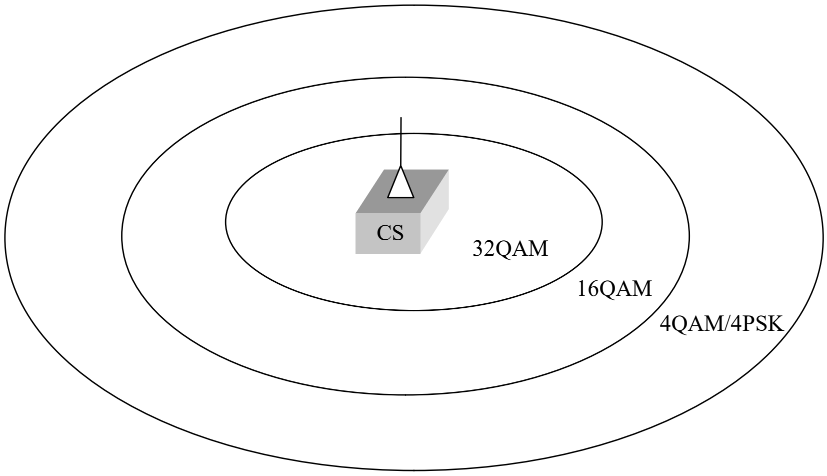


Figure 13: Example of using adaptive modulation in a P-MP network, serving terminals with different link budgets (CS= central station)

Multipoint-to-multipoint networks (MP-MP), also known as meshed networks, are intended to serve a large number of densely located fixed terminal stations. Meshed networks would therefore provide an alternative for P-MP networks. Meshed networks do not require central (base) stations for communications between terminal stations. Instead, each and every terminal station may act as a repeater and pass on the traffic to/from the next terminal station. Such networks would have only one or few drop nodes, which would provide interconnection of the meshed access network to the core transport network. Usually, all the nodes of the meshed network are located on the customer’s premises and act as both customer access and network repeater. In such a way traffic is routed to the addressed customer via one or many repeaters. Nodes located at the edge of the network initially act as terminating points, however may be later converted into repeaters with the further growth of the network, see Figure 14: .

[7] According ECC Report 159 and Report ITU-R SM.2152, a *Cognitive Radio System (CRS) is: “A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.”*

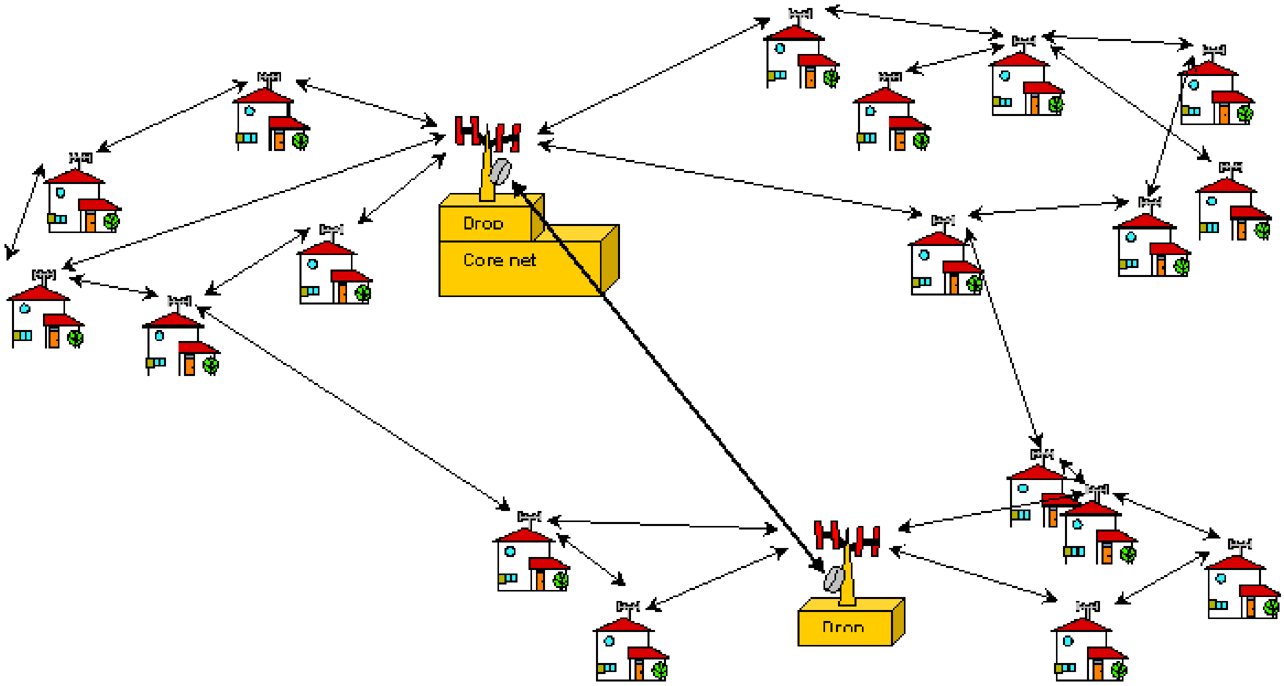


Figure 14: Topology example in a mesh network

Previously, minimal investment has been made in the P-MP and Multipoint-to-Multipoint (MP-MP) networks, owing to the lack of interest and difficult network planning prior to the adoption of block assignment in dedicated bands, the only evolution that was seen was related to the convergence with mobile applications in lower frequency bands. However P-MP has recently gained interest with the new generation of P-MP equipment available on the market. P-MP may be a useful element in the architecture, including mobile backhauling, for carrying packet data traffic in networks.

P-MP networks are finding application for providing last mile connections for mobile broadband networks. P-MP is suited to carrying the data traffic that is becoming the predominant type of information carried over mobile networks. When cellular mobile networks first appeared in the 80's, they carried voice traffic. Later text messaging and then mobile data were introduced. Mobile data is quickly overtaking voice as the dominant form of traffic on mobile networks.

P-MP equipment is based on the observation that mobile data has one characteristic that makes it particularly challenging for FS link networks. Because packet data volume is based on the nature of the data usage characteristics of the users on the network, the traffic presented to the link has a distinct 'shape' – transient, unsynchronised peaks when users or applications are consuming data and troughs when users are idle. Such peaks and troughs are no longer correlated with a specific 'busy hour' that is common across the whole network (although an overall diurnal 'swell' may still be observed). The unpredictable nature of this data traffic makes it difficult for operators to design their network backhaul connections.

P-MP networks can address this challenge by statistically multiplexing the traffic from multiple sites to improve the efficiency of the network (see Figure 15:). This allows the traffic to be merged so that the peaks from one mast 'cancel out' the troughs of another which improves system efficiency.

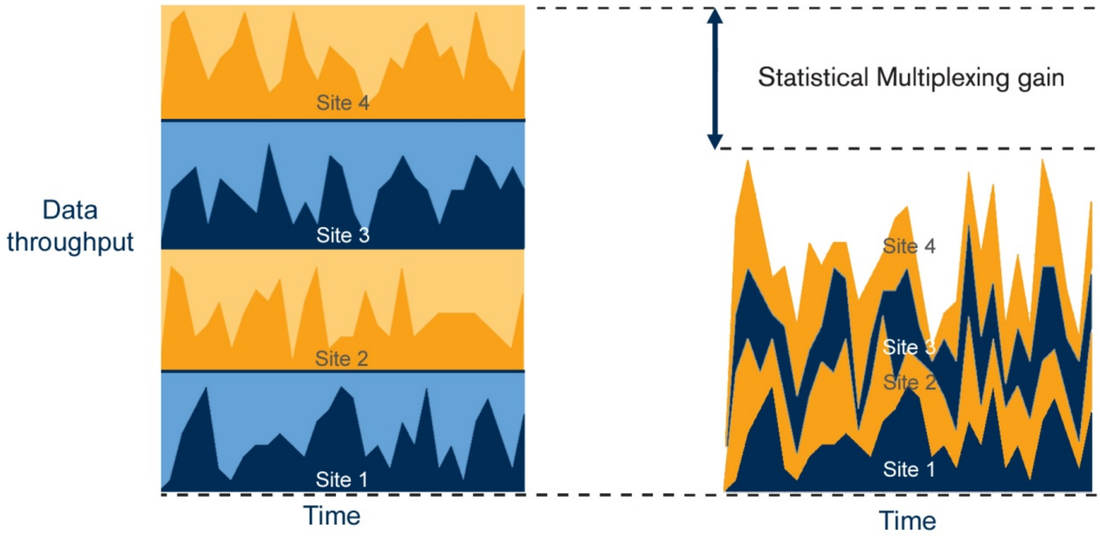


Figure 15: Example of statistical multiplexing gain

4.2.2 FWA Networks technology trend

Until around year 2000, when the forecast for development of Fixed Wireless Access (FWA) networks were much more encouraging, in particular in millimetric frequency bands, the "technology fight" between P-MP and MP-MP technologies, both claimed to be the best choice, was very strong. However, while first generation of P-MP networks were already in place and tested and commercially available, the proponents of MP-MP structures had soon disappeared due to the investment cuts in the field of “pure” FWA, in particular for the millimetric bands where most of the MP-MP studies aimed to; the market had, de facto, no opportunity of real testing MP-MP systems and networks.

Therefore, no new development is expected in the MP-MP field.

On the contrary, P-MP systems have been deployed and a new generation of equipment is on the market. New products in higher frequencies have been developed and released in most of the popular P-MP bands including 10 GHz, 26, 28 GHz and 42 GHz.

In addition, in the lower frequency band, P-MP gained more momentum from the advent of Broadband Wireless Access (BWA) requirements on the market, where Fixed Wireless Access (FWA) and Mobile Wireless Access (MWA) are converging. Next section 4.2.3 describes in detail the current situation in the field of BWA.

4.2.3 Broadband Wireless Access (BWA) Networks

With increased regulatory liberalisation and particularly in some lower frequency bands (currently 3400-3600 MHz and 3600-3800 MHz), FWA designations have been replaced with BWA designations and in many CEPT countries the original FWA spectrum authorisations have themselves been liberalised to reflect this new flexibility without any change of authorisation ownership. This new BWA designation introduces regulatory flexibility to support fixed, nomadic and mobile services and in many cases the access technology is derived both from fixed and/or mobile standardisation origins for building up Mobile/Fixed Communication Networks (MFCN). Definitions of BWA, FWA, NWA and MWA can be found in Recommendation ITU-R F.1399.

Standardisation activities for broadband FWA included the development of the IEEE 802.16 WirelessMAN-SCPHY specification covering the 10-66 GHz frequency range. This was mirrored within ETSI with the development of the HiperACCESS Technical Specification. The IEEE 802.16 standard was first amended to include the Fixed WirelessMAN OFDM PHY specification covering the licensed spectrum bands below 11 GHz. This was mirrored within ETSI with the development of the HiperMAN Technical Specification. Subsequent amendments to the IEEE 802.16 standard have introduced the WirelessMAN OFDMA PHY for licensed spectrum bands below 11GHz with increasing support for mobile operation within the liberalised BWA spectrum designations. Further enhancements of the WirelessMAN OFDMA PHY have resulted in its adoption into the IMT technology family.

The WiMAX Forum industry body supported a standardised implementation of the IEEE 802.16 specification and has developed an accredited equipment certification process to ensure multi-vendor interoperability. WiMAX Certified products are available based on the WirelessMAN OFDM PHY specification targeting the 3400-3600 MHz band.

4.2.3.1 Frequency bands below 10 GHz

3.4-3.8 GHz

In lower frequency bands mobile applications are dominant so spectrum availability is limited for BWA/FWA. The 3400-3600 MHz and 3600-3800 MHz ranges are the most popular for BWA and underpinned by harmonisation measures in ECC/DEC(07)02 and EC Decision 2008/411/EC and 2014/276/EU.

However, following the identification of the frequency range 3400-3600 MHz for IMT systems at WRC-07, the mobile usage in this frequency range is likely to grow in coming years: the ECC has produced a new ECC Decision (ECC/DEC/(11)06) harmonising the band arrangements for MFCN usage (including IMT) in these bands. This complements the BWA framework with specific harmonised frequency channel arrangements. It should be noted that ECC/DEC/(11)06 provides, in 3400-3600 MHz, arrangements for both FDD and TDD systems, while, in 3600-3800 MHz, only TDD arrangements are considered; this should be taken into account also when simple FWA networks (including, when appropriate, backhauling infrastructure) are considered.

FWA licences have expired in Ireland and they will expire in 2018 in Estonia, growth of use is foreseen by Greece.

5.8 GHz

In the lightly licensed 5.8 GHz frequency band FWA (fixed and nomadic) operation continues to be possible on a national basis under the framework set by ECC Recommendation ECC/REC(06)04 and ETSI Harmonised Standard EN302 502. Coexistence considerations result in a low e.i.r.p. constraints and a need to implement a demanding Dynamic Frequency Selection (DFS) feature for the protection of primary Radiodetermination service.

1-10 GHz
In the frequency range 1-10 GHz an increase of the number of Fixed Wireless Access (FWA) networks is indicated by Russia.

4.2.3.2 Frequency bands between 10 GHz and 60 GHz

In these frequency bands, 10.5, 26, 28 and 32 GHz, despite early FWA standardisation efforts in ETSI and IEEE, technology costs remained high and commercial uncertainty prevented widespread take up and deployment for access applications.

In addition, the 42 GHz frequency band, originally designated for exclusive Multimedia Wireless Systems (MWS) use (ECC/DEC(99)15) in 2009, was not exploited anywhere in Europe, apart from some applications in the Russian Federation. Thus during 2010 the ECC decided to open this frequency band also to P-P links in order to relief link congestion in the 38 GHz band which is heavily used for mobile backhauling.

However the recent explosion in data demand over mobile networks and the very rapid evolution of mobile technologies could lead to future renewed interest in the capacity of the higher frequency bands particularly in the light of technological developments that could lead to effective commercialization of new infrastructures in multipoint technology in these frequencies.

In the 10 to 20 GHz range, no significant growth was declared by Russia.

In the 20 to 50 GHz range, no significant growth was declared by Russia; an increase is indicated in 26 and 42 GHz in Greece.

4.2.3.3 Frequency bands above 60 GHz

In 2016, ECC approved “CEPT roadmap for 5G”, containing an action item intended to review the conditions applicable to the band 57-66 GHz in order to ensure less restrictive, flexible and streamlined regulations for backhauling as well as for SRDs (WiGig), also taking into account ITS in 63-64 GHz.

4.2.4 Antennas for FS

4.2.4.1 Antenna types

Directive P-P antennas

At frequency bands of 60 GHz and higher, the smaller antenna size gives rise to the option of integral antennas. Integral antennas have several advantages, particularly in terms of equipment cost and cost of installation. Improved aesthetics granted by the simpler overall system design are also important if these systems are to be deployed as street furniture, with greater concern being shown by residents about the unsightly appearance of traditional radio tower and dish antennas.

P-P fixed service links use dish antennas to direct radiation between sites in order to achieve longer hop lengths and for reducing interference from and to other stations. Additionally, the microwave frequencies allow making highly efficient use of directive antennas, by reusing the same frequency channel several times at the same site into different directions. Reuse depends on many parameters, e.g. the antenna radiation pattern and the required interference attenuation.

Antenna reference radiation patterns for P-P are available from antenna manufacturers or they can be estimated, for sharing studies, for bands below 30 MHz from the Recommendation ITU-R F.162, and for frequency range from 1 to about 70 GHz from Recommendation ITU-R F.699 (for peak side lobes) and F.1245 (for average side lobes). Radiation patterns for sharing studies, for low gain directional antennas for P–MP applications can be estimated from Recommendation ITU-R F.1336.

In addition, for integral and stand-alone P-P link antennas the following conformance specifications are referenced in ETSI harmonised standards EN 302 217-4 for several classes of antennas depending on the potential of interference scenarios; see ANNEX 4: for details. Directive antennas for P-MP terminals are standardised, also subdivided in different classes, in EN 302 326-3.

Near future evolution in the antenna technology may be related to the deployment of new mobile access networks, IMT-Advanced and beyond, which will use smaller size cell footprint, especially in urban areas, the backhauling will require denser and shorter link networks (see section 4.1.3). In addiction equipment may be installed on light poles at street level and shall not have a large visual impact. This will drive the use of smaller antenna which would likely be integral to the equipment itself.

The consequent loss of directivity might be compensated using smart steering antenna, which can keep pointing in adaptive way even in an urban and changing environment where pole can be bent causing pointing misalignment (Figure 16).

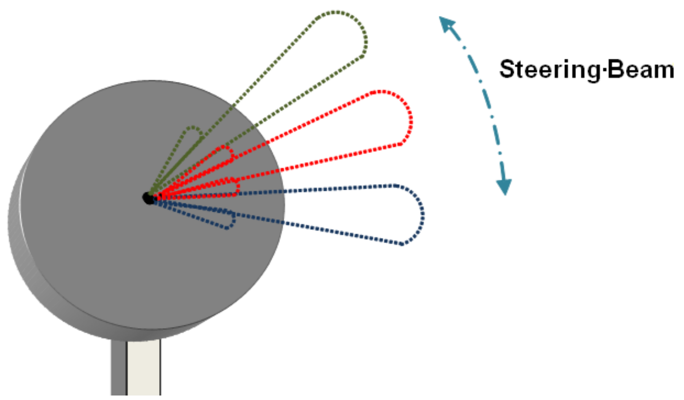


Figure 16: Smart antenna with steering beam (both transmitting and receiving)

Sectorial and omnidirectional antennas

P-MP fixed service systems normally use sectorial or omnidirectional antennas at central stations and directive antennas at terminal stations.

For the omnidirectional and sector antennas, their radiation patterns may be estimated from the Recommendation ITU-R F.1336. The conformance specifications for such integral and stand-alone antennas are referenced in the following ETSI standards: EN 302 326-3 for frequency bands between 1 and 40 GHz, EN 301 215-3 for the 40.5-43.5 GHz. See ANNEX 4: for details.

4.2.4.2 Antenna characteristics

In the legacy trunk networks, important antennae characteristics are front-back ratio and decreased cross-polar radiation close to the main beam. In the access and backhauling networks, for improving their density, the interference from lower off-axis angles becomes more and more important; this requires, besides a good Net Filter Discrimination (NFD) of the equipment, high performance antennas with reduced sidelobes and improved cross-polar discrimination.

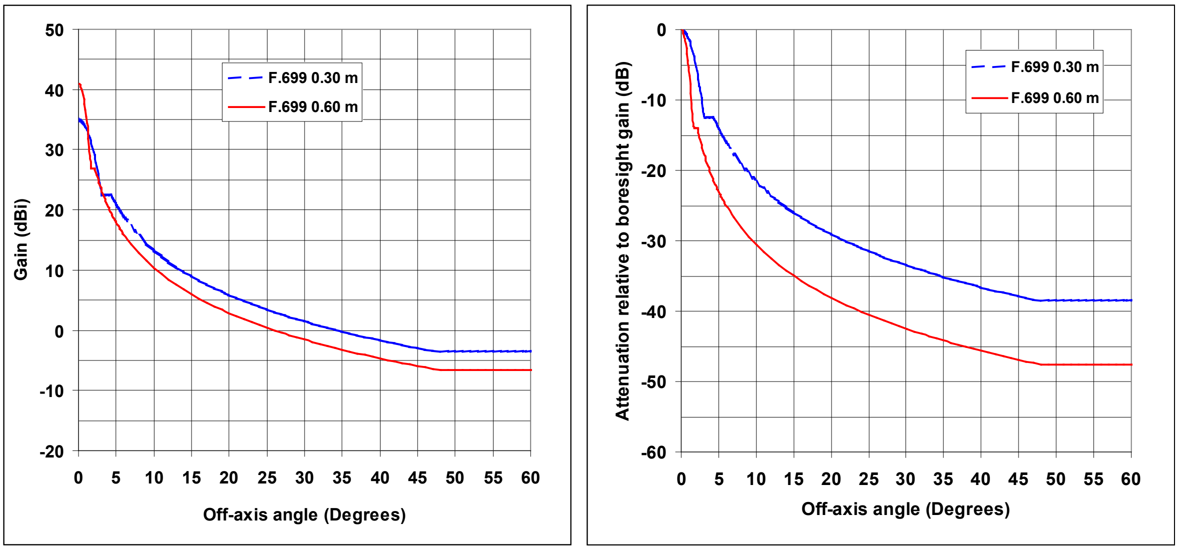
For economic reasons small gain antennas or low performance antennas are used in practice, especially for links with the short hop lengths. However, when it is necessary to improve frequency reuse or limit inter-service sharing difficulties through reduction of side-lobe interference, then use of such small gain or low performance antennas should be limited to cases where careful cost to benefits evaluation justifies it.

4.2.4.3 Impact of antennas in P-P frequency reuse

P-P fixed service links in the access and infrastructure support networks are often arranged in star configuration. For an efficient spectrum utilisation (i.e. high frequency reuse), the directivity of the antenna placed at the star-centre stations plays a major role; if necessary and/or advantageous, less directive and lower gain antennas may be used at the star-point stations.

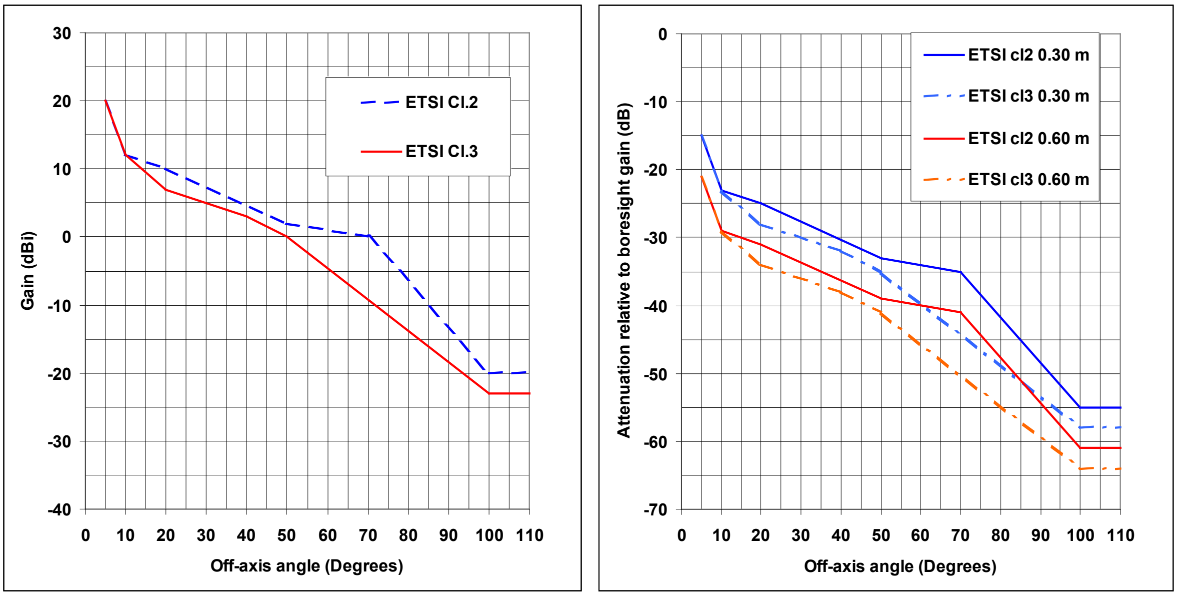
A typical access network could operate at 23 GHz using 0.6 m dish antennas at the central station and 0.3 m dish antennas at the remote stations. For extended coverage 0.6 m dish antennas can also be used at remote stations. As an example, we could assume that 40 dB attenuation is required between co-channel hops in star configuration. Based on the reference radiation pattern described in Recommendation ITU-R F.699, see Figure 17, an offset angle of 24 degrees is necessary for 0.6 m dish antennas, while 0.3 m dish would not be able to supply enough attenuation. However, the ITU-R formulas in F.699 are studied for plain dishes without any front-to-side/back enhancement.

Based on practical antennas available on the market and referenced in ETSI EN 302 217, see Figure 18, the required off-axis angles are 46 and 60 degrees for 0.6 m class 3 and 2 antennas, respectively; in this case also 0.3 m antennas can be used offering angles of 60 and 77 degrees for classes 3 and 2, respectively.



a) Absolute Gain b) Relative attenuation

Figure 17: Antenna radiation pattern at 23 GHz, based on Recommendation ITU-R F.699-7



a) Absolute Gain b) Relative attenuation

Figure 18: Antenna radiation pattern envelope at 23 GHz, based on ETSI EN 302 217-4-2

Note 1: Being only a reference, the radiation pattern in F.699 does not guarantee that the required attenuation is obtained in all case; therefore, additional safeguard should be considered in term of larger azimuth angle. On the contrary, ETSI patterns are Radiation Pattern Envelopes (RPE) representing the worst case attenuation; therefore, the angles obtained already contain the necessary safeguard.

Note 2: It should also be considered that, due to physical constraints, the smaller are the antenna size, the more difficult it is to obtain a high directivity; therefore, the higher ETSI classes might become unpractical when the antenna gain becomes too low.

Then one can easily estimate that the maximum frequency reuse is 360/46=7.8 and 360/60= 6 for 0.6 m class 3 and class 2 antennas, respectively. Frequency reuse can still be practical by using a smaller 0.3 m antenna also at the central station, offering reuse factors of 6 or 4.6 for classes 3 or 2, respectively.

If another polarisation can be used, the minimum off-set angle is reduced to the order of 5 degrees. This is mainly determined by main beam cross-polar attenuation, which is specified between 27 and 30 dB in ETSI EN 302 217.

4.2.4.4 Impact of antennas on sharing and co-existence with other services and applications

Directive antennas could reduce the potential of interference in shared frequency bands, e.g. with satellite services, for which typical cases of interference calculations are the co-ordination area around a satellite Earth station, interference from/to Geostationary Satellite Orbit (GSO) satellites and interference from/to non-GSO satellites.

Typical radio-relay link parameters to be used in sharing and coexistence studies between the FS and other services and applications are given in the Recommendation ITU-R F.758 while, in ITU-R RR Appendix 7, satellite Earth station parameters for co-ordination are also described.

The highest level of interference is produced through the main beam, particularly when the highest gain antenna is used in calculations. However, these high levels are associated with a low probability (in time for non-GSO satellites or in number of impacted links for GSO satellites). When small gain antennas are considered for short hop links or sectorised deployment, this decreases the maximum level of main beam interference, but increases the aggregate interference through side lobes, which then becomes the limiting factor. Care should be taken in future when the use of higher number of small gain antennas should be considered in frequency assignments in the shared bands.

Interference from Short Range Devices (SRD) and Ultra Wide Band (UWB) devices should be considered as these systems become more used and widespread.

5 ANALYSIS OF THE CURRENT AND FUTURE FIXED SERVICE USE

This section provides an analysis of the responses received from CEPT administrations to the questionnaires on current FS use and future trends. It is believed that the number of responses received and the range of countries responding is sufficient to represent the overall European trend of FS developments.

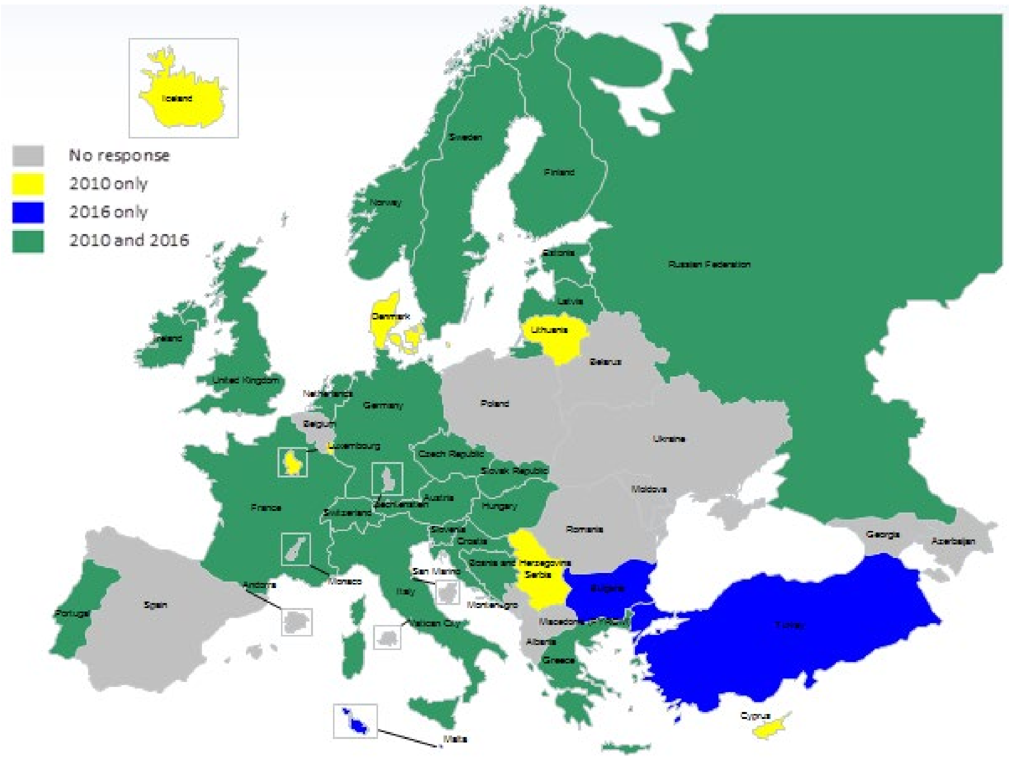


Figure 19: Countries who responded to CEPT questionnaires (green: 2016 -2010-2001-1997), yellow: 2010, grey: did not respond)

Whilst every possible effort was made in interpreting data and providing statistical analysis, some levels of inaccuracy are unavoidable due to inherent differences in national definitions of FS applications, different accounting techniques, various licence exempt or otherwise unregistered FS uses, etc.

A special mention has to be made concerning the P-MP figures. In various replies it was indicated that figures could not be provided, due to “block” allocations and licenses. Deployment and numbers of fixed links in spectrum made available in blocks (in some cases also on a technology/service neutral basis) have also not been accounted for in this report. Therefore the figures used throughout this Report, mainly for P-MP, are in some cases underestimated.

A summary of the responses for all the countries for each band is embedded in the following MS Excel worksheets, respectively developed for the analyses of answers related to:

- all frequency ranges in 2016;
- only frequency ranges higher than 50 GHz (specific questionnaire in 2015);
- elaboration of answers to 2010 questionnaire for comparison with data in 2016.

Below and above 50 GHz 2016.xlsm

Above 50 GHz ADMIN mar 2015.xlsx

Below and above 50 GHz 2010 .xlsm

5.1 DEVELOPMENT OF FS BETWEEN 2001 AND 2017

A comparison of the data recorded in 2001 with those derived from the 2010 and the 2016 questionnaires allows an evaluation of the overall FS developments between 2001 and 2016. The previous analysis of evolution of FS between 1997 and 2001 allowed in some cases also a comparison over a wider period.

Although the statistics of FS use presented in Figure 5: of Chapter 3 seem to indicate clearly the overall development of FS in Europe, in individual countries the pace of such development may be different.

Whilst the previous section described the FS in general, analysis of usage records per individual band helps in identifying those frequency bands which showed the highest positive or negative growth in terms of absolute number of accommodated links (See ANNEX 1:).

The bands which have shown the highest positive growth are shown below in Figure 20 and Figure 21.

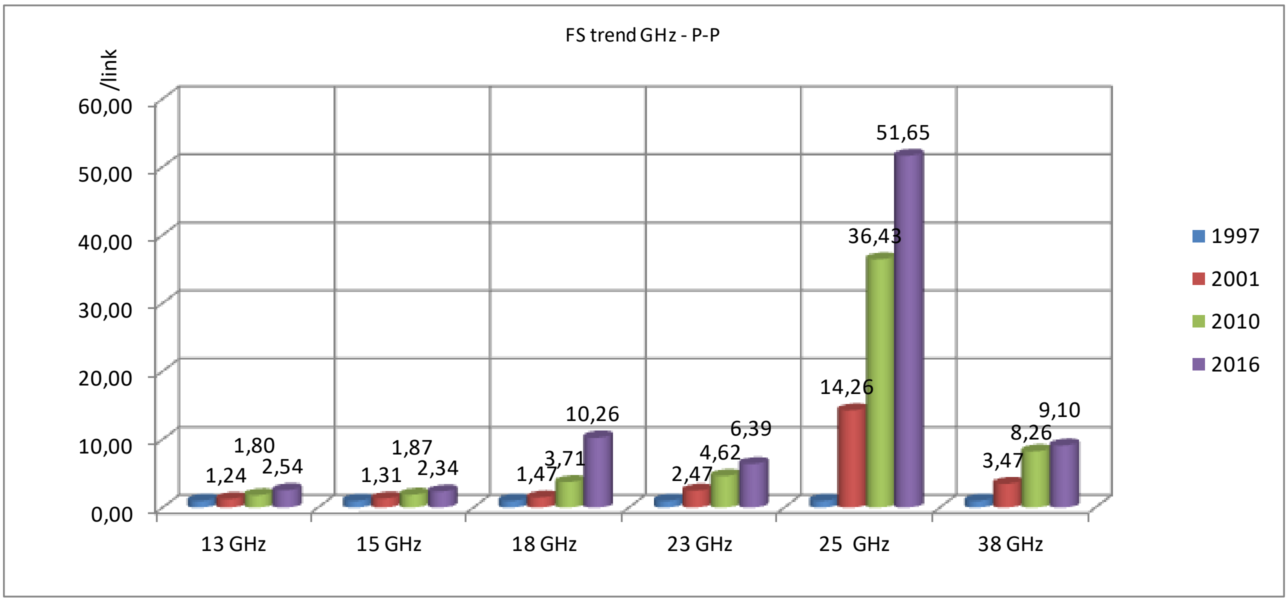


Figure 20: Historical (normalised to 1 link in 1997) trends for P-P links in CEPT in frequency bands which showed the highest FS growth between 1997 and 2016 (P-P only)

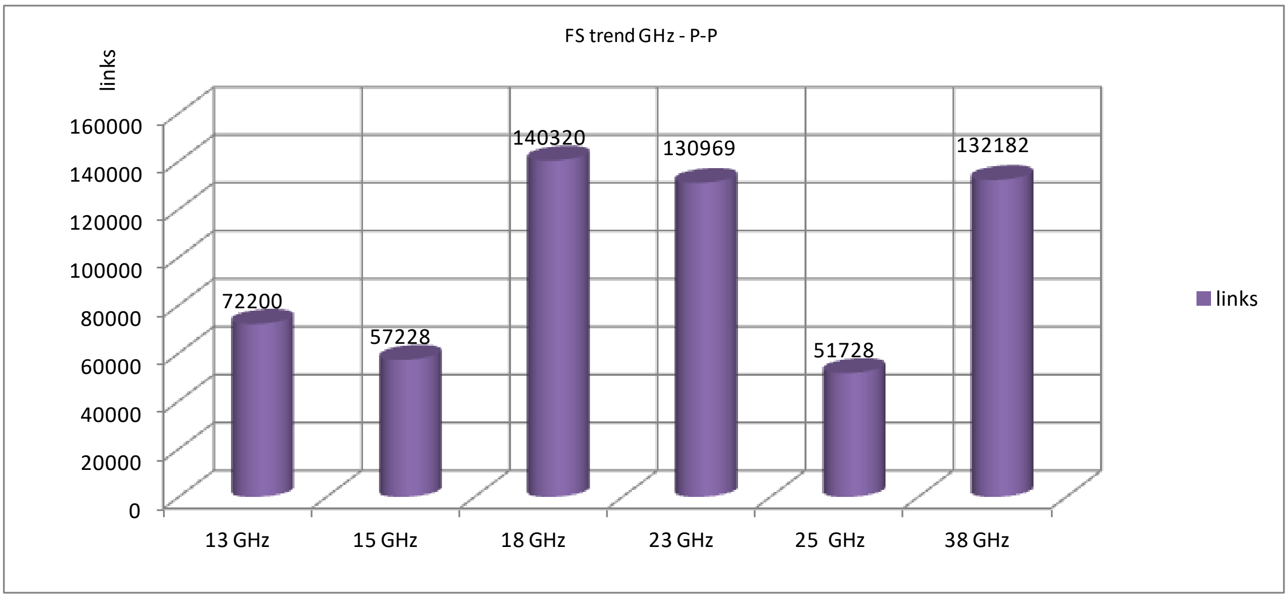


Figure 21: active links in 2017 in frequency bands which showed the highest FS growth between 1997 and 2017 (P-P only)

It is to be noted that Figure 20 takes into account P-P links only. This is quite relevant for the bands 24.5-26.5 GHz where a high number of Fixed Wireless Access (FWA) systems have been developed in the past decade. Many administrations did not indicate any figure for it in replying to the questionnaire, as the regulatory regimes sometimes do not require operators to notify the Central Stations and sometimes even the Base Stations.

With regard to the bands where number of FS links decreased, the situation is less obvious. Those few bands, where negative growth was detected, showed a decrease of the total number of links by only one or two thousand links. As such a relatively small number may depend on the change of use (e.g. refarming of the band) in one or few bigger countries only. Therefore it would be impossible to draw statistically reliable conclusions applicable on a wider European scale.

Addressing those particular bands, some examples may be cited:

- The band 3.6-4.2 GHz had a continuous negative trend since 1997 and has now probably reached its minimum possible number of links. The links that are still in operation are mainly long-haul links for telecommunication and broadcasting network infrastructure;
- The band 14.25-14.5 GHz also had a continuous negative trend since 1997;
- The band 10.0-10.68 GHz had a negative trend in the period 1997-2001 and has now showed to remain stable, with a slight inversion of trend due to the deployment of new FWA systems;
- The band 10.7-12.5 GHz had been impacted by the difficulties of sharing with satellite services. This resulted in a negative trend from 1997 to 2001. After that decrease, it experienced a positive trend.

The rest of the bands with negative growth are concentrated below 3 GHz, confirming the different use of these bands (mobile/broadcasting, etc.).

5.2 THE HARMONISATION PROGRESS IN FS USE

In this section, an attempt is made to evaluate the scope of harmonisation in utilisation of the various frequency bands by FS across CEPT countries.

Harmonisation in this context means bands that show a dominant uniform use across CEPT countries and a high degree of relevant CEPT channel arrangements or frequency plans being implemented.

Updated information about FS frequency bands, reference Recommendation and implementation within CEPT, allowing to evaluate the degree of harmonisation, is available in ECO Report 04.

CEPT administrations should enter the information about their adoption for each ECC Decision to ECO database. Information with regard implementation of ECC/ERC Recommendations could be provided by CEPT administrations to EFIS.

At the time of the publication of this Report, most of the bands are used with significant degree of harmonisation (i.e. percentage of administrations referring to the same deliverable). However, the relatively high number of countries that have not given any information prevents the possibility of a sounding analysis.

From the analysis of data, it becomes obvious that the availability of CEPT channel arrangements becomes a powerful incentive for achieving wide spread European harmonisation of FS usage in a particular band.

In that respect, it might be also interesting to note how particular ERC/ECC Decisions and Recommendations in the FS field are implemented across CEPT countries. For this purpose Figure 22 below show the number of CEPT administrations committing or planning to commit to certain ERC/ECC Decisions, which are most relevant for the planning of FS services. These data are based on the ECO implementation records, as valid for 1 October 2011. In Figure 23 and Figure 24 the high level of the implementation throughout CEPT of Recommendation T/R 12-03 can be found as an example. This kind of geographical visualisation of the implementation in CEPT of Recommendations, as well as the statistical information to show authorisation mechanisms adopted for each channelisation arrangement are provided in EFIS (www.efis.dk).

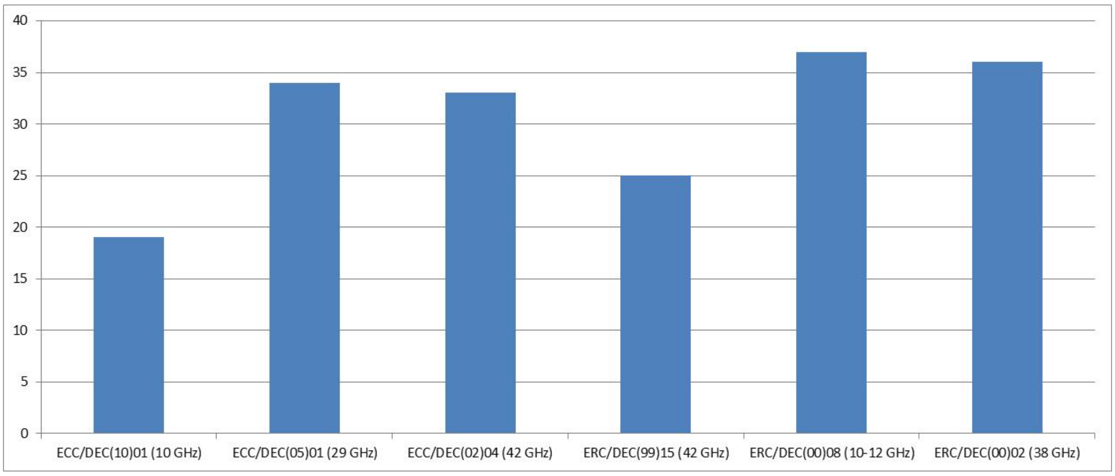


Figure 22: Implementation of some major ERC/ECC Decisions in the field of FS as of November 2017 (source: http://test.ecodocdb.dk/docdb/)

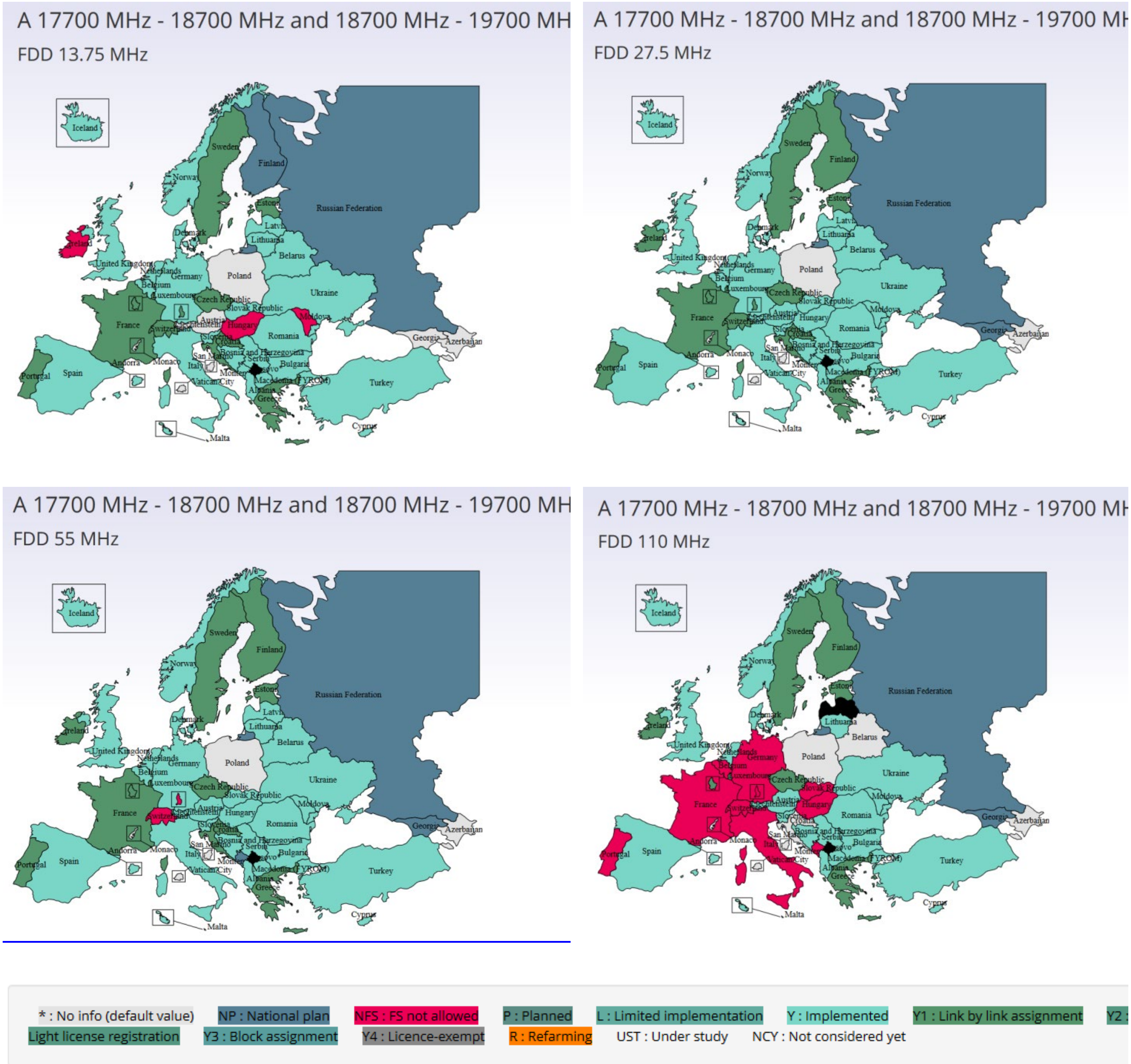


Figure 23: Implementation of ERC Recommendation 12-03 with reference to the different channel spacing (source: www.efis.dk)

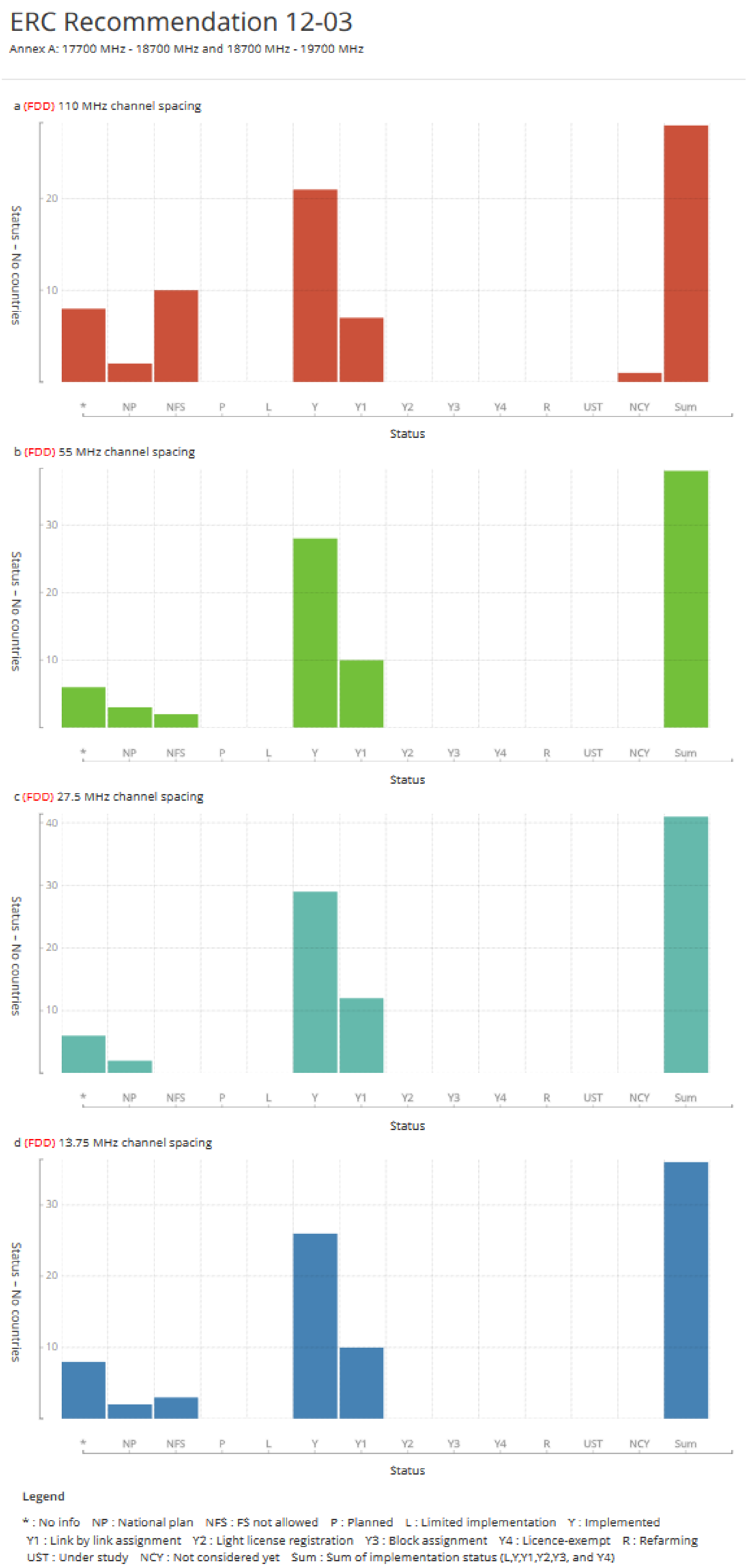


Figure 24: Statistics on the implementation of ERC Recommendation 12-03 on authorisation mechanisms adopted for each channelisation arrangement (source: www.efis.dk)

5.3 BAND BY BAND ANALYSIS OVERVIEW

A band by band analysis has been performed based on the responses from the questionnaire. In general, FS deployment below 5 GHz indicate stable or no growth for P-P applications For all the frequencies there is a trend for increase except for the 31 GHz band being stable.

For further details see ANNEX 1:.

5.4 BAND USAGE VS NUMBER OF LINKS IN OPERATION

The diagrams in the following paragraphs report the number of links declared in operations, according to the answers given.

Information take into account both P-P links and P-MP BS. Information on numbers of links in blocks of spectrum that have been auctioned has not been included in the totals.

5.4.1 Number of active links for each band

The following Figure 25 and Figure 26 compare the number of active links for each specific frequency band.

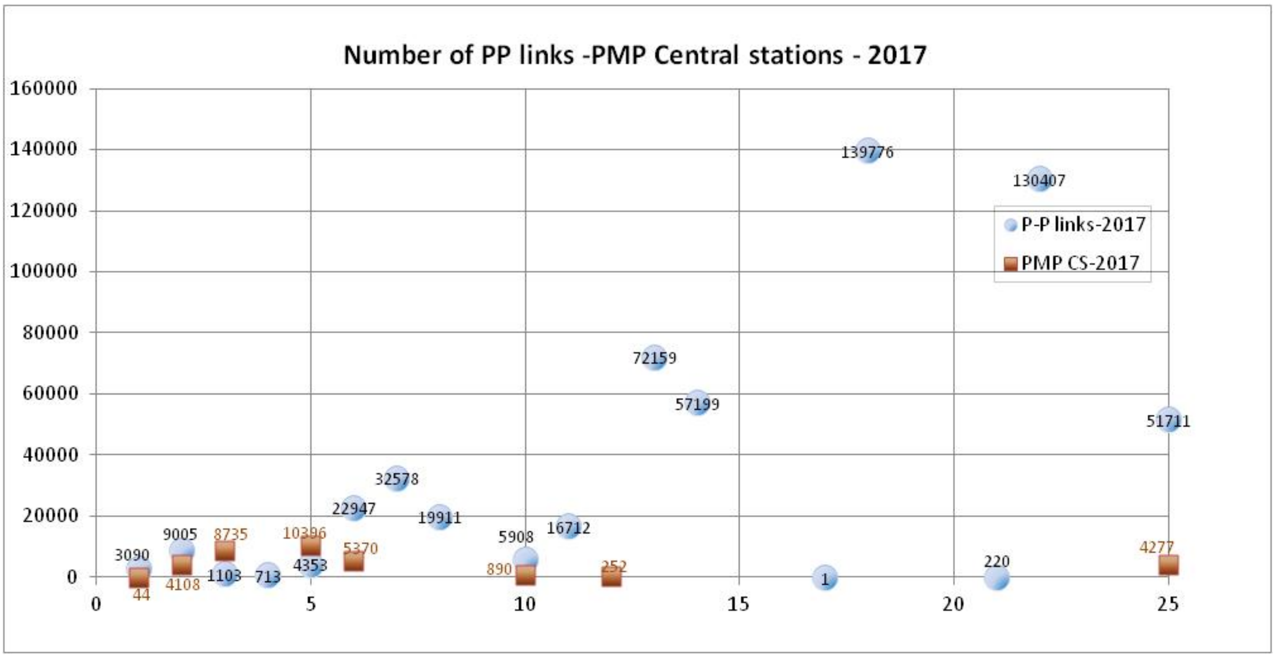


Figure 25: Distribution of links for the frequency bands from 0 to 25 GHz

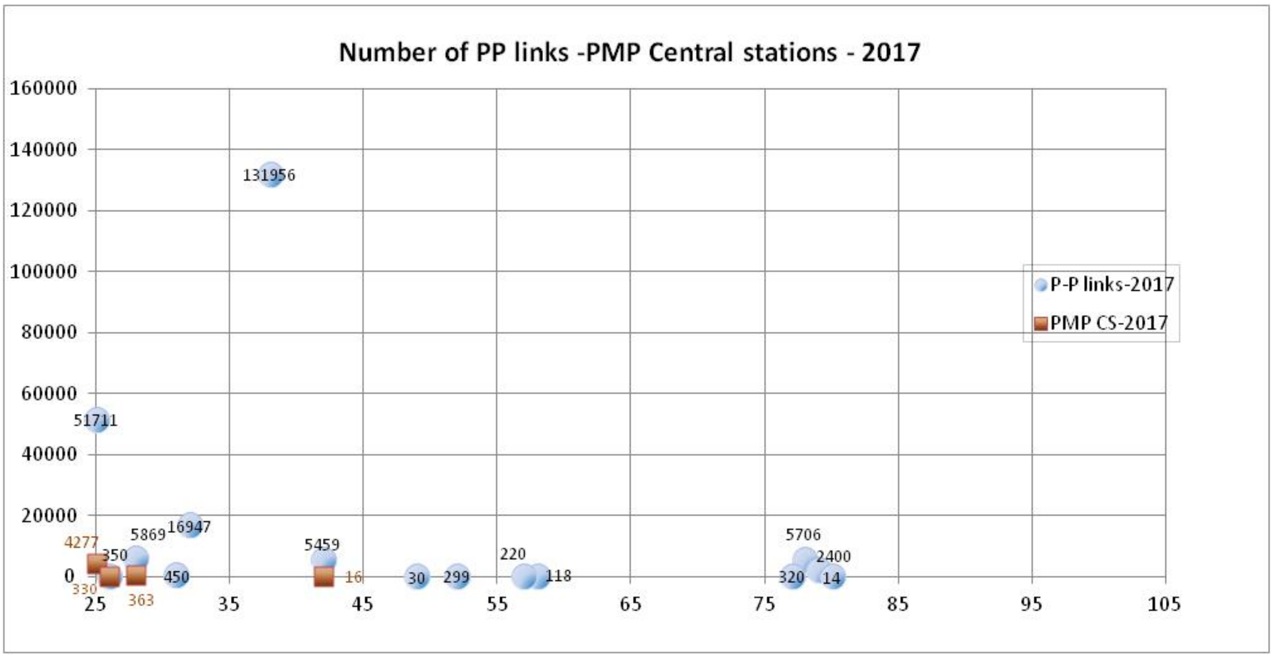
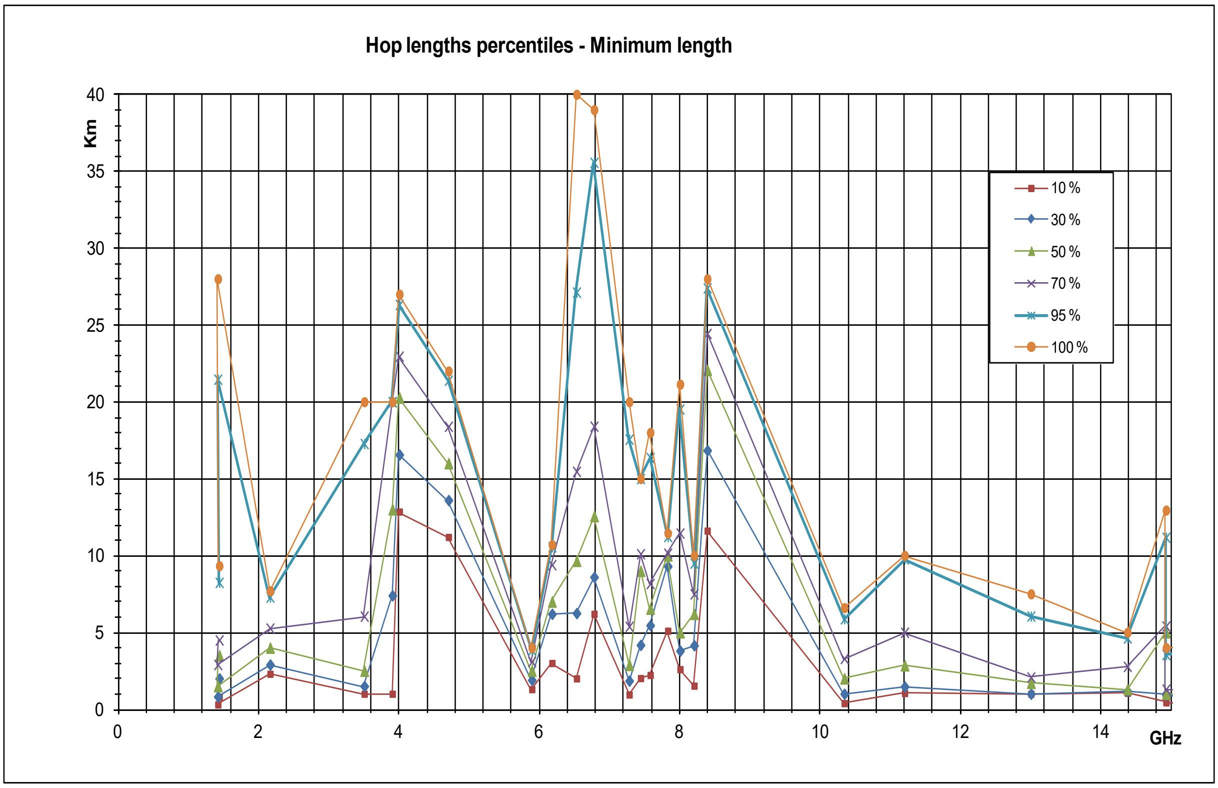


Figure 26: Distribution of links for the frequency bands from 25 to 105 GHz

5.4.2 Hop length distribution

The following Figure 27, Figure 28 and Figure 29 show percentiles of hop length, in the overall used frequency range.



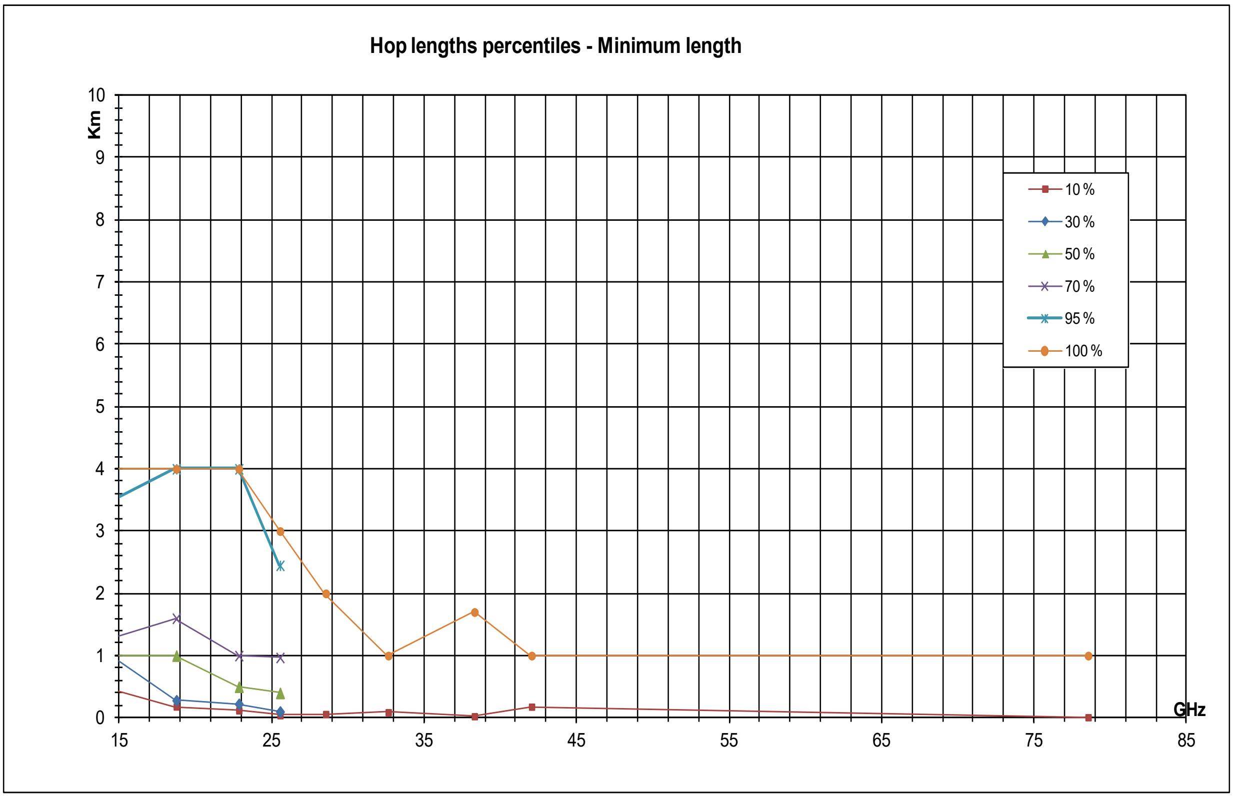
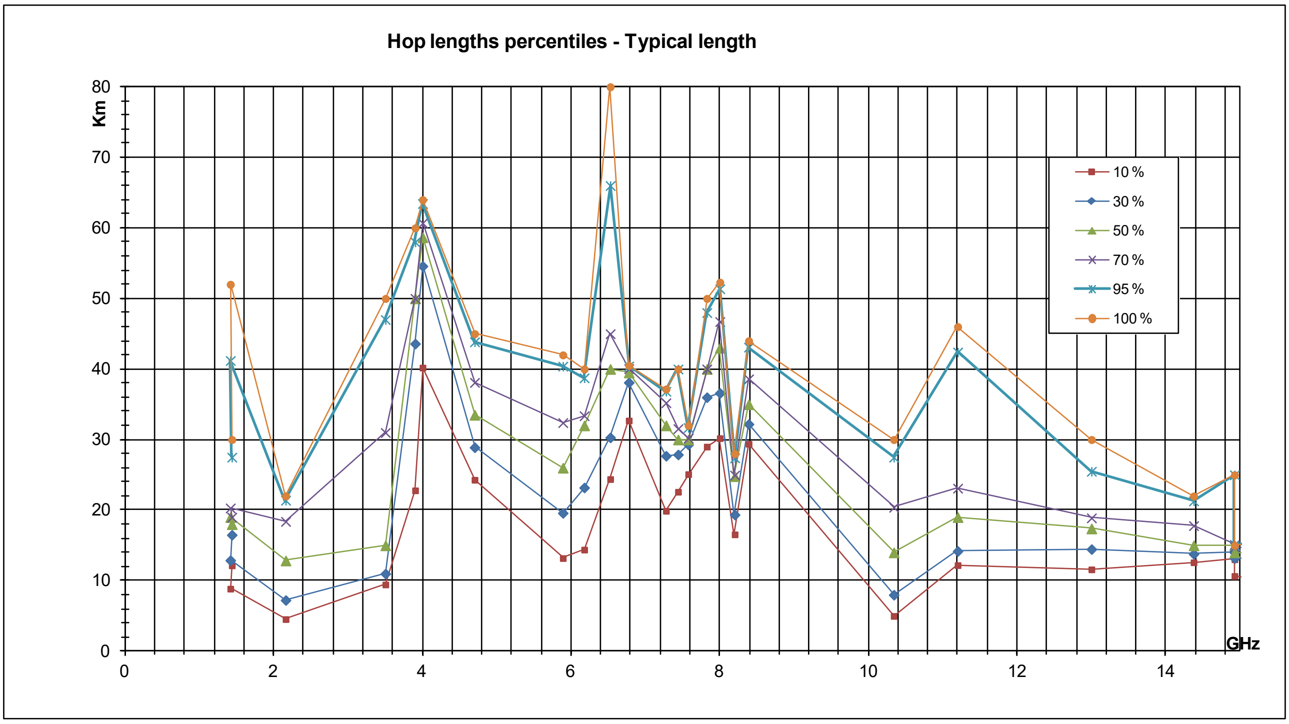


Figure 27: Hop length percentile for frequency bands from 0-15 GHz and 15-80 GHz (Distribution of hop length defined as "Minimum" by CEPT administrations)



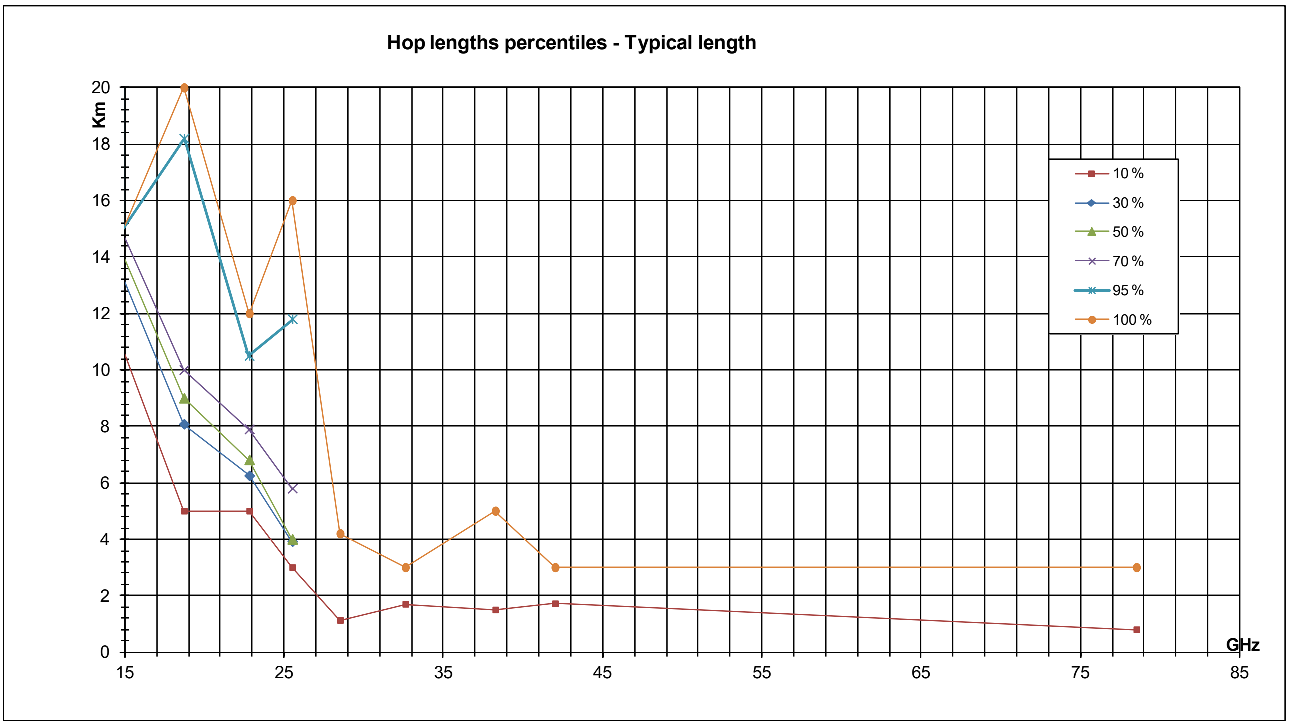
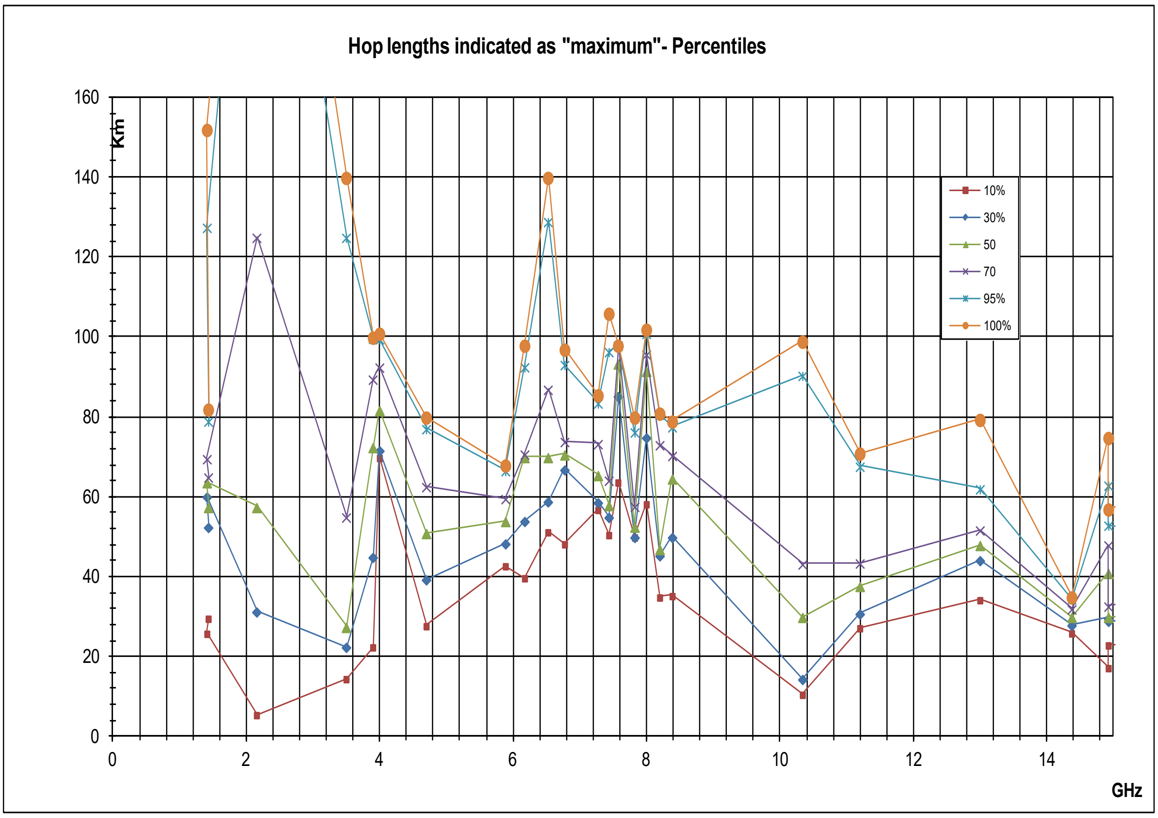


Figure 28: Hop length percentiles for frequency bands from 0-15 GHz and 15- 80 GHz (Distribution of hop length defined as "Typical" by CEPT administrations)



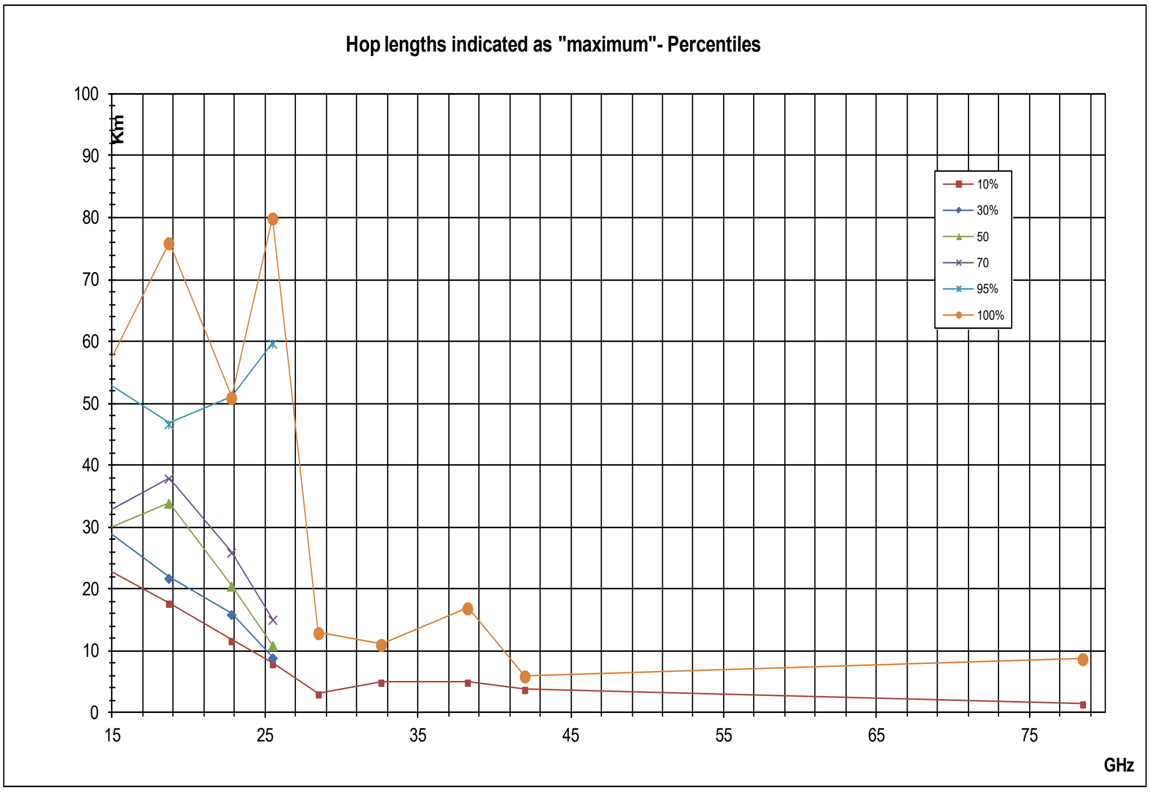


Figure 29: Hop length percentiles for frequency bands from 0-15 GHz and 15-80 GHz (Distribution of hop length defined as "Maximum" by CEPT administrations)

Practically, the probability of a generic link, in X-axes frequency band, to be shorter then Y-axes values (km) can be determined by the parameter of the curve closest to the (X,Y) point.

The points above upper curve have probability as high as 1.

Answers by each administration have been given for three cases: minimum, typical and maximum length.

Although the "typical" case can be considered the most useful, distributions of lengths considered as minimum or maximum are useful for having a complete view of the installations cases.

5.5 CURRENT FS APPLICATIONS

This section analyses some of the most prominent applications in the Fixed Service. Although usage would vary between countries, it should be recognised that fixed links are also used by a large number of disparate users that make up a small percentage of the overall usage market when compared with mobile infrastructure (e.g. the use of fixed links by local councils, utilities, emergency services etc.)

5.5.1 Long-haul trunk/backbone networks

As reported in the 2002 in the ECC Report 003, long-haul trunk networks are probably the oldest major application in the fixed service. Such trunk networks were originally used for transmission of long-distance telephone traffic between the regional switching centres within the national PSTN networks of incumbent telecom operators, also forming part of international connections. Usually such long-haul trunk networks were made of long chains of high-capacity links (often with several parallel channels, sharing a protection channel on n:1 basis), with a typical hop length of some 40-50 km and more. Later such chains were often completed to form several nation-wide rings for more adaptable and reliable routing of traffic.

These backbone networks tend to be replaced by larger capacity fibre networks; unless geographical remoteness still justifies their permanence in service; only some connections (maybe with fewer channels) might remain as partial redundancy to fibre (e.g. for disaster relief).

On the other hand, newer networks, as used by mobile operators, have changed their deployment pattern following the introduction of densely deployed widely distributed mobile networks. They now have to provide many more densely located fixed links in complex chain/ring/star configurations. Therefore, frequencies used for these types of trunk networks have been or are going to be reused for networks now classified as "infrastructure support" (see 5.5.2) and used for the longer connections between big exchange centres.

It should be noted that backbone networks (but with far less capacity transported) are remaining in use for some "utilities" networks (typically for energy-related use), which, for safety reasons, prefer keeping a radio media alternative.

5.5.2 Infrastructure support networks

Infrastructure support networks of FS are usually used to provide connectivity between switching centres (one or several) and various nodes at different layers of telecommunications networks identified as Public Mobile Telephony Networks or Fixed Wireless Access (FWA) networks. Infrastructure support networks are distinguished from trunk network by presence of many layers and different connectivity configurations, which are ultimately formed by fixed links. Configurations of infrastructure support networks range from the chains connecting remote underlying network segments, nation-wide rings of backbone routing and combined ring/star networks for connecting many base stations (or other kind of bearer network terminal points) to regional switching or multiplexing centres. One simplified fragment of such infrastructure support network is given in Figure 1 of this Report.

The growth of internal infrastructures of 2G/3G networks was required to support the permanent growth of subscriber bases, and as this still continues today, the infrastructure networks are also likely to grow further. This growth will continue and with the continuous expansion of mobile broadband IMT-Advanced and IMT-2020 networks, further demand for infrastructure support solutions can be expected.

Wireless technology often provides a more practical and economic infrastructure alternative for quick roll out of networks such as mobile networks. The mobile networks already have to erect towers for their base stations at least every 20-30 km, in rural environment, and far more closer in more populated areas (down to few hundred meters are expected in dense urban areas); therefore, inter-connecting them with wireless FS only adds the cost of the FS terminal equipment to the overall cost. On the other hand, laying down fibre or cable links demand significantly higher additional work and costs. Therefore, fibre only becomes viable when the payload capacity collected and aggregated in the mobile network has grown significantly to the level where wireless infrastructure links cost may become comparable or they have reached their capacity limits (which is, however, also extending up and up approaching the gigabit/system). But this usually happens only for core layers.

5.5.3 Fixed Wireless Access networks

Fixed Wireless Access (FWA) networks are designed to provide a direct connection between the Customer Premises Equipment (CPE, essentially user terminal or data servers) and an operator's core network (PSTN network, data communication network). FWA normally uses P-MP radio technology to serve a large number of CPEs within the coverage area of a central station, as was illustrated in Figure 3. Thus, FWA essentially applies the principle of a cellular network, already well-established in mobile communication networks, into a fixed service scenario.

FWA is also aiming at providing access solutions capable of provisioning truly broadband (multimedia) services to end-customers. Therefore FWA networks capable of providing broadband services are also sometimes called Broadband Fixed Wireless Access (BFWA).

The scope of FWA in the bands around 3.5 GHz and below was to provide basic narrow-band telecommunication services (telephony, internet access at ISDN data rates) to customers, which could not be reached economically by other media or those served by non-incumbent operators, having no copper infrastructure in place. However, the rapid evolution of technologies supporting both fixed and mobile applications (e.g. WiMAX) has, de facto, realised the convergence of FWA and MWA into what is now called Broadband Wireless Access (BWA defined by ECC/DEC/(07)02).

In the higher bands (10 GHz, 26 GHz and above) the original scope of FWA, as depicted in late 1990's, was to provide basic telephony, but also high bit rate data services (anything up to 2 Mbit/s and above) for Internet access, video conferencing, interactive multimedia services (e.g. video on demand, etc.).

However, although FWA is in principle well suited for serving any customers, ranging from residential to small businesses (SOHO/SME) and large corporations, the analysis of current market situation shows that "pure" FWA operators have today less and less hope to make profitable business plans by serving residential customers. After residential access (including ISDN and broadband DSL services) prices were driven down by competition and by the advent of efficient BWA in lower bands, it became extremely hard for FWA to compete in residential market because of still high CPE pricing.

Therefore, FWA networks in these higher bands are confined in niche deployments and no real expansion is expected. In particular, the band 40.5-43.5 GHz designated in 1999 by CEPT for MWS, and mostly unused since then, has been re-designated also for P-P links use (see ECC/DEC/(99)15 revised 2010). Other bands used for FWA in a few European countries are mostly those below 3 GHz (around 1.5 GHz and 2-2.7 GHz), however they are used on a very limited national basis only.

Increase of capacity and related technical requirements (high order modulation scheme, MIMO. active antennas), are also indicated for FWA systems.

5.6 TRENDS IN NETWORKS AND FS APPLICATIONS

An increase in demand for capacity is anticipated, which is driven by the extension of networks towards 5G, also including 4G, leading to more demanding request from mobile operators for backhaul/fronthaul.

High capacity system is indicated by Slovak Republic, Ireland, Finland, Norway, Hungary, Italy, Slovenia, Russian Federation, Greece, Austria, Bosnia and Herzegovina, Mobitel, Orange, Telenor, Telia, OTE.

Increase of cell density (macro cells, small cells) has been indicated by Ireland, Greece, France and Telenor.

Capacity range from 1 to 10 Gbps is expected, requiring proper technological capabilities: wider channel bandwidth (up to 112 MHz), adaptive modulation, higher order modulation (up to 4096 QAM), XPIC have been addressed by a very high percentage of answers.

Packet compression, MIMO (Sweden, Russia) and ATPC are also noted.

Platforms based on Software defined Radio have been indicated by Slovak Republic.

Band and Channel aggregation (BCA) has been indicated to offer challenging peak throughput and high capacity full duplex are also possibilities.

Use of asymmetric P-P fixed links is indicated by Portugal, possible for Ireland, not supported by Croatia,

Need for low latency related aspects was indicated by Ireland, Austria.

Both Line of Sight (LOS) and Non Line of Sight (NLOS) links are required, including point-to-point.

Point-to-Multipoint and mesh networks are indicated by several respondents (Ireland, Hungary, Malta, France, Czech Republic, Austria, Bosnia and Herzegovina, OTE).

Possibility of replacement of links with fibre was indicated by Austria (urban) and Malta.

Detailed information on timeframes is not provided in most cases.

The information gathered for developing the present Report gives the evidence that the current trends in the FS market place are for an ever increasing provision of high bandwidth capacity for the mobile networks infrastructures. These very high capacity links are able to provide a viable alternative to deploying fibre optic cable especially in rural areas but equally in high density urban areas where there would be severe disruption caused by digging up roads etc. to lay down fibres.

5.7 TRENDS IN BANDS USAGE

Use of systems adopting aggregation of channels in different bands (BCA) is indicated by Austria and by Orange.

<u>< 10 GHz</u>

In the 2016 questionnaire, in the 1-10 GHz range, stability or small reductions in the band usage have been indicated by Bosnia and Herzegovina, Austria, Croatia, Slovenia, Italy, Hungary, Romania; increase by Russia, Latvia, Malta, Norway, Bosnia and Herzegovina (long-haul), France, Telenor; congestion was indicated by Germany in 6.2-7.7 GHz in urban areas and by Bosnia and Herzegovina in main frequencies below 8 GHz.

This frequency range is indicated to be still important for infrastructure by Switzerland, Sweden (6-8 GHz), Austria addressed dense urban use. Number of links is not felt to increase significantly, upgrading of existing links is indicated.

Suitability of 1.4 GHz range for electric power utilities needs and low capacity services was addressed.

Use of radio frequency bands < 3 GHz was noted by Sweden (rural), Slovenia.

In the 2.4-2.483 GHz range an increase of use in P-P FWA networks (TDD) and of P-MP FWA networks (TDD) of small telecom operators is indicated by Russia.

Possibility of upgrading existing links is noted by Sweden (lower frequencies), Portugal, Orange (8 GHz).

<u>10 to 20 GHz</u>

Expectation of increase of use in the overall band was indicated by Norway, Latvia, Slovenia (recent years), Switzerland, Croatia, France, Romania; Russian Federation, Greece; stability was indicated by Sweden, Austria.

18 GHz is indicated for increased use in Italy, Germany.

<u>20 to 50 GHz</u>

In this frequency bands, increase was signalled by Norway, Latvia, Slovak Republic (unlicensed bands), Slovenia Switzerland, Croatia, France, Romania (except 40 to 70 GHz), Russian Federation, Germany (22 to 29.5 GHz), Greece, Austria (>50 GHz), Bosnia and Herzegovina, Portugal .

Decrease of use was declared by Sweden (fibre increase), Austria (20 to 50 GHz).

Decrease of low capacity links is declared by Germany, due to capacity upgrading.

<u>> 50 GHz</u>

E-band was indicated as possible facilitator by Ireland; in condition where link length allows.

5.8 BANDS STRATEGY

CEPT members were asked to provide strategical vision of the bands for the next years.

Due to different situation among countries, there are several views expressed by respondents on the importance of specific bands, with different bands in all ranges considered important by different administrations and industry, and some respondents consider all bands as equally important.

Some common viewpoints are noted below.

- Due to the introduction of 5G, several bands will become strategically important in the longer term, including RF bands below 6 GHz;
- Bands below 17 GHz remain important to provide long distance rural coverage, in particular bands lower than 10 GHz are also indicated for important infrastructure needs, backhaul of mobile network, provision of services for power related uses (electricity, oil etc.), possibility to use NLOS; They are also important for high capacity in rural areas, and to relieve existing congestion in certain bands (e.g. 38 GHz);
- Strategic vision of higher bands is foreseen to increase, due to the possibility to convey high capacity.
- E-Band (71-76 GHz/81-86 GHz) is noted as strategically important by several administrations and industry due to the potential for high capacity dense networks for small cell backhaul. Flexible channelling and low cost licensing are particular benefits;
- Higher bands such as D-Band (130-170 GHz) could become important to provide backhaul for 5G;
- Unlicensed or Light licensed bands are expected to become increasingly important.

It is also noted that not every frequency band could be supported by industry, due to investment optimisation, so some specific bands (e.g. 23 GHz, E-band) could be preferred to convey applications with characteristics in line with the ones achievable also in nearby bands.

5.9 CRITERIA FOR RF RANGE SELECTION

The following criteria are used by several respondents:

- Technical characteristics: link length, bandwidth, capacity, reliability, link budget, rain zone, minimum modulation, ATPC;
- Economic criteria: fees, availability and cost of equipment, antenna size, maintenance, specific market needs;
- Regulatory framework: minimum link distances, sharing with other services;
- Band use, available channels and congestion.

In some administrations the desired frequency band is selected by the licensee, in some cases a basic set of minimum requirements to be compliant is provided.

Some administrations consult on a regular basis the stakeholders to adapt regulation to evolving needs and environment.

Maximisation of social benefit of radio spectrum over time has been indicated.

No change is foreseen on RF range selection criteria.

Concerning congestion, it was noted by many respondents that this condition happens mostly close to big cities, and is therefore to be intended in geographical sense, rather than being related to the country in general. As such, an area with congestion could be intended as an area where the probability of finding an assignment for a new application is low. The trigger for defining congestion could be when less than X% of the channels in the specific frequency band are available in the wanted direction. Threshold of 20% is used by one administration.

5.10 LICENCE FREE, LIGHT LICENCE OR BLOCK ASSIGNMENT

Several respondents believe bands above 50 GHz are suitable for light licensing, licence exemption and/or block assignment.

In particular 57-66 GHz (V-Band) is noted as suitable due to oxygen absorption properties which allow for better interference management; the same for 71-76/81-86 GHz (E-Band) where interference is also easier to manage. Light licensing is already used in these bands by some administrations. Higher bands are also considered suitable to be covered by these licensing regimes, although effective use is not started yet.

Some respondents note specific bands below 50 GHz which could be suitable for block assignment, but there is no clear common view.

Block licensing is beneficial where a limited number of operators wish to deploy a large number of links in a single band.

It is noted that there is already existing block assignment in some bands in some administrations.

Concerning license exemption, it was noted that it can be used to provide adequate performance level, on condition that specific requirements for equipment (such as ATPC, DFS, antenna proper RPE) are standardised.

Some others have not taken a final position jet, while a few administrations just consider link by link licensing regime, at least in next future.

The following Table 3 provides an overview of results, related to the answer to questionnaire about the suitability of a different licensing regime than link by link.

Table 3: RF bands suitability for licensing regime other than link by link

GHz	Unlicensed	Light licensing	Block licensing
1.4			EUTC
3.5			Slovak Rep., Croatia and Germany
5.7			Greece
10			Slovak Rep.
26			Slovak Rep., Ireland, Turkey, Austria, Bosnia and Herzegovina (+ 28 GHz)
32			Croatia, Austria
38			Turkey, Austria
42			Ireland, Croatia, Greece, Bosnia and Herzegovina
50			Croatia, Bosnia and Herzegovina
57-66.	Slovak Rep., Ireland, Finland, Norway, Malta, Sweden, Russia (<63GHz), Germany, Greece, Austria(<63GHz), Telia, OTE, Huawei	Hungary (59-64 GHz)	Bulgaria, France, Greece, Bosnia and Herzegovina, Telia
71-86	Slovak Rep., Ireland, Finland, Russia (>95 GHz), Bosnia and Herzegovina, Mobitel, Telia, Orange, Huawei	Hungary, Telenor	Bulgaria, Telia, OTE
92-115 GHz	Bulgaria, Russia, Germany Bosnia and Herzegovina, Telenor, Telia, Orange, Huawei		Latvia, Telia
130-170 >GHz	Bulgaria, Germany, Bosnia and Herzegovina, Telia, Orange, Huawei		Latvia, Telia

The majority (16) administrations are not planning any changes, but some of these note recent changes including introduction of light licensing in 70/80 GHz. 7 administrations are considering changes, mainly the implementation of light licensing at 70/80 GHz and in 1 case block licensing in some bands below 50 GHz.

6 CONCLUSIONS

The Fixed Service (FS) is and remains a key service for telecommunication infrastructure development. Since 1997 the CEPT has provided public information to present a picture of the FS deployment in Europe with the intention to use it as a reference and for guidance purposes for administrations, operators and manufacturers.

In 2010, the ECC decided to start the edition of a new report as an updated version of the ECC Report 003 (published in 2002), in order to verify the assumptions of the previous studies and to collect updated information on the number of fixed links for each band in CEPT countries. Therefore, this Report builds on the results of the original ERO Reports on FS trends post-1998 and post-2002 by revising it and updating the information on FS use.

Developments in the technologies show the new trends in the FS sectors: ranging from higher modulation schemes (up to 4096 levels), adaptive modulation schemes to Hybrid/Ethernet technology equipment, better suited for different QoS levels and high capacity links.

Fixed Wireless Access (FWA) applications are either stable/decreasing in higher frequency bands or migrating to converged Broadband Wireless Access (BWA) networks in bands at around 3.5 GHz or below.

The information gathered for developing this Report gives the evidence that the current trends in the FS market place are for an ever increasing provision of high bandwidth capacity for the mobile networks infrastructures. These very high capacity links are able to provide a viable alternative to deploying fibre optic cable especially in rural areas but equally in high density urban areas where there would be severe disruption regarding fibres such as the ones caused by digging up roads and/or emergency and disaster situations.

As a consequence the report highlights the strategic importance of some frequency bands for the FS. Some of these bands have already started to show a rapid growth in terms of number of links (13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz), and on which special attention from administrations should be taken; while others are still preparing to take off (32 GHz, 50 GHz, 70/80 GHz, 92 GHz) In addition, the potentially interesting issue of NLOS urban backhauling for the new generation of mobile networks might open for new applications also in FS bands below about 6 GHz.

This report highlights also the fact that the CEPT proactively responds to the industry demand for efficient usage in the new millimetric wave (mmW) bands with a set of new or revised recommendations. In term it creates a healthy competitive FS environment with wider harmonisation use of FS, including frequency ranges higher that the ones already implemented in networks but technically feasible with today' s technology such as the W-band (92-114.25 GHz) and D-band (130-174.8 GHz). As part of the development strategies, the CEPT, in 2011, revised the recommendation on the usage of the band 7125-8500 MHz with a view to harmonise its use in Europe for countries that are in a position to refarm it, as it is the only FS band lacking harmonisation incentives (in terms of clear CEPT policy and/or channel arrangements).

Regarding the assignment procedures used, the responses show that for P-P links the most used method foresees conventional link by link license and centralised coordination. However, assignment/auction of frequency blocks in certain bands becomes also popular; this is particularly true when also P-MP (or, in some cases, even mixed FS and other telecommunication service) are permitted.

ANNEX 1: BAND BY BAND REVIEW OF THE FS USAGE

This annex presents a deeper band by band analysis extracted from the replies to the questionnaire.

It should be noted that clauses related to frequencies lower than 50 GHz (clause A1.25 included) have been addressed by all questionnaires, while sections for higher frequencies are considered only in the last two surveys (2010- 2016).

In following tables, the amount of equipment refers to overall numbers declared.

Due to different number of countries answering all questionnaires (specifically answers for 1997 and 2001 revisions are not available in an electronic format), trends have been compute based on the overall number of links / band given in the previous version of ECC Report 173 (edition 2012) for 1997, 2001 and 2010, while trend for 2010-2016 is derived from answers of related questionnaires.

At the end, for more comprehensive visualisation of variation of number of links in field, the cumulative trend for all period has been applied to one hypothetical single link, assumed operating in 1997.

A1.1 FREQUENCIES BELOW 2 GHZ

This frequency range is used by many applications, mostly related to the mobile world (GSM 900/1800, UMTS, HSPA, LTE, etc.). However the answers to the questionnaire indicate that also P-P applications exist in almost all countries, with limited level of harmonisation (about 10 different sub-ranges are indicated).

Two sub-bands (1350-1375 MHz paired with 1492-1517 MHz and 1375-1400 MHz paired with 1427-1452 MHz) are declared as open by about 15 administrations, although effective use is limited to about 7 of them.

Each of the other sub-bands is used by just one administration.

About 4000 P-P active links are reported, with significant increase of bidirectional links.

Few P-MP applications have been reported by some administrations. However, these latter bands, even if providing limited bandwidth, might be potentially suitable for NLOS backhauling applications (see section 4.1.4).

The number of active links reported is indicated in Table 4, while trend is reported in Figure 30.

Table 4: Number of active links declared in 2010 and 2016 in RF range below 2 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	4655	2291	154
2016	3998	908	44

Low capacity links are generally implemented, with a low percentage of medium capacity; licensing regime appears link to link in general, few administrations allow block assignment.

The only harmonised bands for FS below 2 GHz are: 1350-1375 MHz paired with 1492-1517 MHz and 1375-1400 MHz paired with 1427-1452 MHz which are using the Recommendation T/R 13-01 Annexes A and B, used in the majority of countries.

Several national plans are indicated in this frequency range.

Intention to decrease the use of these frequencies has been declared by several respondents, similarly to possible allocation to other services / applications; use of analogue system with limited BW is reported by one administration.

In most used sub-band (1375-1400 MHz paired with 1427-1452 MHz), intention to decrease is declared by Croatia, Sweden, Switzerland, while reallocation is anticipated by Finland, Croatia, Latvia, Norway, Portugal, Sweden, Switzerland, Slovenia.

Hop length: 95% percentile of “typical” length is in the range of about 30 to 40 km in different sub-ranges (10 to 20 km for those indicated as “minimum”) 60 km is the 50% percentile of “maximum” indication.

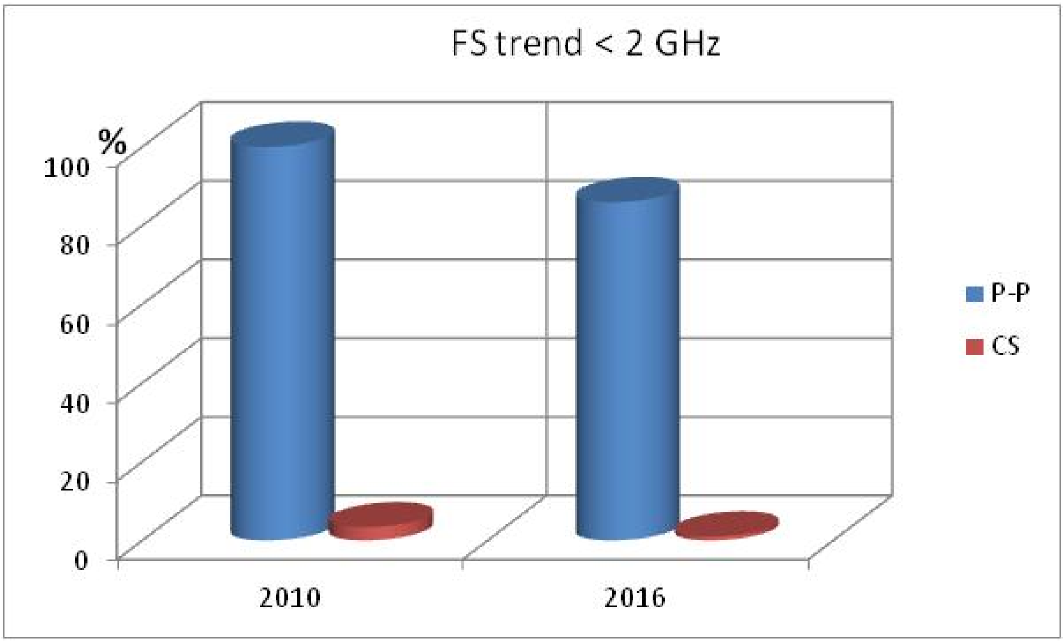


Figure 30: Trends for the P-P links in the band below 2000 MHz in CEPT (P-P links in 2010 =100%).

A1.2 2.025-2.4 GHZ BAND

This frequency range is available for many applications, mostly related to mobile service (IMT and so on; ENG/OB is indicated) and MSS. Four sub-ranges are indicated for FS among them 2025-2110 and 2200-2290 MHz is open by about 15 administrations, but used by only 4 with limited density. Some analogue links are still used in one country.

About 9200 P-P links have been indicated in operation in addition to about 4100 base stations.

Low capacity links are generally indicated, with a low percentage of medium capacity. Licensing regime is mostly link-by link based.

Use appears mostly for broadband infrastructure.

Great majority of applications (9100 FS links, all CS) are in one single country (Russia), in sub-range 2400-2483.5 MHz; related data for 2010 questionnaire were not present. For other countries addressed in previous questionnaire, the use is reduced (about 300 FS links, no BS).

CEPT Recommendation T/R 13-01 is the most frequently referred channel plan. Few countries indicated the existence of a national plan.

A trend for increased use is indicated by Russia (P-MP and P-P FWA networks (TDD)) and Croatia; decrease use is indicated by Greece; temporary use by Finland.

The use of this band for the fixed service seems to be stable or in reduction or in almost all countries. However, the 2 GHz band (CEPT Recommendation T/R 13-01 Annex C), providing ~ 80 MHz of paired bandwidths (presently up to 5 $\times$ 14 MHz paired channels), might be potentially suitable for NLOS backhauling applications (see section 4.1.4).

Hop length: 95% percentile of "typical" length is in the range of about 20 km in different sub-ranges (7 km for those indicated as "minimum") 60 km is the 50% percentile of "maximum" indication.

A1.3 3.4-4.2 GHZ BAND

This frequency range is available for IMT (3.4-3.6 GHz as established by WRC-07) and P-MP applications (3.4-3.8 GHz), including WiMAX, as well as Fixed Service P-P traditional applications. The 3.4-3.8 GHz band is also addressed by the European Commission Decision 2008/411/EC where neutrality with regard to technology and service is required. 6 different sub-ranges, among which the 3400- 3600 and the 3600 to 4200 MHz are indicated by many administrations. Links in operation are indicated in great majority of open bands.

P-MP use is indicated by 18 administrations in 3400-3600 MHz frequency range, 10 administrations in 3800-4200 MHz frequency range. P-P use is referred by 8 administrations in 3400-3600 MHz frequency range, 8 administrations in 3800-4200 MHz frequency range.

The results of the questionnaire indicated more than 8500 base stations in operation, in addition to about 1800 P-P links. The number of base stations is underestimated, as block and link based licenses are foreseen in many countries.

It should also be taken into consideration that the portion 3.8-4.2 GHz (ERC/R EC 12-08 Annex B part 1), providing up to 6 × 29 MHz paired channels, might be potentially suitable for NLOS backhauling applications (see section 4.1.4). However, sharing with FSS should be carefully considered.

Number of active links reported is indicated in Table 5, while trend is reported in Figure 32Figure 31.

Table 5: Number of active links declared in 2010 and 2016 in RF range 3400-4200 MHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	5252	624	12664
2016	1790	285	8735

Band 3.4-3.6 GHz (also 3.6-3.8 GHz) is allocated to providers of electronic services in Slovak Republic, Fixed Wireless Access (FWA) is used or planned in Bosnia and Herzegovina and Czech Republic Broadband Wireless Access (BWA) in Lithuania, Portugal and Slovenia.

Mid/High capacity links are mostly implemented. Links are mostly used in network/broadcast infrastructure. Minor use is declared for mobile backhaul.

Link by link (17 administrations in various bands) and block licensing regimes (14 administrations) are used.

The great majority of countries refer to ERC/REC 14-03 and ERC/REC 12-08; Finland, Russia and Croatia adopt a national frequency plan.

In the full band, growth is foreseen in Slovak Republic, decrease in Germany and Hungary, stability or scarce use was indicated by Austria, Romania and Russia.

In 2016 questionnaire, in 3.4/3.8 GHz band, increase of use in next years are indicated by Bosnia and Herzegovina, Czech Republic, Serbia, Slovenia, Sweden, Hungary, Greece, Lithuania, Latvia, Slovak Republic and Ireland.

Concerning 3.6-4.2 GHz band, increase is expected in Russia (long-distance multi-hop links), Croatia, Hungary, Sweden, Bosnia and Herzegovina; decrease in France, Italy and Greece.

Some administrations indicate possibility to reallocate part of the band to other services (9 for the 3.4-3.6 GHz, 6 for the 3.6-4.2 GHz).

Hop length: 95% percentile of “typical” length is in the range of about 50 to 60 km in different sub-ranges (20 km for those indicated as “minimum”) 70 to 80 km is the 50% percentile of “maximum” indication.

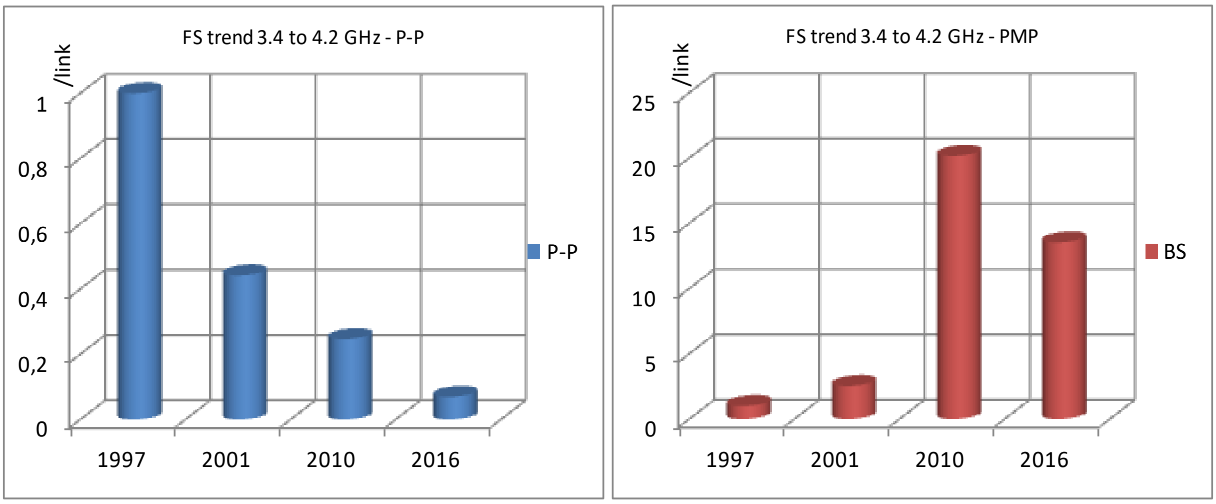


Figure 31: Historical (normalised to 1 link in 1997) trends for P-P and P-MP links in band 3400-4200 MHz in CEPT

A1.4 4.4-5.4 GHZ BAND

This band appears scarcely used for P-P and P-MP links.2 sub-bands are indicated, it is open by 7 administrations, but used just in Austria (P-P only) and Russia. Few links were reported, most of them in Russia for FWA (P-P and P-MP) in frequency band 5150-5350 MHz.

Number of active links reported is indicated in Table 6, while trend is reported in Figure 32.

Table 6: Number of active links declared in 2010 and 2016 in RF range 4400-5400 MHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010 (4500-5000 MHz only)	484	-	-
2016	1603	10	5419

Used mainly for medium/high capacity links mainly in fixed /broadcasting infrastructure for telecom operators, FS Military use is noted in some countries.

Licensing regime is link by link.

4400-5000 MHz range is used with a national plan in Austria, 5150-5350 MHz range is referred to ITU-R Rec. F.1099 and F.746.

Possible increase of use is reported by Russia in P-MP FWA networks (TDD) in small telecom operators' networks.

Hop length: 95% percentile of “typical” length is in the range of about 43 km (21 km for those indicated as “minimum”) 50 km is the 50% percentile of “maximum” indication.

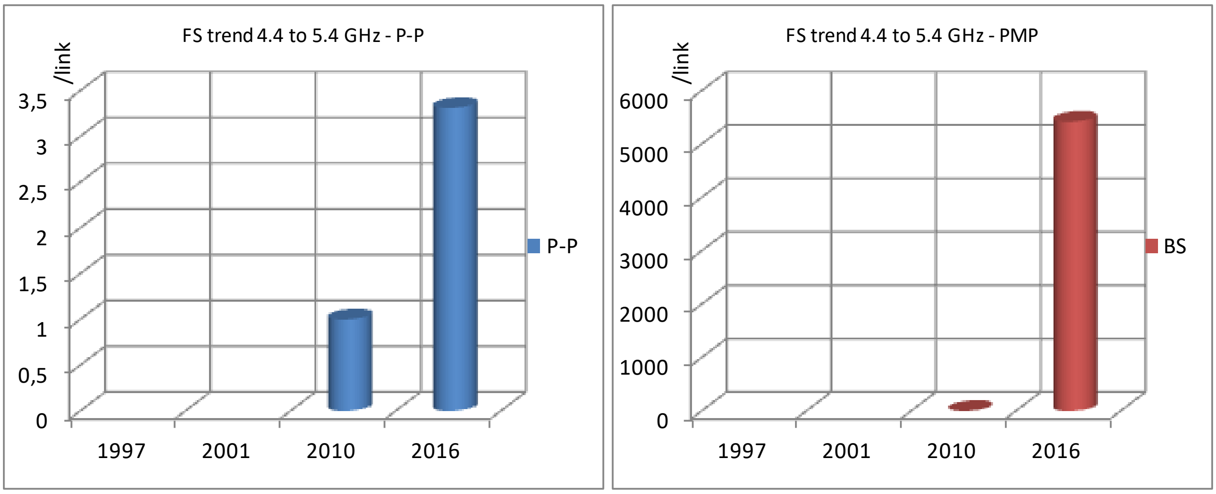


Figure 32: Historical (normalised to 1 link in 2010) trends for P-P and P-MP links in band 4400--5400 MHz in CEPT

A1.5 5.65-5.95 GHZ BAND

This frequency range is open for P-P and P-MP applications by 7 administrations, some allowing both uses. Three sub-ranges are indicated (5650-5850 MHz, 5725-5795 MHz, 5850-5925 MHz); among them the 5650-5850 MHz range accounts for highest number of links, while 5850-5925 MHz range is indicated by most administrations. Active links are indicated in Austria, Greece and Russia.

The band has meaningful use in Russia, while appears scarcely used elsewhere in Europe.

Number of active links reported is indicated in Table 7, while trend is reported in Figure 33.

Table 7: Number of active links declared in 2010 and 2016 in RF range 5650-5950 MHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010 (5650-5850 MHz no info)	1568	187	623
2016	3071	-	4977

Low, medium and high capacity applications are used in network infrastructure.

All licensing regimes are used; unlicensed use is noted by 3 administrations (Norway, Portugal and Switzerland).

National plans are declared by Austria and Russia.

Trends for increase of use are indicated by Russia (P-P FWA networks 5650-5850 MHz) and Greece (5625--5795 MHz).

Hop length: 95% percentile of “typical” length is in the range of about 40 km (4 km for those indicated as “minimum”) 54 km is the 50% percentile of “maximum” indication.

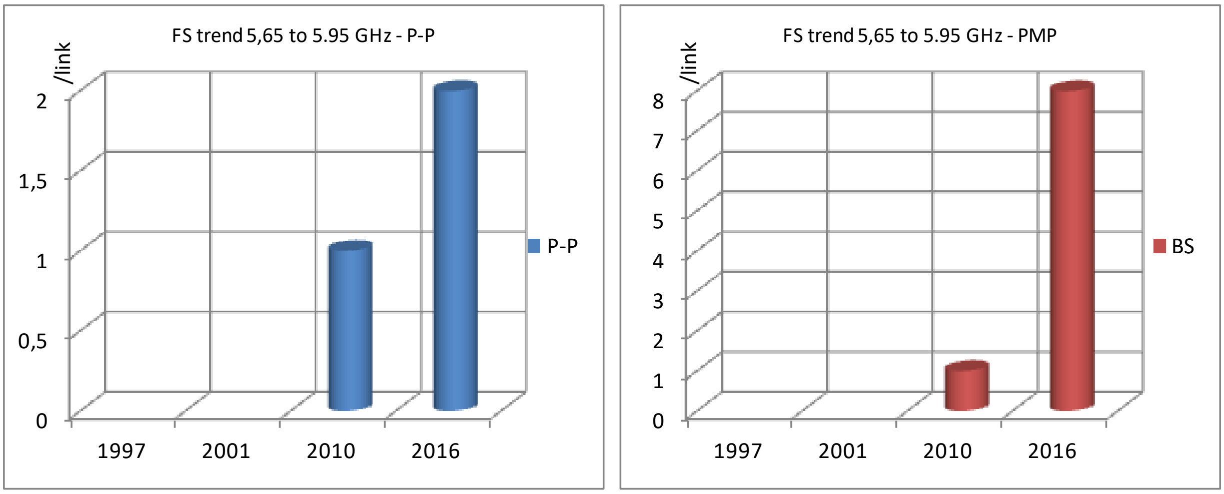


Figure 33: Historical (normalised to 1 link in 2010) trends for P-P and P-MP links in band 5.65-5.95 GHz in CEPT

A1.6 5.9-7.1 GHZ BAND-

This frequency range has been traditionally used in Europe for P-P links since quite a long time. P-MP use is also allowed. 5 sub-bands are used. Band is open in about 20 countries. After a negative trend towards the end of the 20th century, mainly due to the migration from analogue to digital links, and a stable situation till 2010, there was a significant increase. 4 different sub-ranges are indicated (5925-6425 MHz, 5925-7125 MHz, 6425-7110 MHz, 6425-7125 MHz), the second being open and used for P-P by about 20 administrations. P-P and P-MP FWA is also used in Russia (5925-6425 MHz) and some P-MP in Slovak Republic (5925-7125 MHz).

About 23000 P-P active links are indicated in total by administrations and 5300 base stations are used in Russia, together with P-P links. The use of unidirectional links has been significantly reduced, mainly in Germany.

Number of active links reported is indicated in Table 8, while trend is reported in Figure 34

Table 8: Number of active links declared in 2010 and 2016 in RF range 5900-7100 MHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	17663	4253	1942
2016	23027	80	5370

High capacity, long distance P-P links are implemented, mainly forming part of fixed, mobile and broadcasting infrastructure.

Used frequency plans are in accordance with ERC/REC 14-01 (5925 to 6425 MHz) and ERC/REC 14-02 (7425-7125 MHz). No national frequency plans are noted.

Licensing regime is mostly link by link; block assignment is foreseen in Estonia (5850-5925 MHz) and available, in addition to link by link, in Norway (5925-7125 MHz).

In the 6 GHz (5.9-7.1 GHz) band, trend to increase the use of the band is indicated by Slovak Republic, Finland, Croatia, Sweden, Greece, Russia, Netherlands, Italy, Latvia, Malta, Portugal, Switzerland. Stability or slight decrease was indicated by Romania and Germany. Intention to use narrow channels in the guard bands and centre gaps of the lower 6 GHz and upper 6 GHz bands was indicated by Portugal; congestion was indicated by Slovenia, Bulgaria, Croatia, Sweden, Germany, Finland, Netherlands, Mobitel; heavy use is noted in France. Possible future reallocation to other services/applications is noted by Portugal.

Hop length: 95% percentile of “typical” length is 40 km for 5.9-6.4 GHz range, 65 km for the 6.4-7.1 GHz range (about12 km for those indicated as “minimum”); 70 km is the 50% percentile of “maximum” indication.

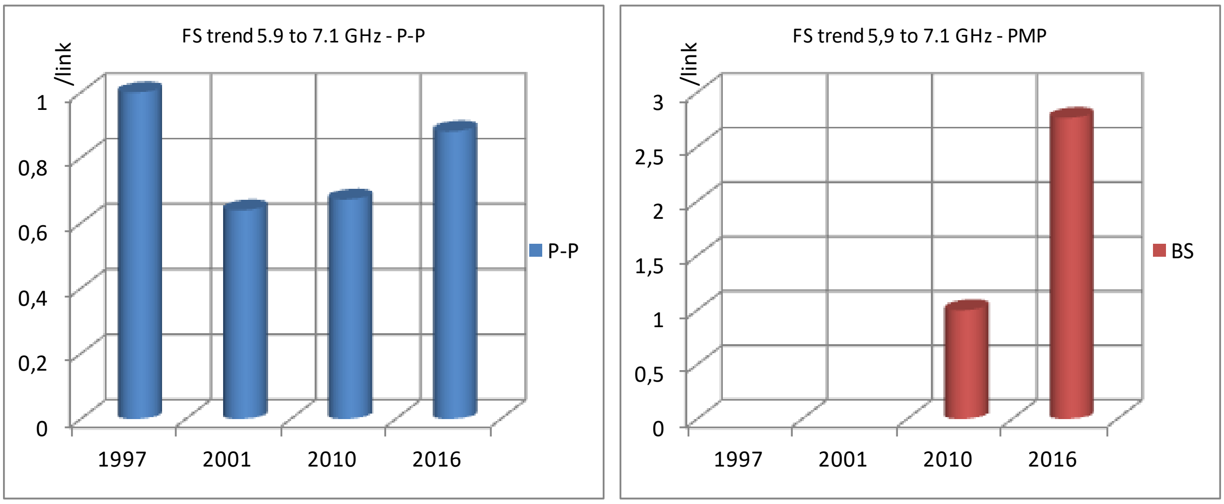


Figure 34: Historical trends (normalised to 1 link in 1997) for P-P and P-MP links in band 5900-7100 MHz in CEPT

A1.7 7.1-8.5 GHZ BAND

This range is also an historical and widely used band for P-P applications. 11 sub-ranges are used, three of them are widely used.

7125-7750 MHz is open and used in 17 countries, 7750-7900 MHz is open in 9 countries and used by 6, 7900-8500 MHz is open in 13 countries and used by 9. Significant use is declared in Russia for 7250-7550 MHz sub-range; no P-MP is allowed.

Number of active links reported is indicated in Table 9, while trend is reported in Figure 35.

Table 9: Number of active links declared in 2010 and 2016 in RF range 7100-8500 MHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	36036	5166	-
2016	52670	181	-

The great majority of countries refer to high and medium capacity, link based license, mainly forming part of network infrastructure, mostly for mobile backhauling; broadcast infrastructure is also involved.

Military use has been also reported, (7.25-7.3 GHz, 7.975-8.025 GHz); further details on military usage of this band can be found in the ECC Report 163.

Frequency use in this band appears very complicated, due to the fact that use has started quite long time ago, with analogue systems, and many countries adopted national plans at that time, without coordination with other countries.

In later times, most of used channel rasters have been incorporated in ITU-R Recommendations, but no frequency harmonisation was possible, since equipment was already in operation. Nevertheless in 2011 the ECC/REC/(02)06 was revised with a view to harmonise the use of the band in Europe for countries planning to refarm it. A high percentage of answers (60%) refers to the adoption of this Recommendation, but the total range of different sub-bands is still significant (12).

National plans are indicated by Bulgaria end Finland in some portions of the band.

Licensing regime has been adopted by all administrations. Finland and Norway adopt, in addition, block license in 7.9-8-5 GHz frequency range.

Significant number of countries (including Bosnia and Herzegovina, Netherlands, Italy, Latvia, Malta, Norway, Portugal, Sweden, Switzerland, Slovak Republic, Bulgaria) plan to increase the usage of this range (10 to 25% increase), possible reduction is declared by Finland, Portugal and Greece in some sub-bands. The comparison analysis with previous reports seems to show an overall stable situation in the band.

Congestion is declared in some ranges by Finland (some parts Upper 6 GHz), Turkey, Slovenia, Croatia, Sweden, Germany and the Netherlands.

Hop length: 95% percentile of "typical" length is in range 30 to 50 km (about 18 km for those indicated as "minimum"); 90 km is the 50% percentile of "maximum" indication in the band.

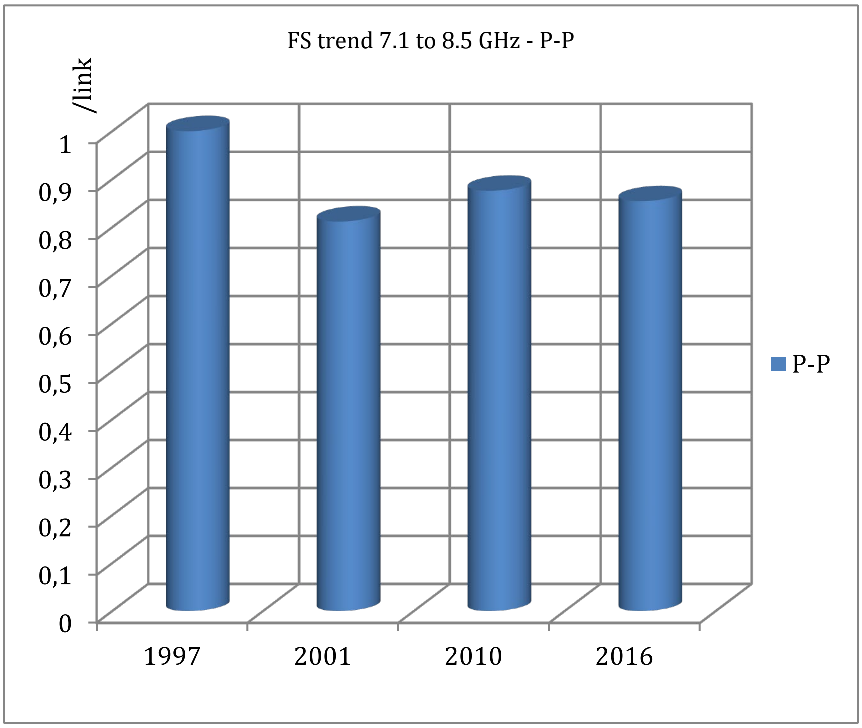


Figure 35: Historical trends (normalised to 1 link in 1997) for P-P links in band 7100-8500 MHz in 19 CEPT countries available for comparison

A1.8 10-10.68 GHZ BAND

Use of this RF band has been declared by about 20 Countries, with 4 different sub-ranges, three of them being used within just one country. Band is used for P-P and P-MP applications. Significant percentage of central stations is used in just Russia.

Number of active links reported is indicated in Table 10, while trend is reported in Figure 36.

Table 10: Number of active links declared in 2010 and 2016 in RF range 10-10.68 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	3803	2662	1760
2016	6195	287	890

All range of capacities is reported in this band.

Most applications are part of infrastructure for mobile and broadcasting networks.

Most licensing regimes are based on individually licensed links; block assignment is also referred in some sub-bands (Latvia, Norway, Sweden, Slovak Republic, Slovenia, UK and Turkey), license free use is indicated in Czech Republic (10.301-10.588 GHz).

Frequency allocation is practically based on CEPT Recommendation ERC/REC 12-05 (and annexes) while the ECC/DEC/(10)01 regulates the sharing condition between FS, MS and EESS; in addition, some national plans (Greece and Czech Republic) exist. National plan is used Czech Republic in the bands 10.301-10.42 GHz and 10.476-10.588 GHz, but according to operator's announcements, the band is getting congested.

Need for growth has been indicated by few countries (Bosnia and Herzegovina, Latvia, Norway, Switzerland, Slovak Republic and Bulgaria); few others indicate trend to decrease (Greece and Latvia).

The band is not congested in average.

Hop length: 95% percentile of "typical" length is 27 km (6 km for those indicated as "minimum"); 30 km is the 50% percentile of "maximum" indication in the band.

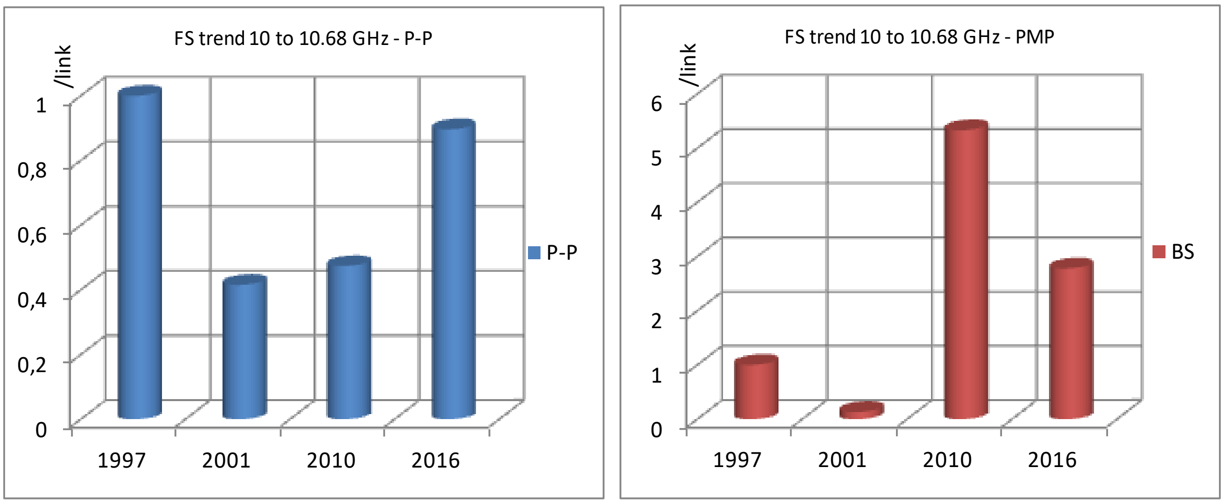


Figure 36: Historical trends (normalised to 1 link in 1997 for P-P and P-MP links in band 10 to 10.68 GHz in CEPT

A1.9 10.7--12.5 GHZ BAND

This radio frequency range was allocated many years ago to fixed service and used mostly by P-P. Four sub-ranges are used (10700-11700 MHz, 10755-11725 MHz, 11700-12500 MHz, 11725-12500 MHz). The most used is the 10700-11700 MHz, opened in about 20 countries and used by about 15. P-MP links are used in Bosnia and Herzegovina, Hungary (restricted MVDS use only in the 12.3-12.5 sub-band) and Slovenia.

Use of P-P is quite wide, about 16000 P-P links are in service in this range. In 10.7-12.5 GHz some P-MP base stations are reported, mainly in Hungary in the 12.3-12.5 GHz sub-band (about 150 base stations in total).

It has to be noted that due to satellite sharing problems, some countries have stopped the introduction of new links in this band (see ERC/DEC/(00)08).

Number of active links reported is indicated in Table 11, while trend is reported in Figure 37.

Table 11: Number of active links declared in 2010 and 2016 in RF range 10.7-12.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	7271	196	2025
2016	16770	58	252

The majority of applications consist of high capacity links, individually licensed, forming part of telecommunication (including mobile backhaul) and broadcasting infrastructure networks.

Link by link regime is widely adopted; block assignment is used in Norway, Bosnia and Herzegovina, and Slovenia in specific sub-bands.

Frequency usage refers to CEPT ERC/REC 12-06, as well as Recommendation ITU-R F.387, with few national plans (Latvia, Slovenia and Bulgaria).

Some countries (Greece, Italy, Latvia, Switzerland, Slovak Republic, Bulgaria and Malta) intend to increase the use in next years and in one country (France) congestion is indicated in 10.7-11.7 GHz band.

Bosnia and Herzegovina, Norway, Portugal declared trend to reduce usage, no use is reported in Germany; heavy use is declared by France, Greece. Possible reallocation to other services is foreseen by Bulgaria.

Hop length: 95% percentile of "typical" length is 40 km (10 km for those indicated as "minimum"); 40 km is the 50% percentile of "maximum" indication in the band.

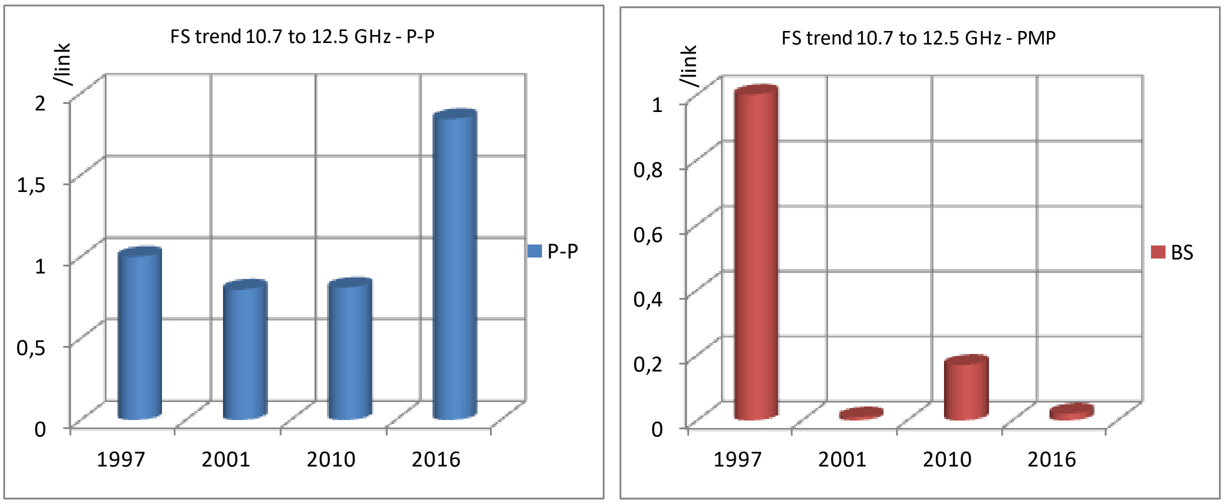


Figure 37: Historical trends (normalised to 1 link in 1997) for P-P and P-MP links in band 10.7 to 12.5 GHz in CEPT

A1.10 12.75-13.25 GHZ BAND

This RF range was allocated many years ago to fixed service, and is open and used widely for P-P by the great majority of countries in CEPT (open in 24 countries, used by 23).

Number of active links reported is indicated in Table 12, while trend is reported in Figure 38. The trend chart shows a continuous increase since 1997.

Table 12: Number of active links declared in 2010 and 2016 in RF range 12.75-13.25 GHz

Year	P-P total	P-P(unidirectional)	P-MP Central Stations
2010	51313	7951	7
2016	72200	41	-

The major utilization is for medium-high capacity links, individually licensed, most of them belonging to mobile backhaul, fixed, and broadcast infrastructure.

Link by link regime is widely adopted; block licence is also available in Norway.

The frequency usage has high a harmonisation level; all answers refer to CEPT ERC/REC 12-02.

Regarding the usage, about 10 countries indicate expectations to moderate increase in coming years (10-25% increase). Expectation to decrease is declared by Finland, congestion exists in Ireland, Slovenia, Hungary, Germany; Ireland, Croatia, Sweden, Russia, Greece, stable link amount was noted by Finland, Germany; increase by Hungary; Bosnia and Herzegovina; heavy use in Romania, Estonia, France; congested situations in big cities are reported by Hungary. .

Hop length: 95% percentile of “typical” length is 6 km (25 km for those indicated as “minimum”); 48 km is the 50% percentile of “maximum” indication in the band.

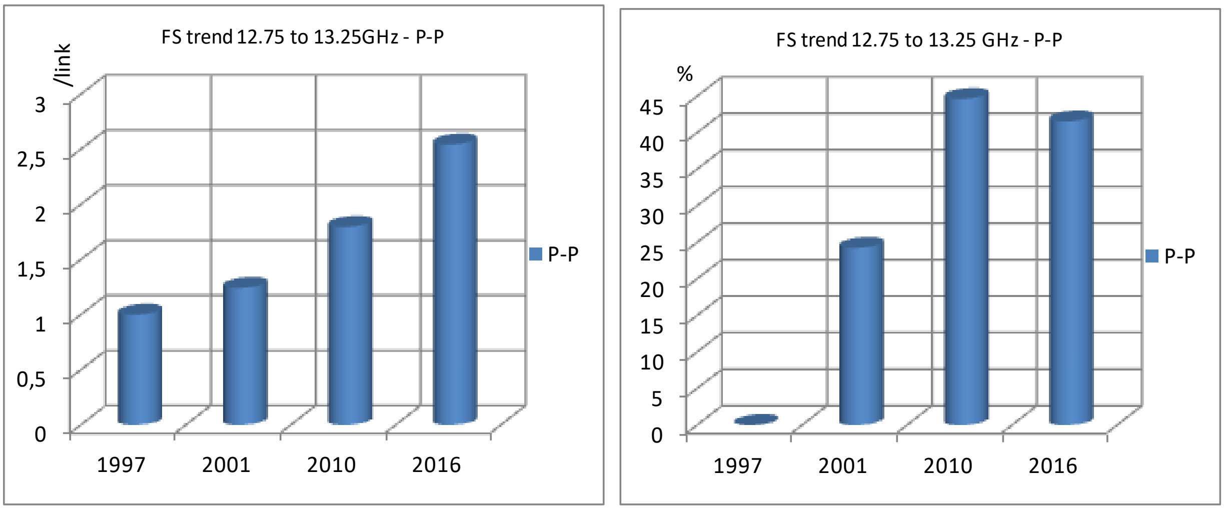


Figure 38: Historical (normalized to 1 link in 1997) and percentage trends for P-P links in band 12.75 to 13.25 GHz in CEPT

A1.11 14.25-15.35 GHZ BAND

Three sub-bands have been indicated in this range, only for P-P links.

14.25-14.5 GHz sub-band is used for FS by a lower number of countries (Estonia, France, UK, Italy, Latvia, Portugal and Russia), with about 1400 active P-P links. In the UK and France the 14.25-14.5 GHz band is closed to new fixed links (around 150 existing links still in use in each country in 2016).

In this sub-band, no FS use or new deployment is indicated in Ireland, Hungary, Portugal, Malta, Latvia, Slovenia, Switzerland, Croatia, Estonia, Sweden, Russian Federation, Greece, Czech Republic, Austria as well as Bosnia and Herzegovina. Exclusive reservation for PPDR is indicated by Germany.

Sub-band 14.5-14.63 GHz, paired with 15.23-15.35 GHz, is widely (about 20 countries) and densely used all over Europe, with more than 57000 P-P active links in operation.

Number of active links reported is indicated in Table 13 and Table 14, while trend is reported in Figure 39. The trend chart shows a continuous increase since 1997 in range 14.5-15.35 GHz.

Table 13: Number of active links declared in 2010 and 2016 in RF range 14.25-14.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	1568	1044	-
2016	1424	1091	-

Table 14: Number of active links declared in 2010 and 2016 in RF range 14.5-15.35 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	46996	12239	-
2016	57228	362	-

- Major utilization is for low-medium capacity links, although a significant percentage assigned to high capacity use has been also indicated, mostly for mobile backhaul, fixed and broadcasting infrastructure. Military use is indicated by one country.
- Links appear mostly individually licensed; block licence is possible in Norway and Turkey. The great majority of links are part of fixed and mobile infrastructure (especially mobile backhaul).
- Frequency use refers to CEPT ERC/REC 12-07. Sweden and Greece refer to a national plan
- About 10 countries indicate expectation of growth in next years (10-20% increase), while congestion is declared by 6 administrations.

In the overall band, congestion was declared in Ireland, Germany; heavy use in Romania, Germany and Estonia. Trend to decrease is expected in Germany, Finland and France. Reallocation to other services is expected in Italy.

Hop length: 95% percentile of “typical” length is 20 km (5-10 km for those indicated as “minimum”); 30-40 km is the 50% percentile of “maximum” indication in all sub-bands.

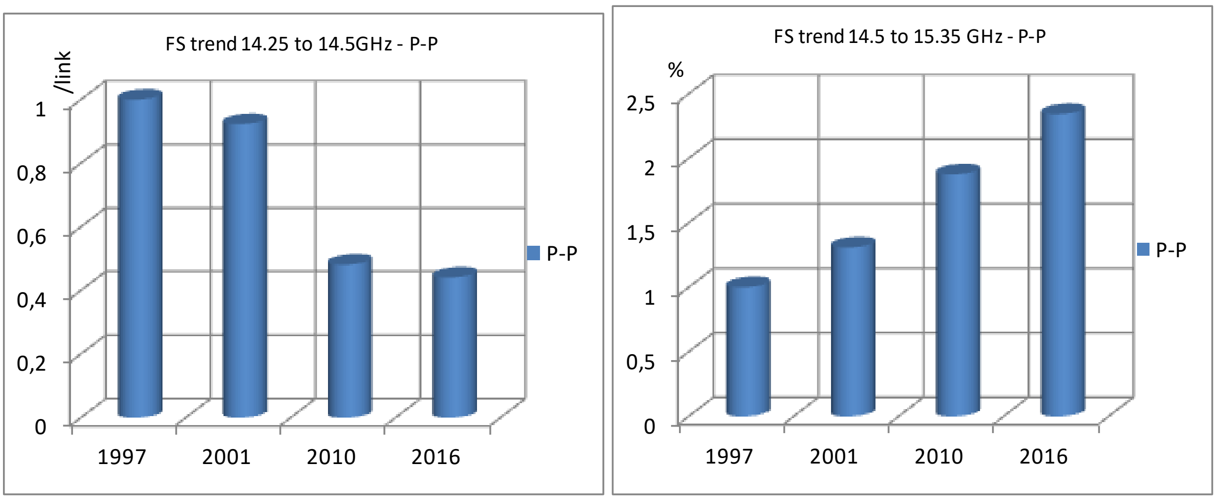


Figure 39: Historical (normalised to 1 link in 1997) and percentage trends for P-P links in band 14.25 to 15.35 GHz in CEPT

A1.12 17-17.7 GHZ BAND

Band is practically not used for FS P-P.

Former version of ERC Recommendation 70-03 made the frequency band 17.1-17.3 GHz available for wideband data transmissions systems. As there was a lack of the Harmonised Standards, in some CEPT countries, the applications of wideband data transmissions systems were limited to backhauling applications delivered by P-P links. In 2012 the ERC Recommendation was updated and the frequency band 17.1-17.3 GHz was removed. Nevertheless, based on existing applications within some CEPT countries, the CEPT Report 44 provides the possibility that individual countries may still use the band for licence-exempt applications. Due to the licence-exempt regime, the number of such a links is unknown.

A1.13 17.7-19.7 GHZ BAND

Heavily and widely used historical FS band, only for P-P (all 25 countries answering 2016 questionnaire indicated the band open and used). About 140000 active links have been indicated by all countries answering the 2016 questionnaire.

Number of active links reported is indicated in Table 15, while trend is reported in Figure 40. The trend chart shows a continuous increase since 1997.

Table 15: Number of active links declared in 2010 and 2016 in RF range 17.7-19.7 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	50833	71	-
2016	140320	544	-

The major utilization is for high capacity links, with a comparable usage of medium and a lower use for low capacity applications.

Majority is allocated to network infrastructure, with significant application for mobile backhaul (19 countries) and fixed infrastructure (16 countries). Use in broadband infrastructure is also indicated.

Most links are individually licensed, block assignment is also allowed in Norway.

Band usage is highly harmonised: the channel plan is based on the CEPT ERC/REC 12-03 (ITU-R F.595 is also indicated); no national arrangements are used.

Concerning the usage, significant increase is expected in next years (5-50% increase) in about 15 countries including Finland, Hungary, Italy, Croatia, Romania, Germany, Bosnia and Herzegovina and Slovak Republic.

A moderate situation of congestion is already reported (Ireland, Slovenia, Hungary, Greece). Future possible reduction is foreseen in Sweden.

Hop length: 95% percentile of “typical” length is about 20 km (4 km for those indicated as “minimum”); 30 km is the 50% percentile of “maximum” indication in all sub-bands.

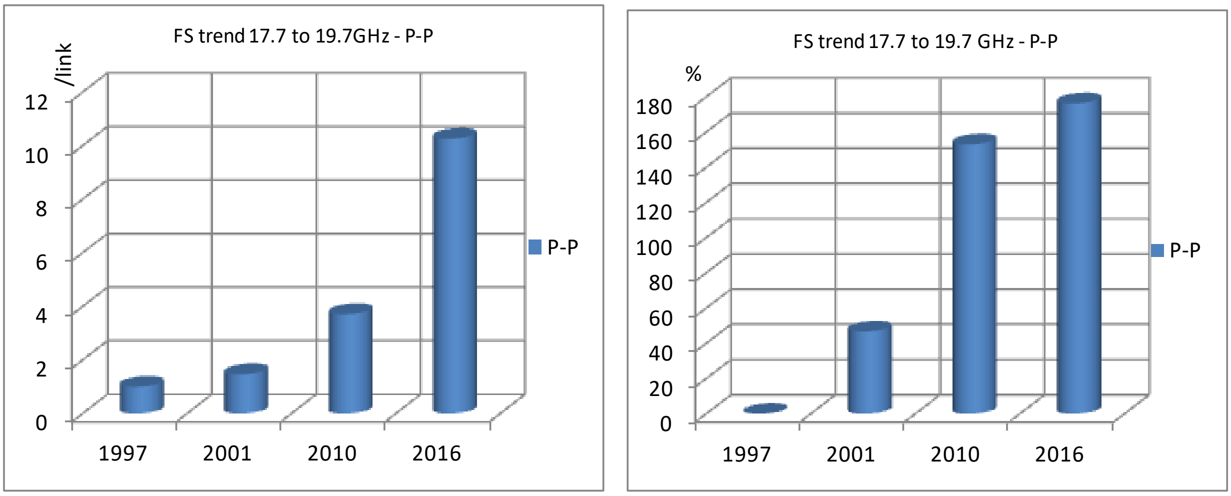


Figure 40: Historical (normalised to 1 link in 1997) and percentage trends for P-P links in band 17.7-19.7 GHz in CEPT

A1.14 21.2-22 GHZ BAND

This is a poorly used P-P band. 220 links are active in this range in UK, although 7 countries indicate the possibility to use it with link by link regime (some of them are legacy links). Most hop length indicated as “typical” is below 5 km (3 km for those indicated as “minimum”).

Links appear mostly low-medium capacity. Frequencies are used according to Recommendation ITU-R F.637 or local national plan.

No expectation to increase is reported, nor congestion.

A1.15 21.2-23.6 GHZ BAND

This is a heavily used historical P-P FS band, five sub-bands are used. About 30 uses of one or more sub-bands are indicated. Sub-bands 22000-22600 and 23000-23600 appear as the most widely adopted (open and used in 21 countries). No P-MP application is indicated.

In 2016, more than 130000 P-P active links were indicated in CEPT by all countries answering the questionnaire.

Number of active links reported is indicated in Table 16, while trend is reported in Figure 41. The trend chart shows a continuous increase since 1997.

Table 16: Number of active links declared in 2010 and 2016 in RF range 21.2– 23.6 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	98881	24321	-
2016	130969	562	-

High/medium capacity use is more frequently indicated, but significant use for low capacity links is noted. The majority of links are addressed to fixed and mobile infrastructure. A significant percentage of links (about 50%) is used for mobile backhaul. Use mostly in urban areas is indicated (Austria); possible sharing problems are noted in Switzerland.

Licensing regime is substantially link by link (24 Countries in the 6 indicated sub-ranges). Norway and Turkey indicate block based license in 22000-22600 MHz and 23000-23600 MHz.

Use of channel plan is well harmonised, about 20 administrations indicate use of CEPT T/R 13-02, national plan is indicated in Greece. This Recommendation was updated in 2010 to introduce additional channel arrangements in the centre gap.

In the 2016 questionnaire, trend for increase was declared by more than 10 countries, including Italy, Croatia, Germany, Bosnia and Herzegovina. Heavy use was indicated by Romania, Latvia; congestion or possible congestion was declared in Ireland, Slovenia, Hungary, Finland, France, Germany, Estonia; reduction is expected in Sweden. Trend to decrease is declared by Finland. Possible reallocation to other services is declared by Portugal.

Hop length: 95% percentile of "typical" length is about 10 km (4 km for those indicated as "minimum"), 20 km is the 50% percentile of "maximum" indication.

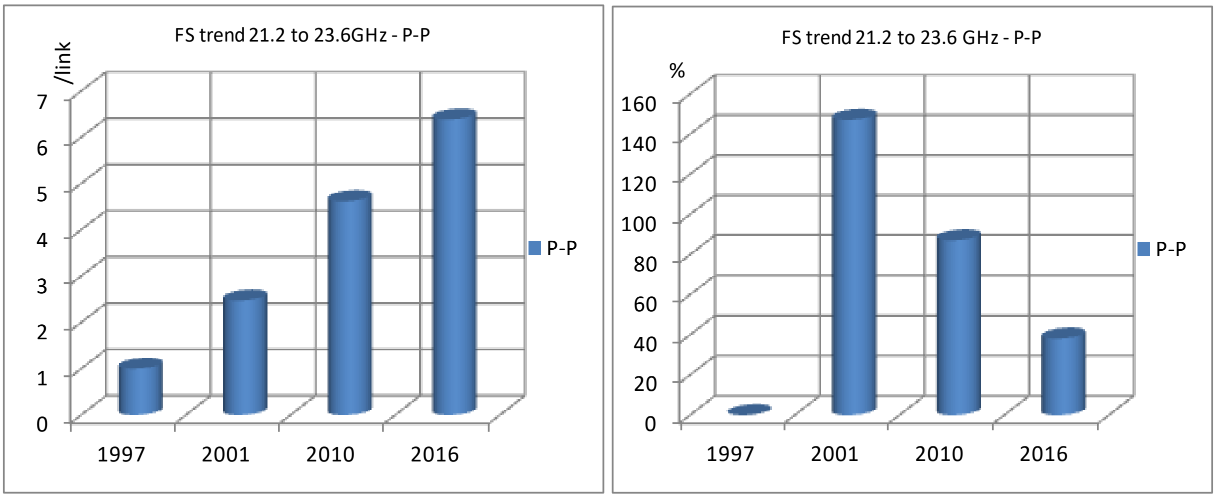


Figure 41: Historical (normalised to 1 link in 1997) and percentage trends for P-P links in band 21.2-23.6 GHz in CEPT

A1.16 24.2-24.5 GHZ BAND

This band is declared open by 9 countries, but very poorly used.

P-P use possibility was indicated by few countries, with link by link regime. In general, licensing regime appears link by link; unlicensed use is declared in Norway.

Recommendation CEPT T/R 13-02 has been indicated by 3 countries as reference; national plan is indicated by Greece.

A1.17 24.5-26.5 GHZ BAND

The band is open in a large number of countries for P-P and P-MP use. Four different sub-ranges are indicated.

In 20 administrations the band is open and use is indicated by almost all. About 10 countries allow use of P-MP; in Austria, Bosnia and Herzegovina, Bulgaria, Greece, Hungary and Slovak Republic both P-P and P-MP are allowed.

More than 50000 P-P links and 4200 P-MP links are declared. Due to presence of block assignment, the declared number of links can be lower than the effective number of links in operation.

Number of active links declared is indicated in Table 17 while trend is reported in Figure 42. The trend chart shows a continuous increase since 1997.

Table 17: Number of active links declared in 2010 and 2016 in RF range 24.5-26.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	37158	19453	1646
2016	51728	17	4277

Medium and high capacity links are declared, minor use of low capacity is also noted; the majority of links is allocated to fixed and mobile infrastructure. Military use (25.25-25.492 GHz and 26.25-27.5 GHz) is declared by one administration.

Licenses are assigned by link (17 administrations) or by blocks (11 administrations) according to the use.

Four sub-bands are related to this frequency range, use appears well harmonised. Indicated P-P channel plan follows the CEPT T/R 13-02 in great majority of answers, no national plans are indicated. The P-MP channel plan reported is the ERC/REC/(00)05 (superseded by the ECC/REC/(11)01).

Significant use is reported by Ireland, Hungary (traffic shift from congested bands), Bosnia and Herzegovina (mobile infrastructure); possible congestion close to urban areas is indicated by Germany and Netherlands.

Possible trend to increase of use is indicated by Latvia, Bulgaria, Greece, Netherlands, Switzerland, Slovak Republic, Slovenia; reduction is indicated in Sweden.

Finland, Greece and Portugal indicate possible reallocation to other services.

Hop length: 95% percentile of “typical” length is about 10 km (3 km for those indicated as “minimum”), 11 km is the 50% percentile of “maximum” indication.

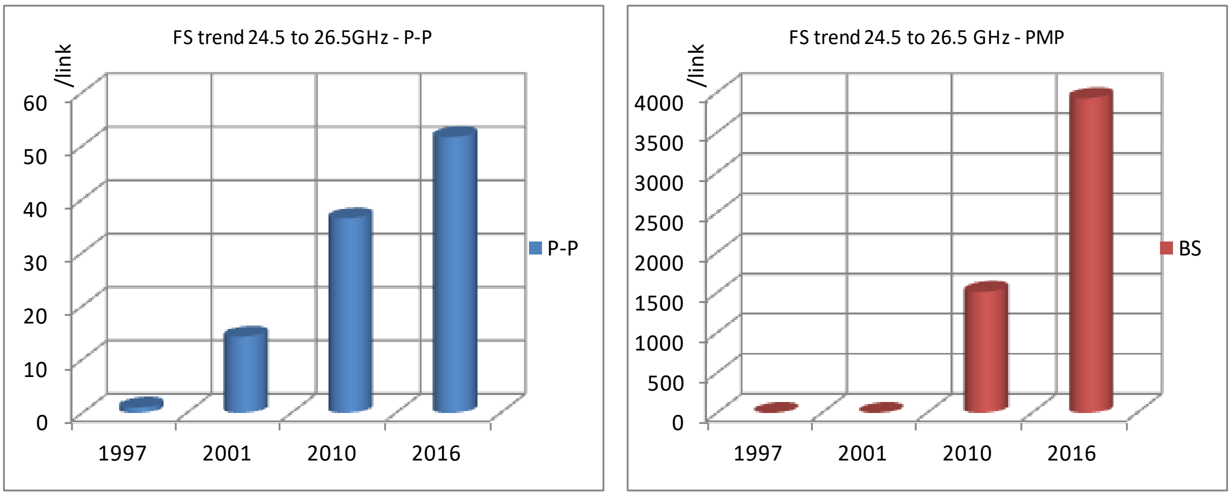


Figure 42: Historical (normalised to 1 link in 1997) trends for P-P and P-MP links in band 24.5 to 26.5 GHz in CEPT

A1.18 26.5-27.5 GHZ BAND

This band is not used for P-P or P-MP applications. Indication of use for military use is given.

No expectation to increase the use in next years is envisaged, possible future reallocation to other services is indicated in Sweden.

A1.19 27.5-29.5 GHZ BAND

This band contains two ranges (overall range for most countries), 27828.5–28444.5/28948.5–29452.5 MHz for Latvia. Band is open in about 20 CEPT countries and used in about 10, with limited density of use; only in Austria and Germany, the number of active links is about 1000 to 2000.

P-P and P-MP applications are allowed; Austria, Bosnia and Herzegovina, Greece, Slovak Republic and Latvia allow both use.

Number of declared active links is indicated in Table 18, while trend is reported in Figure 43.

Table 18: Number of active links declared in 2010 and 2016 in RF range 27.5-29.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	2471	1424	183
2016	5869	-	363

Licensing regime is mostly link by link, but significant number of countries allow block assignment. It has to be noted that in many countries the block assignment does not require any link notification. Therefore the figures provided for this kind of band could be well underestimated.

Use for high and medium capacity is mostly reported. Majority of links is allocated to mobile backhaul, other uses are for fixed and broadcast infrastructure.

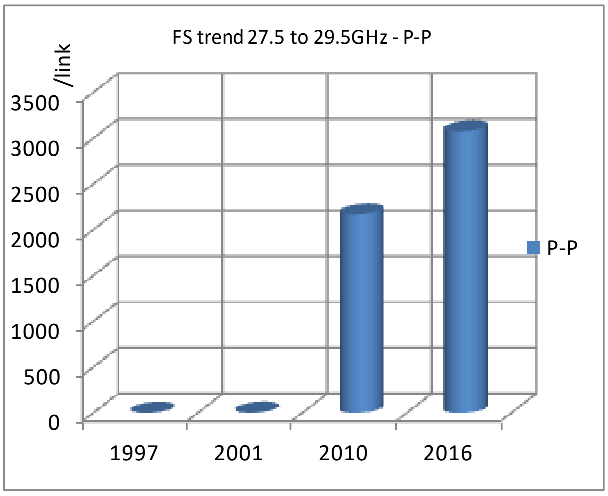
Licenses are assigned by link (12 countries for the all declared cases) or blocks (Bosnia and Herzegovina, Czech Republic, Germany, UK, Greece, Norway, Portugal, Sweden), according to the use;

The band is well harmonised, the P-P channel plan follows the Recommendation T/R 13-02,the block assignment guidance for P-MP links is provided in the ECC/REC/(11)01, no national frequency plan is indicated.

Bulgaria, Germany, Finland, Greece, Netherlands, Croatia, Switzerland, Slovak Republic and Latvia indicate expectations to increase the use in next years (mostly below 10%, Few indicate higher expectation), no one indicate decrease, no congestion is reported. At the moment, Portugal has no use of FS possible future allocation to other services is indicated.

This band has been segmented between FS and uncoordinated FSS usage with the ERC/DEC/(05)01. The majority of CEPT administrations have implemented this Decision.

Hop length: 95% percentile of “typical” is about 10 km (3 km for those indicated as “minimum”), 11 km is the 50% percentile of “maximum” indication.



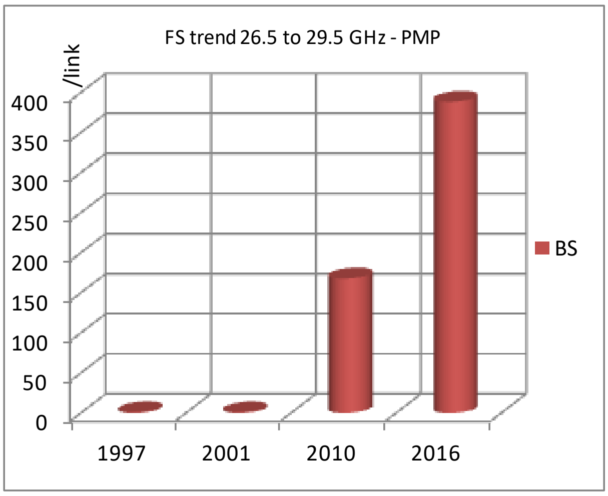


Figure 43: Historical (normalised to 1 link in 1997) trends for P-P and P-MP links in band 27.5 to 29.5 GHz in CEPT

A1.20 31-31.8 GHZ BAND

Very limited use is indicated for this band, with very few indications (9 administrations out of 31). 450 P-P links are used in UK. Scarce equipment availability is indicated by Switzerland.

Licensing regime appears link by link.

The channel plan follows ECC/REC/(02)02, in addition to national plan adopted by UK.

No significant expectations to increase the use in next years are reported. Portugal indicates plan to reallocate the band to other services.

A1.21 31.8-33.4 GHZ BAND

This band is declared open in about 20 CEPT countries, and used in 11, few of them with relatively high density of use; in Germany about 10000 P-P active links are indicated in 2016.

P-P and P-MP applications are possible, but no P-MP is indicated; Portugal and Latvia allow both use.

The number of declared active links is indicated in Table 19, while trend is reported in Figure 44. The use of the band became effective after 2001.

Table 19: Number of active links declared in 2010 and 2016 in RF range 31.8-33.4 GHz

Year	P-P total	P-P (unidirectional)	PmP Central Station
2010	3177	1466	-
2016	16947	-	-

Use appears mostly for medium and high capacity and for mobile backhaul. Some uses for fixed and broadcast infrastructure are declared.

Licenses are assigned mostly by link (14 countries for all declared sub-ranges), although block assignment has been reported by UK and Norway.

The P-P channel plan follows the ERC/REC/(01)02, no national plan is indicated.

Germany, Finland, Greece, Netherlands, Portugal, Switzerland, Slovak Republic, Latvia expect an increase in the usage in coming years (10-20% and more). Sweden indicates trend for decrease of use. No congestion is reported. Portugal and Finland indicate possibility of allocating band to other services/applications.

Hop length: 95% percentile of “typical” length is about 3 km (1 km for those indicated as “minimum”), 6 km is the 50% percentile of “maximum” indication.

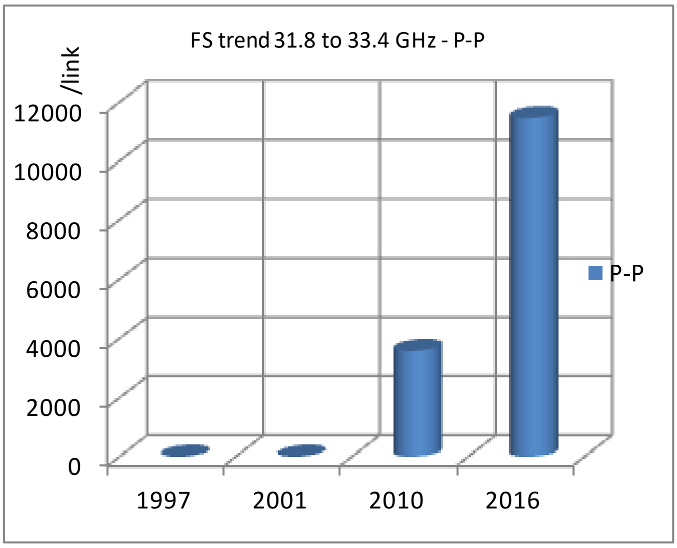


Figure 44: Historical (normalised to 1 link in 1997) trend for P-P links in band 31.8 to 33.4 GHz in CEPT

A1.22 36-37 GHZ BAND

In the 2016 revision, no P-P active links are indicated by any of the CEPT countries answering the questionnaire. Band is not indicated open for FS. Military use is indicated by one country.

In previous revision (2010), the Russian Federation indicated 132 links in operation, P-P, with licensing regime for link and for blocks.

A1.23 37-39.5 GHZ BAND

This band is heavily used historically for P-P FS by most of the CEPT countries with high density. All administration responding to questionnaire declared this band opened and used. No P-MP use is allowed.

The number of declared active links is indicated in Table 20, while trend is reported in Figure 45. Trend shows continuous increase since 1997.

Table 20: Number of active links declared in 2010 and 2016 in RF range 37-39.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Stations
2010	119923	42646	-
2016	132182	226	-

All capacities are reported, individually licensed (24 administrations); Norway and Turkey indicated that block licenses can be used in their administrations domains.

Great majority of links is used for mobile backhaul and fixed infrastructure, limited use for broadcasting infrastructure is declared. In Hungary 37.926-38.220/39.186-39.480 GHz sub-band designated for non-civil FS.

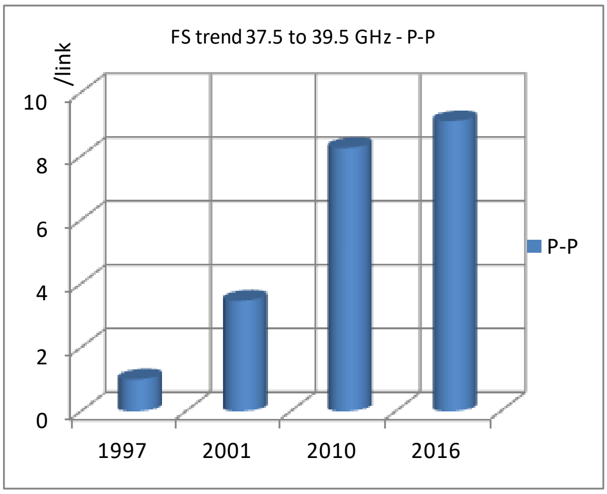
Band is widely harmonised; frequencies are utilized according to Recommendation T/R 12-01, ITU-R Recommendation F.749 is also mentioned; no national plan is indicated.

Concerning trends, increase in the use of the band is reported in coming years (10-50% increase) in 12 countries (one indicate decrease). Congestion is reported by Hungary, Slovenia, France, Austria. Possible sharing problems were declared by Switzerland; trend for future decrease is indicated by Sweden. Possible reallocation to other application is indicated in Finland.

In France, a new regulation was put in place in 2013 in order to offer more capacity to backhaul needs with higher bandwidth; Russia declares an increase of use, above all for mobile backhaul and in telecom operators' infrastructure and in industrial process communications.

The band is one of the potential candidate bands under study for 5G, for WRC-19 decision.

Hop length: 95% percentile of "typical" length is about 3 km (1 km for those indicated as "minimum"), 6 km is the 50% percentile of "maximum" indication.



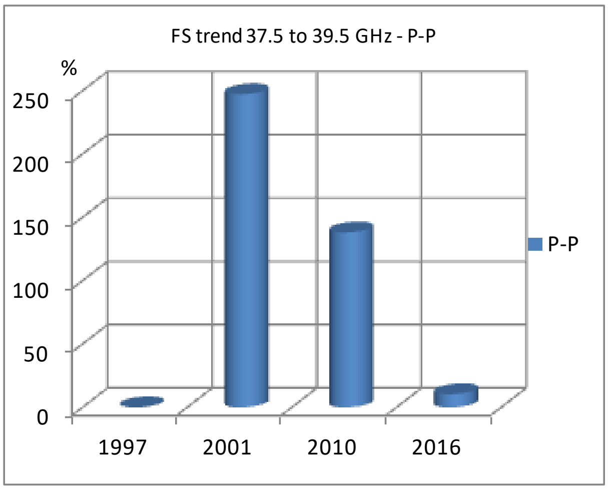


Figure 45: Historical (normalised to 1 link in 1997) and percentage trends for P-P links in band 37.5-39.5 GHz in CEPT

A1.24 40.5-43.5 GHZ BAND

In the 2016 revision, 18 countries declared the band to be open to P-P, while Latvia, Portugal and Russia are also open to use of P-MP.

The number of declared active links is indicated in Table 21, while trend is reported in Figure 46. This band has been opened to P-P applications in 2010.

Table 21: Number of active links declared in 2010 and 2016 in RF range 40.5-43.5 GHz

Year	P-P total	P-P (unidirectional)	P-MP Central Station
2010	73		3
2016	5459	-	16

Individually license (12 administrations) and block license (Norway and Turkey) are present; in Greece the allocation of the 41334-42000 MHz paired with 42834-43500 MHz is for P-P links, while potential future block assignment will address the rest of the band.

Majority of links are addressed to mobile backhauling and network infrastructure; in Russia, use addresses existing telecom operators' communications networks.

The channel plan follows the ERC/REC/(01)04. Expectation for growth is expressed by Germany, Greece, Italy, Latvia, Portugal, Switzerland, Slovak Republic. Possibility of allocation to other applications is given by Finland, Greece and Portugal.

Hop length: 95% percentile of "typical" length is about 3 km (1 km for those indicated as "minimum"), 4 km is the 50% percentile of "maximum" indication.

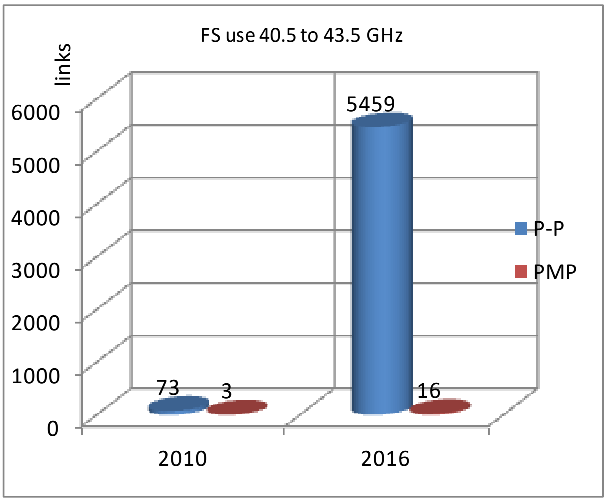


Figure 46: Historical trend for P-P and P-MP links in band 40.5-43.5 GHz in CEPT

A1.25 48.5-50.2 GHZ BAND

Quite limited use is indicated for this band, 30 P-P active links are indicated in UK above 49.2 GHz.

Planning is for a P-P use belonging to fixed and mobile network infrastructure, with licensing regime mostly on link by link.

The channel plan follows Recommendations ERC/REC 12-10 and ERC/REC 12-11.

No significant expectation to increase the use in next years is reported.

Possibility of future replanning for other services/applications is indicated by Finland and Portugal.

Low availability of equipment was noted.

The band is one of potential candidate bands under study for 5G.

A1.26 50.4-51.4 GHZ BAND

Very limited use is reported in FS for this band, with very few indications (8 administrations indicate the band as open for use, while in 22 administrations the band is currently not open). Link-by link regime is generally foreseen; 4 administrations consider band opening or licensing regime variation. Block assignment is reported in 2 cases.

One link only is reported in use in Denmark, 1.8 km length.

28 MHz channel BW is indicated, with 52 dBm e.i.r.p.. Possibility of future replanning for other services/applications is indicated by Finland.

Low availability of equipment was noted.

The band is one of potential candidate bands under study for 5G, for WRC-19 decision.

No significant expectations to increase the use in next years are reported.

A1.27 51.4-52.6 GHZ BAND

This band, available for P-P applications, is almost empty with the exception of the 299 links in Switzerland, with length about 800 m. It is currently open in 22 CEPT countries, while in 7 it is not open.

Links appear as block licensed, while majority of answering countries gave indication for link-based license; 3 administrations declared possibility to change to/add block licence.

e.i.r.p. limits of 85 and 60 dBm are reported by 6 countries.

Majority of answers relate to allocation for network infrastructure.

The channel plan follows the Recommendation T/R 12-11.

Latvia and Portugal report expectations to increase the use in coming years; Switzerland expects decrease of use.

Possibility of future replanning for other services/applications is indicated by Finland and Portugal.

Low availability of equipment was noted.

The band is one of potential candidate bands under study for 5G, for WRC-19 decision.

A1.28 55.78-57 GHZ BAND

No active links have been indicated. From the replies to the questionnaire it seems that the planned licensing regime will be mostly link based (21 countries gave reply), with few indicating possibility of block assignment, and the band should be used for fixed and mobile infrastructure. 2 administrations consider possibility to open or simplify usage.

The channel plan follows the Recommendation T/R 12-12.

Channel BW from 3.5 to 56 MHz are given in most answers, maximum e.i.r.p. of 85 dBm is mostly indicated.

Concerning the usage of the band, expectations to increase the use in coming years are reported by few countries. There were indications that no equipment with sufficient capacity was available in 2016.

Possibility of future replanning for other services/applications is indicated by Portugal.

A1.29 57-64 GHZ BAND

The channel plan for this band (57-59 GHz) follows ECC/REC/(09)01 which combines the whole 57-64 GHz range specifically for P-P application with Multi Gigabit Wireless Systems (MGWS) following ERC Recommendation 70-03 and EN 302 567.

27 administrations indicate that the band is open already, 2 administrations plan to open it, in Ireland the band is closed and there is no indication of possible change.

Around 400 links are in use in this band in 6 countries.

Almost all capacities have been reported, most being licensed on a link by link basis (18 answers), but some administrations foresee also block licence (4 answers) or light licence (3 Administrations). 11 administrations also indicate possibility of unlicensed use.

12 administrations show interest in changing regime, mostly to open the band or replacing link by link licensing regime with less stringent regimes, indication of possible transition from unlicensed to light licence regime was given by one Administration.

In 11 Administrations the band, or part of it, is unlicensed.

Great majority of links is allocated to fixed and mobile infrastructure.

Concerning the usage, new equipment following the new Recommendation is becoming available and one link is already reported in Norway. Others should follow.

Possible use for P-MP is reported by 3 administrations, while in 19 these systems are not allowed.

Channel BW obtained by aggregation of “n” consecutive 50 MHz channels, up to 2500 MHz wide, are reported.

Most frequent e.i.r.p. reported is 55 dBm (7 answers), in Germany higher values (65-70 dBm) are allowed.

Few indications of link lengths are available, all referring to links typically in range from few hundred meters to 1 km.

It shall be noticed that band 59 to 61 GHz can be used for NATO/military applications also, as well as for SRD (ISM possible in 61-61.5 GHz).

A1.30 64-66 GHZ BAND

Band is declared as open in 27 Countries, but no active links are reported in this band.

5 Countries indicated unlicensed regime, while 3 Countries declared light licence.

A general trend for a link by link authorisation regime can be referred (14 answers).

Foreseen application for high capacity P-P links is reported.

The frequency band is used according to the ECC/REC/(05)02.

SRD use has also been indicated, with potential openings and lack of equipment.

A1.31 71-76 GHZ / 81-86 GHZ BAND

In some countries (5 administrations) part of the band (71-74/81-84 GHz) is reserved for military use (NATO).

The use of these joined bands is recent.

The number of declared active links is indicated in Table 22, while trend is reported in Figure 47. This band has been was opened to P-P applications between 2005 and 2010 and the trend shows continuous increase.

Table 22: Number of active links declared in 2010 and 2016 in RF range 71 to 86 GHz

Year	P-P total	P-P(unidirectional)	P-MP Central Stations
2010	96	-	-
2016	8440	-	-

22 answers indicate this joined bands as open, while in 6 administrations they appear as closed.

Most administrations indicate maximum e.i.r.p. of 85 dBm.

Channel BW from 250 to 4500 MHz have been frequently indicated, 4 administrations indicated possibility of sub-channelling.

Maximum throughput of 2Gbit/s have been indicated

Most answers relate to link by link licensing regime (17 Countries), with the exception of 4 Administrations, indicating both link by link and block based approach.

3 administrations refer to unlicensed regime, light-license regime are indicated by 2 Administration.

Most applications are foreseen for P-P links used for mobile backhaul and fixed infrastructure, and some test links are going on (e.g. Germany).

4 Administrations showed possibility of changing existing licensing regime, towards light licensing /blocks.

Expectation to increase of band use in next future was indicated by Bulgaria, France, Greece, Netherlands, Croatia, Italy, Portugal, Sweden, Switzerland, Slovenia Latvia and Romania, fast growing use was indicated by one administration.

The referred Recommendation for this band is ECC/REC/(05)07.

Portugal reported use also for SRD.

Hop length: 95% percentile of “typical” is about 2.6 km (1 km for those indicated as “minimum”), 3.5 km is the 50% percentile of “maximum” indication.

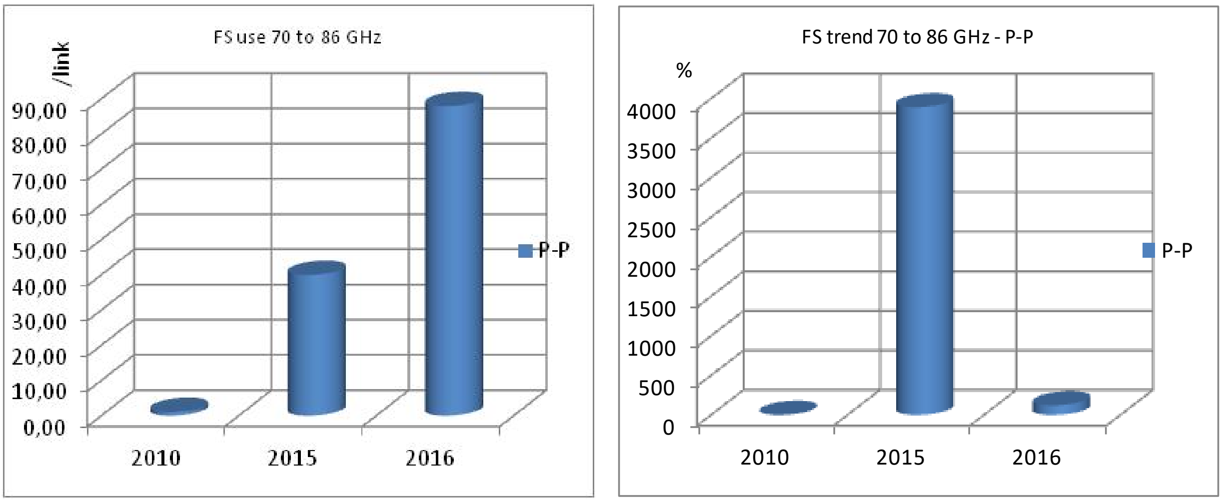


Figure 47: Comparative (normalised to 1 link in 2010) and percentage trends for the P-P links in the band 71-76/81-86 GHz in CEPT

A1.32 92-95 GHZ BAND

Only 1 link in Czech Republic is indicated.

Band is currently open in 9 Administrations, among which seven refer of link by link licensing regime, while the Russian Federation indicated preference for unlicensed use; two administrations are considering to open it as unlicensed.

Most applications are foreseen for high capacity P-P links used in support of the fixed and mobile infrastructure.

ECC Recommendation (14)01 is given as reference by most answers.

National frequency plan has been indicated by Ireland.

A1.33 FEES

In general, licence fee depends on channel bandwidth (28 answers) and RF band (25 answers). In several cases, the number of Tx is considered in calculation fees (21 answers), while 11 administrations include also geometric considerations (area). 22 administrations intend to use incentives to promote use of higher frequencies, while 5 are not interested at the moment.

Concerning licence duration, most used time slot is 5 years (8 administrations); time base of 10 years is indicated by 4 administrations, 15 years by two countries, 6 and 8 years by one admin respectively; 3 administrations adopt 1 year. In general, all licences can be confirmed after time slot has ended.

Indication of links to websites where info related to fees determination procedures has been given by most administrations. Not for all of them a translation in English is available.

List of answers is given in Table 23.

Table 23: Fees related website list

Country	Webpage	Functional link	English
ALB	http://akep.al/informacion/pagesa/llojet-e-pagesave; http://akep.al/informacion/pagesa/aktet-e-pagesave ;	Y	N
AUT	http://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10012777	Y	N
BIH	http://spektar.rak.ba/en/Kalkulator.aspx	Y	Y
BUL	http://crc.bg/files/_bg/TaxTarif_.pdf	Y	N
SUI	http://www.admin.ch/opc/fr/classified-compilation/20072116/index.html#a8	Y	N
HRV	http://www.hakom.hr/default.aspx?id=273)	Y	Y
CYP	http://www.mcw.gov.cy/mcw/DEC/DEC.nsf/All/D55CAB220E004339C22579C1004DD8B6?Opendocument	Y	Y
CZE	http://www.ctu.cz/ctu-online/poplatky-vybirane-ctu/poplatky-za-vyuzivani-radiovych-kmitoctu.html	Y	N
DNK	https://ens.dk/sites/ens.dk/files/Tele/afgifter_2018.pdf	Y	N
EST	https://www.riigiteataja.ee/en/eli/511022015002/consolide	Y	Y
FIN	No info		
F	http://www.arcep.fr/index.php?id=11976 http://www.arcep.fr/fileadmin/reprise/dossiers/taxes/simulateur-cout-fh-nov2014.xlsm	Y	N
D	www.bundesnetzagentur.de	Y	N
GRC	https://www.eett.gr/opencms/export/sites/default/EETT_EN/Electronic_Communications/Radio_Communications/Rigths_Of_Use/FixedService/FeesFixedService.pdf	N	
HUN	http://njt.hu/cgi_bin/njt_doc.cgi?docid=136918.319221	Y	N
IRL	http://www.comreg.ie/radio_spectrum/search.541.874.10014.0.rslicensing.html	N	
I	http://www.parlamento.it/parlam/leggi/deleghe/03259dl4.htm	N	
LVA	http://likumi.lv/ta/id/267460	Y	N

Country	Webpage	Functional link	English
LTU	http://www.rrt.lt/rrt/lt/verslui/istekliai/radijo-dazniai/rrl.html	Y	N
Malta	http://www.justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=9065&l=1	Y	Y
MNE	http://www.ekip.me/download/koriscenjeRF/Pravilnik_o_metodologiji_i_nacinu_obracuna_visine_godisnje_naknade_za_koriscenje_radio-frekvencija%2016-2014.pdf http://www.ekip.me/download/Odluka%20o%20vr.%20boda%20za%20RF%20za%202015.%20godinu.pdf	Y	N
HOL	http://www.agentschaptelecom.nl/onderwerpen/zakelijk-gebruik/straalverbindingen/tarieven-straalverbindingen	Y	N
NOR	http://eng.nkom.no/technical/frequency-management/fees-and-regulations/frequency-charges	Y	N
POR	http://www.anacom.pt/render.jsp?contentId=1180549#.VN3n6Sy4Jek	Y	N
ROU	http://www.ancom.org.ro/uploads/forms_files/decizia_2012_551_versiune_consolidata_4_iulie_20141405000552.pdf	Y	N
RUS	http://rkn.gov.ru/communication/p552/	Y	N
SRB	Rulebook on radio-frequency usage fees	N	
SVK	http://www.teleoff.gov.sk/data/files/26551.pdf	Y	N
SVN	http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_827 http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_1010	Y	N
E	No info	N	
S	http://www.pts.se/upload/Foreskrifter/PTSFS%202014_4-avgifter.pdf ; http://www.pts.se/upload/Ovrigt/Radio/Radiotillstand/sammanfattning-av-arsavg-2015.pdf	Y	N
TUR	Examples have been given in response to the questionnaire	N	
G	http://www.legislation.gov.uk/uksi/2011/1128/contents/made	Y	Y

ANNEX 2: NATIONAL EXAMPLES OF REGULATING FIXED SERVICE

A2.1 FRANCE

Overview

In France, the overall frequency management responsibility (in particular international policies and frequency co-ordination) fall into the hands of Agence Nationale des Fréquences (ANFR). However the authorisations for telecommunication activities, including authorisations for civil use of the radio spectrum, are issued by the Autorité de Régulation des Communications Electroniques et des Postes (ARCEP), the independent regulator set up in January 1997.

The ARCEP is therefore responsible for co-ordination and assignment of frequencies for public and private network operators and then for issuing appropriate licences for operators. ARCEP manages, amongst others, the following FS frequency bands: 1.5, 3.5, 4, 6, 7-8, 11, 13, 18, 23, 26, 28, 32, 38, 71-76/81-86 GHz.

Regularly, ARCEP updates the strategy for the use of the different frequency bands allocated to the FS. These guidelines are defined in relation and with the co-operation of all the different actors involved (ARCEP web site: http://www.arcep.fr/).

The fixed link assignment system that has been developed by the ARCEP is efficient in meeting the demands of customers. The ARCEP has developed an exchange format to handle electronic licence application, which has reduced significantly the treatment time for fixed link assignments, which is now less than 2 months. In some bands, certain “preferential channels” are assigned to specific operators, where they can deploy their P-P FS links in a more flexible way.

Generally speaking, the use of fixed links is closely linked to the evolution of the international regulation (such as the frequency bands allocations in the ITU RR, the adoption of relevant ERC Recommendations or Decisions). Such modifications may sometimes lead to the necessity of band refarming, recently becoming a familiar process for the French telecommunication users.

The regulation has also to take into account the recent arrivals of the new players in the FS field. New operators are being authorised by the ARCEP according to two classes of networks given by the French Law: the class L33-1 applies for networks open to public and the class L33-2 applies for private networks. The range of telecom operators include: the incumbent operator (obligations of public service), operators of public mobile networks, operators of private mobile networks (PMR, PAMR, etc.), operators of Fixed Wireless Access (FWA) networks, the incumbent broadcasting operator, FM broadcasting operators and about 250 users of private FS networks. These telecom operators come in addition to the governmental users, who obtain frequency spectrum through the offices of Prime Minister and do not need authorisation from the ART.

The FS frequency bands, as designated in the French National Frequency Allocation Table, may be thus used by both the civil companies authorised by the ARCEP and by governmental bodies.

Co-ordination with other services and organisations

International co-ordination processes are dealt with by the ANFR, especially when satellite services are involved. At the national level, the co-ordination is also dealt with by the ANFR through a consultation process between all the concerned user groups so as to respect the interests of the existing users while ensuring, to the greatest extent, an access to the spectrum required for the new ones.

Spectrum pricing

At the moment in France only civil telecom operators have to pay fees for using the spectrum. An administrative incentive pricing system applies to the FS, this meaning that the fees depend on the bandwidth, the frequency band used by the operator and the spectrum efficiency. The bigger is the bandwidth, the higher are the fees; the higher is the frequency band, the lower are the fees.

Spectrum refarming

In France, a procedure for spectrum refarming is based on statutory texts and had been used in practice already for several years. This procedure is based on a sound economic approach and makes it possible to meet the demands of operators in the sector. Furthermore, it does not call into question the procedures for attribution and assignment of frequencies that are laid down at international level by the ITU and the CEPT and at national level by the regulatory authorities.

The spectrum refarming procedure establishes evaluation of the cost of the refarming and the management of a fund needed to finance this refarming.

The user who is to leave a frequency band usually receives compensation. This often takes the form of a financial contribution and assignment of frequencies in an alternative frequency band, except when a wire-based technology may be used as a substitute. This compensation process is discussed by all concerned parties within a specific advisory commission, set up by the ANFR to deal with the financial aspects of spectrum refarming: the Refarming Commission.

Moreover, in France, the State plays the role of intermediary by initially financing from the state budget the relocation of old services, with subsequent reimbursement of these funds from the new users of refarmed spectrum once they have obtained their demanded frequencies. An intermediary role played by the State makes it possible to increase significantly the speed of refarming process, by making the spectrum freed exactly in time when it is needed for new users.

The ANFR has also set up a commission to study the cases where the international obligations accepted and adopted by the French Administration lead to the necessity of changing, usually in a shorter term than the usual life-time of the equipment, the use of a part of the spectrum.

Normally the cost of refarming depends on the necessary speed of the replacement of old equipment and the cost of new, replacing equipment. This cost is ultimately born by the new users of the spectrum to the extent possible.

A2.2 HUNGARY

Organisation

The National Media- and Infocommunications Authority (NMHH) consist of several divisions dealing with various fields. There are four departments under the Infocommunications Division each of which is subdivided into units. With respect to frequency management the following units can be highlighted: spectrum management, frequency planning and coordination, frequency licensing. Nearly the same structure can be seen in the non-civil department. As the civil and the non-civil frequency management can be found under the same unit, the cooperation between them is highly efficient.

Assignment methods, licensing

Regarding the Fixed Service bands, several types of assignment methods can be applied. The most commonly applied method is the link by link assignment which is used in most point-to-point frequency bands on first-come-first-served basis. In some cases the most effective method is the block assignment-usually in such cases when the frequency usage rights can be gained in an awarding procedure and the licence holders can manage the frequency use in their own blocks. In Hungary the block assignment method is applied in those bands where point-to-multipoint systems can be used (3.5 GHz; 26 GHz). Light licensing method can be used in such bands where the potential of interference is low due to the reduced hop length (resulting from the wave propagation characteristics and the atmospheric attenuation) and the highly directional antennas (60 GHz, 70/80 GHz). In the 5.8 GHz, P-P and P-MP applications can be used on a licence-exempt basis.

Planning and design

In Hungary, the radio networks are designed by the applicants, or the applicants hire third party designers for the job. The authority provides data for the affected parties for the design of radio connections. These data also cover the interference environment, which must be taken into consideration in the design phase. Only professionals with authority licence may perform design work. The designer carries extensive responsibility in the respect of the interference calculations. After planning, the authority granting the licence is entitled to check the plans.

Frequency fees

In Hungary, frequency fees are charged on the use of the frequencies. The fee consists of two components:

- one-time frequency reservation fee;
- monthly frequency usage fee.

The amount of the frequency usage fee is determined by legal rules and consists of the following factors: frequency usage unit fee [HUF/kHz] (depending on the frequency band) and channel bandwidth.

International co-ordination

For the effective utilisation of the radio spectrum and for the adequate handling of situations relating to the possible interferences, there is a need for international coordination or notification of frequencies in several cases. NMHH fulfils its international frequency coordination activity according to the effective international agreements, regulations and recommendations. In the absence of rules relating to the international frequency coordination or to prevent the harmful interferences, the Office may prescribe additional rules. Basically the ITU regulation (Radio Regulations) gives guidance with respect to the international co-ordination. Hungary applies the HCM (Harmonised Calculation Method) agreement – signed by several European Authorities - as a basis with respect to the co-ordination with most of the neighbouring countries. In some frequency bands bi- or multilateral agreements on preferential channels or codes have been concluded.

Fixed Service frequency bands in Hungary

- National regulations are fundamentally based on the relevant ECC Decisions and Recommendations;
- 1.5 GHz and 2 GHz frequency bands are no longer used for fixed service applications;
- The high-capacity microwave backbone networks are operated at lower frequencies (in the 4 GHz, L6 GHz, U6 GHz) but they are losing ground to optical cable transmission, so the number of the links is stable;
- 7/8 GHz band has not been used so far, but some investments are foreseen in the near future;
- In the 11 GHz band there are plenty of high capacity backhaul links (no increase). In the lower part of the band restrictions for fixed service use are applied due to broadcasting satellite service;
- In the 12 GHz band (12.3-12.5 GHz) Multipoint Video Distribution *System* (MVDS) for TV program distribution is operated to meet an essential demand for residential sector (special national use). It provides coverage only in the capital at present (restricted frequency usage rights) but potential network extension is foreseen in the future;
- The Electronic News Gathering/Outside Broadcasting (ENG/OB) bands (7.725-7.9 GHz, 10-10.68 GHz, 21.2-21.4 GHz, 22.6-23 GHz, 24.25-24.5 GHz) are very slightly used;
- 13 GHz band is heavily used by high capacity links with relatively long hops (slight increase in number of links);
- 15 GHz band had been a popular band for medium capacity links in the civilian sector until a significant part of the band was dedicated to the non-civil sector. Increase of the non-civil use is foreseen;
- 18 GHz band is heavily used by high capacity links and the relatively small antenna can be efficiently deployed in order to make connection between the urban and suburban areas;
- 23 GHz band is used by medium capacity (mostly backhaul) links with relatively small antennas (30-60 cm) in urban areas. A part of the band is used for non-civil purposes;
- 26 GHz band can be used by P-P and P-MP systems. In Hungary frequency blocks was auctioned through an awarding procedure and block assignment method is applied. The band is heavily used by high capacity links mostly for backhaul purposes;

- 28 GHz band is not used for fixed service applications;
- 32 GHz band is currently not used;
- 38 GHz band used by high capacity (mostly backhaul) links in urban areas. A part of the band is used for non-civil purposes;
- The frequency range 40-58 GHz is very rarely used by fixed service applications;
- 60 GHz and 70/80 GHz bands are used for very high capacity short-haul links applying light licensing method. The operators register the links in the database and can design the network taking into account the existing links;
- 90 GHz and higher frequencies are not used for fixed service applications, yet.

Future use

Some fixed service bands are foreseen to lose ground to future new generation broadband mobile systems taking into consideration the relevant decisions of the WRC-15 regarding the candidate frequency bands that can be identified for 5G IMT systems in the frequency range between 24.25 and 86 GHz. This list of the candidate frequency bands contain the following bands mainly used by fixed service applications so far: 26 GHz, 32 GHz, 38 GHz, 42 GHz, 49 GHz, 52 GHz, 70 GHz, 80 GHz. On EU level the following bands have been defined as primary or pioneer bands that can affect the fixed service use: 3.4-3.8 GHz below 6 GHz and 26 GHz above 6 GHz. Earlier the 3.4-3.8 GHz band was used in many countries by P-MP and P-P systems but for the time being mobile use is also an option. The 26 GHz band is heavily used in several European countries for backhaul (P-P and also P-MP systems can be deployed). In Hungary the operators released the congestion in the 23 GHz and 38 GHz by gaining frequency blocks in the 26 GHz band at auction. If the current studies will show that this band can be used for 5G systems, the existing fixed service links will probably need to be migrated. It could be an issue also in the 70/80 GHz band in the future pending on the relevant studies, the mobile lobby and innovation.

A2.3 UNITED KINGDOM

Overview

In the United Kingdom, the Office of Communications (Ofcom) is responsible for management of the radio spectrum for civil use. Recognising the large density of high capacity point to point links in the UK it is essential for the UK to effectively manage and secure optimal use of the fixed service spectrum and strategy which is developed through on-going consultations with UK industry, and aids national, European and global regulatory planning and development.

Ofcom makes spectrum available for fixed service use in a variety of ways:

- Link by link assignment coordinated by Ofcom;
- Block assigned spectrum made available through auctions;
- Self-coordinated spectrum;
- Assignment by a third party on behalf of Ofcom;
- Licence exemption.

The authorisations above may either; specify fixed service use (e.g. link by link assignment) or, in the case of block assigned spectrum, permit fixed service use, but are not limited to that use only. This is because the decision whether to use authorised spectrum for the fixed service is a decision for the party who is successful in the auction as Ofcom’s policy is to generally award spectrum on a technology and service neutral manner.

Link by Link Assignment Process

Fixed point to point link assignments are made by Ofcom in the 1.4 GHz, 4 GHz, Lower 6 GHz, Upper 6 GHz, 7.5 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 26 GHz, 38 GHz, 52 GHz, 55 GHz, and parts of the 70/80 GHz bands.

The customer provides all of the technical information required to support the e.i.r.p. and frequency assignment process e.g. site information, proposed high/low operation at sites, equipment, polarisation and the required propagation availability.

If the application is valid, frequency coordination procedures are run, including:

- High/Low protocol checks (this is a check to assess whether the candidate link-end respects the established high/low designations);
- e.i.r.p. assignment;
- Inter-service coordination (e.g. coordination with permanent earth stations (PES),and radio astronomy service (RAS));
- Other coordination routines (e.g. UK military);
- Intra-service coordination (noise-limited frequency assignment criteria).

In general, the request queue is handled on a first come first served basis and links are assigned the first available channel working up-band from channel one in most bands.

A fixed link within a predefined band specific coordination zone of an earth station is coordinated with that victim earth station. Interference assessment between earth stations and fixed links is managed on the basis of I/N criteria for the protection of earth stations; and for fixed services faded/non-faded fixed service receiver sensitivity levels encompassing the relevant wanted to unwanted ratios for the fixed service system under assessment.

The licence is formally issued when all clearances have been received with confirmation from all necessary affected parties.

Block assigned spectrum

In 2008 Ofcom auctioned a number of bands (approximately 6 GHz of spectrum) on a technology neutral basis. These include the 10 GHz, 28 GHz, 32 GHz, 40 GHz. Whilst these bands are allocated to the fixed service, users of that spectrum are not limited to using this spectrum for the fixed service.

Self-Coordinated Spectrum

The 65 GHz, and parts of the 70/80 GHz bands have been made available in the UK on a self-coordinated light licensed basis. These bands are for fixed terrestrial millimetre-wave point to point links, typically for short hop high capacity wireless access and infrastructure networks.

At the present time the bands are being administered under interim licensing and link registration processes. The interim procedures which consist of mainly manual procedures will be in place until Ofcom announces the permanent procedures for self-coordinated links which are intended to be via a web based tool.

This mechanism of spectrum management consists of a simple registration process with the responsibility of coordination delegated to the licensee. To enable coordination and establish priority, all link details are publicly available on Ofcom’s website.

The 5.8 GHz band is also available on a light licensed basis with a simple registration process.

Delegated Assignment Management

The assignment of links in the 31 GHz band and scanning telemetry spectrum at 450 MHz has been delegated to third party organisations that manage the assignment process and make link assignments in the bands. Ofcom issues the licences.

Licence Exemption

The 60 GHz (57-64 GHz) band has been made available for fixed link use on a licence exempt basis.

Spectrum Pricing

The Wireless Telegraphy Act of 1998 (WTA'98) provided a spectrum management tool to enable a fairer, more rational basis for pricing spectrum that takes into account the value of the resource that is used and provides incentives for spectrum efficiency. This is generally referred to as 'spectrum pricing'. The variants of pricing are, administered pricing, where fees are determined by regulation, and the use of auctions where fees are set directly by the market. The approach of spectrum pricing in the UK is also in line with the EU legislation that the mechanism should be used to achieve spectrum management objectives and not to maximise licence revenue. UK industry is consulted in each phase of the development and revision of the policy.

The form of spectrum pricing that has been administered for Ofcom managed point to point FS links coordinated by Ofcom is 'administered incentive pricing' (AIP) in which the fees are set by regulation on the basis of technical and spectrum management criteria e.g. level of demand and bandwidth used. A licence fee algorithm using such criteria has been developed to determine the fixed link AIP fee. Our fees for self-coordinated fixed links are based on cost recovery.

Spectrum Trading and Leasing

In 2004, Under the Wireless Telegraphy (Spectrum Trading) Regulations most point to point fixed link licence classes became tradable. The transfer of rights and associated obligations to use spectrum represented a new approach to spectrum management. It enabled holders of wireless telegraphy (WT Act) licences to transfer some or all of the rights and associated obligations conferred under the licences, to third parties. This would enable spectrum to migrate to users that would use it most efficiently, thus benefiting the economy. Trading is entirely voluntary and no licensee is forced to trade by Ofcom.

This process was further simplified in 2011 to enable leasing in which spectrum may be accessed for a specified period under a contract with an existing licensee without obtaining further authorisation from Ofcom.

A2.4 CZECH REPUBLIC: APPROACH OF LICENSING IN THE 70/80 GHZ BANDS

In the year 2008 the Czech Republic opened to civil use the upper part of the bands only (74-76/84-86 GHz), because the lower parts were allocated to the military use. At the same time there were also defined quite restrictive conditions for their use (i.e. channels could not be aggregated; only FDD systems were permitted; defined minimum gain of the antenna). Towards the end of the year 2009 (after the revision of the Recommendation ECC/REC/(05)07) the rest of the bands have been released from the military applications and opened to civil applications and the link registration process has been established, i.e. the bands are licence exempt, but the operator has to register the link (no frequency coordination is done and no registration or annual fee is requested by administration). This registration is useful for preventing interference and it is also easy to locate a possible source of interference. Furthermore some of the previous restrictions were cancelled (no limitation in using FDD and TDD systems; channels can be aggregated). The database of registered links is publicly available at https://www.ctu.eu/vyhledavaci-databaze/technicke-udaje-pevnych-radiovych-systemu-typu-bod-bod-v-pasmech-71-76-GHz-a-81-86-GHz/vyhledavani.

Since January 2017 the Czech Republic has registered 1243 links and the number of links is still increasing (in 2011, the number of registered links was 140).

The average link length is about 1.164 km (the average link length was about 1.85 km in 2011). Distribution of link length for both situation in 2011 and 2017 is shown in Figure 48. Links usually operate in urban areas.

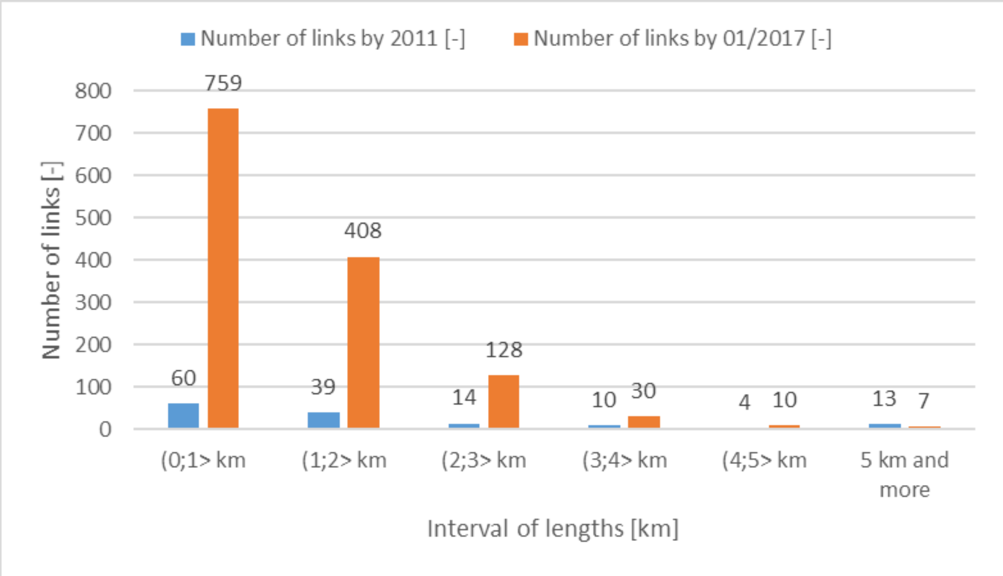


Figure 48: Distribution of link length for 2011 and 2017

It is possible to deploy both FDD and TDD in 70/80 GHz bands. Distribution of FDD/TDD links based on the channel width is shown in Figure 49.

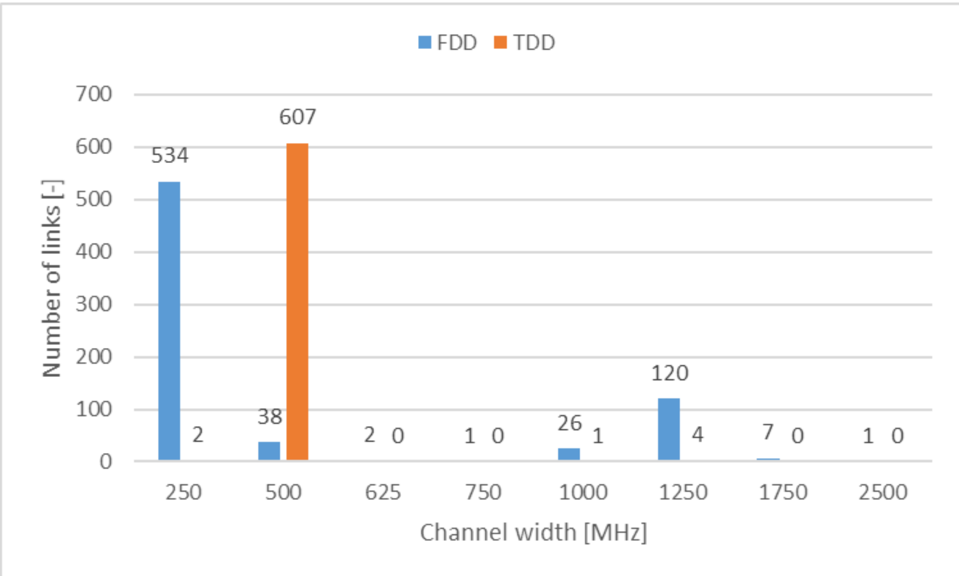


Figure 49: Number of links vs occupied bandwidth for FDD and TDD systems

A2.5 GERMANY

General

In Germany, the Bundesnetzagentur (BNetzA)/Federal Network Agency is responsible for overall management of the radio spectrum for civil use. Section 55(1) of the TKG (Telecommunication Law) states that each frequency usage requires prior assignment by the Federal Network Agency. This is possible provided that the frequency is designated in the frequency usage plan for the intended purpose. Frequencies are assigned by administrative act either ex officio (license exemption published in the Federal Network Agency´s Official Gazette) or upon application (individual assignments). Each assignment defines the particular purpose for which the frequency may be used and the conditions to be met so that the spectrum may be used efficiently and with minimum interference. No-one has the right to be assigned specific frequencies.

The Fixed Service plays an important role for backhaul/ backbone for the mobile networks; therefore the mobile operators hold the highest number of Fixed Service licenses especial in the higher frequency bands. Additionally, there are various smaller telecom operators including public and governmental users, broadcasting operators, private FS network operators etc.

For the Fixed Service there a two different ways of making the spectrum available:

- Link by Link assignment;
- Licence Exemption.

The high density of links, with about 128.000 over all frequency bands, makes effective coordination and management necessary. Therefore most of the frequency bands for Fixed Service are under link by link assignment regime. There is no procedure of authorisation or registration to become able to apply for a FS license. Applications should be processed by the BNetzA within 6 weeks.

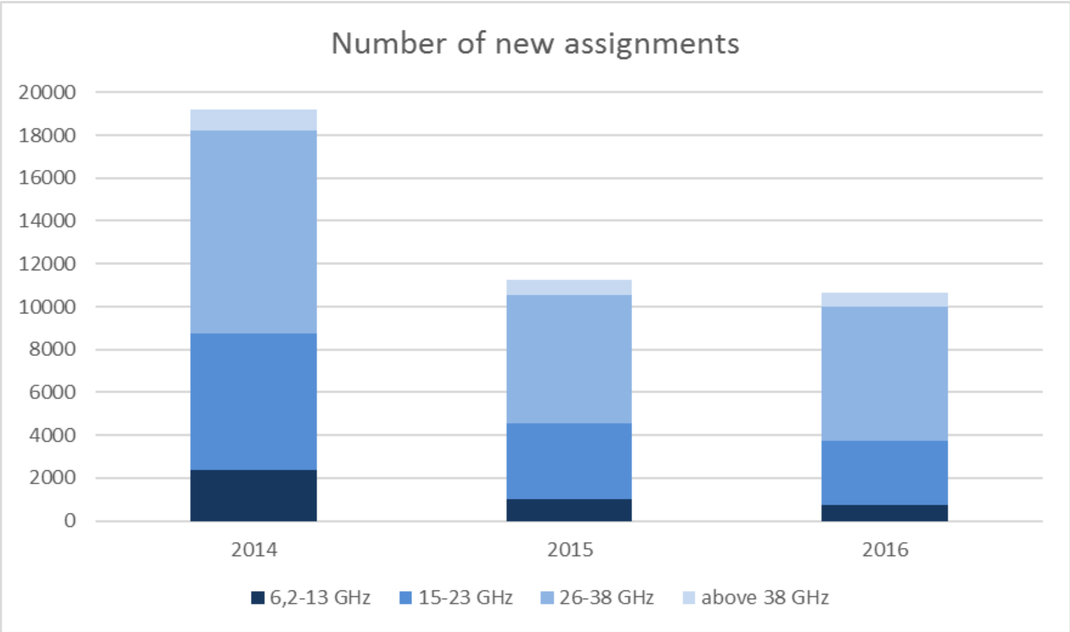


Figure 50: Development of new FS assignment in Germany

Table 24: Number of new links

Year	2014	2015	2016
New links in 6.2-13 GHz	2374	1025	764
New links in 15-23 GHz	6349	3512	2973
New links in 26-38 GHz	9492	6022	6238
New links above 38 GHz	966	666	681
Number of new links total	19181	11225	10656

Figure 50 shows the development of new assigned FS links in Germany. In 2014 an extraordinary high number of assignments has been made, inter alia, due to roll out of new technologies and rearrangement of the mobile telecommunication network. The demand of higher capacity in the mobile networks is linked to an increasing demand of capacity also in the backhaul networks which leads to a high number of new assignments for FS. In the two following years the number of applications declined to the average level of the previous years. It has to be mentioned that especially the lower frequency bands (6-15 GHz) already have a dense use, therefore it is not possible to make new assignments in a high number of cases. Also in some areas in the urban environment the bands from 15 GHz up to 38 GHz are already dense and new assignments are not possible or very difficult to make.

Link by link assignment process

Fixed point to point link assignments are made in the 4 GHz, 6.2 GHz, 6.8 GHz, 7.2 GHz, 7.5 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 26 GHz, 28 GHz, 38 GHz, 42 GHz, 52 GHz and 80 GHz.

The customer has to fill in an application form which is provided on the BNetzA website. For registered customer (operators) an electronic exchange is possible. The costumer has to provide all necessary technical information required for the interference calculations and frequency assignment process e.g. site coordinates, antenna data and height, equipment data like modulation, Tx output power, etc. In this case, also the frequency assignment is send to the customer in electronic format via e-mail.

Costumers have no legal basis for particular transmitting frequencies, but may state their preference. During the assignment procedure the BNetzA will check whether or not the preferred or other frequencies are available and can be coordinated.

If all necessary information has been made available and is plausible the interference calculation will be processed including:

- Coordinate checks;
- High/Low checks;
- Coordination with existing FS links (Threshold degradation of not more than 1 dB of victim link in case of a single interferer);
- Coordination with military users, where appropriate;
- Coordination with other services e.g. FSS.

The frequency requests are handled on a first come first served basis and, if possible, the preferred frequency will be assigned.

For all assigned frequencies an annual and a one-time assignment fee is imposed.

Fees and contributions

Fees as determined in the Frequency Fee Ordinance and contributions as laid down in the Ordinance concerning Contributions for the Protection of Interference-Free Frequency Usage are payable for the assignment of frequencies. The one-time assignment fees are fixed on the basis of assignment parameters like frequency and bandwidth.

The annual contributions are determined on the basis of the costs incurred by BNetzA per radio service each year.

Co-ordination with other services

In some bands a sharing between Fixed Service and other services like Fixed Satellite Service (FSS) is applied. In order to avoid interference there is a close cooperation between the different departments within the BNetzA and a coordination process is established to respect the interests of the existing users.

License Exemption

License Exemption is introduced only for the frequency bands: 37-39.5 GHz; 57.1-57.8 GHz; 58.658.9 GHz and 59-63 GHz. The framework is in line with CEPT/ERC T/R 12-01 and ECC/REC (09)01.

Upcoming developments in conjunction with IMT-2020 / 5G

3400-3800 MHz

The frequency bands from 3.4-3.6 GHz and 3.6-3.8 GHz are harmonised both by ECC Decision (ECC/DEC(11)06) and Commission Decision 2014/276/EU amending Commission Decision 008/411/EC. The RSPG has identified the entire band from 3.4-3.8 GHz for the initial implementation of 5G. In Germany it is planned to provide the whole range for IMT-2020 applications on a TDD basis. It is foreseen to provide spectrum nationwide as well as for regional use. Due to the available spectrum of altogether 400 MHz, it is possible for future assignment holders to get particularly large volumes of contiguous spectrum for broadband applications.

For innovative applications still to develop in connection with 5G it will be necessary to enable flexible, successive access to spectrum over the entire period. Therefore part of the available spectrum will be assigned on a regional basis.

All current assignments expire at the latest on 31.12.2022, but it is intended to make the spectrum available as early as possible.

26 GHz

The 26 GHz band, identified by the RSPG as a pioneer band for 5G applications, is to be looked at for its suitability for provision in line with demand (see also item 1.13 of the agenda for WRC-19 aiming at identifying frequency bands for IMT-2020). ITU-R TG 5/1 is tasked to conduct the necessary sharing and compatibility studies with incumbent services for WRC-19 agenda item 1.13, in accordance with Resolution 238 (WRC-15). In Germany more than 18000 FS links and several P-MP applications are active in this frequency range. The recently published studies in CEPT and ITU-R show that an interference-free co-existence of both services is possible in case of applying a coordination procedure. Therefore it is intended to establish a coordination procedure between IMT-2020 and FS to ensure an interference-free deployment and operation and make the spectrum available on a case by cases assignment basis.

ANNEX 3: LIST OF RELEVANT ECC/ERC DECISIONS, RECOMMENDATIONSAND REPORTS

List of relevant ECC/ERC Decisions, Recommendations, Reports, together with status on national implementations and national restrictions, is available in ECO Report 04 on the implementation status of the Fixed Service in Europe, which is the official repository to find information.

ANNEX 4: LIST OF RELEVANT ETSI STANDARDS

A4.1 STANDARDS FOR P-P FS SYSTEMS

Standard for P-P systems, including antennas, cover a very large range of traffic capacities, channel separations (CS), modulation formats and applications over a very wide range of frequency bands that are summarized in Table 25 including the set of deliverables developed to guarantee alignment with the Directive 2014/53/EU, that has replaced previous Directive 1999/5/EC (R&TTE).

Table 25: Digital Fixed Radio Systems (DFRS) parameters

Parameter	Range
Frequency bands	from 1 GHz to 86 GHz
Traffic capacities	from 9.6 kbit/s to 622 Mbit/s and to Gigabit/s and above in the highest bands
Channel separations	from 25 kHz to 112 MHz and to Gigahertz and above in the highest bands
Modulation formats	from 2 to 512 states (amplitude and/or phase and/or frequency modulated states)
Typical applications	P-P CONNECTIONS: rural and urban low/medium/high capacity links for mobile infrastructure, transport/trunk (long-haul), FWA/BWA/MWA backhaul, access, governmental (non-military) links, private fixed networks, SAP/SAB P to P audio and video links STAND ALONE ANTENNAS: for all of the above applications when integral antennas are not employed

Generic standard for P-P digital fixed radio systems and antennas: EN 302 217.

EN 302 217 is a multipart standard including harmonised parts covering the essential requirements under article 3.2 of the 1999/5/EC Directive as described in the following Table 26.

Table 26: EN 302 217 Multipart standard description

Part	Subject	Status
EN 302 217-1	Overview and system-independent common characteristics	Not harmonised
EN 302 217-2-1	System-dependent requirements for digital systems operating in frequency bands where frequency co-ordination is applied	Not harmonised
EN 302 217-2-2	Digital systems operating in frequency bands where frequency co-ordination is applied; Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive.	Harmonised
EN 302 217-3	Equipment operating in frequency bands where both frequency coordinated or uncoordinated deployment might be applied; Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive.	Harmonised
EN 302 217-4-1	System-dependent requirements for antennas	Not harmonised
EN 302 217-4-2	Antennas; Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive	Harmonised

Part	Subject	Status
EN 302 217-2	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2: Digital systems operating in frequency bands from 1 GHz to 86 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU	Harmonised
EN 302 217-4	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4: Antennas	Not harmonised

EN 302 217 supersedes former harmonised standard EN 301 751 as well as former system specific and antenna specific standards for P-P systems.

EN 302 217-2 supersedes former Harmonised Standards related to Directive 1999/5/EC (EN 302 217-2-2 and EN 302 217-4-2).

A4.2 STANDARDS FOR MULTIPOINT FS SYSTEMS

Technology neutral standards

Standards for Multipoint systems, including antennas, cover a very large range of traffic capacities, channel separations (CS), modulation formats and applications over a very wide range of frequency bands: from 30 MHz to 43.5 GHz for equipment and from 1 GHz to 43.5 GHz for antennas.

With the exception of systems and antennas dedicated to the band 40.5-43.5 GHz all other equipment operating in bands from 30 MHz to 33.4 GHz and antennas is specified in the generic standard for multipoint digital fixed radio systems and antennas: EN 302 326.

The scope of this standard also includes multipoint digital nomadic radio systems.

EN 302 326 is a multipart standard including harmonised parts covering the essential requirements under Article 3.2 of the Directive 1999/5/EC as described in the following Table 27.

Table 27: EN 302 326 Multipart standard description

Part	Subject	Status
EN 302 326-1	Overview and requirements for Digital Multipoint Radio systems	Not harmonised
EN 302 326-2	Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive for Digital Multipoint Radio Equipment	Harmonised
EN 302 326-3	Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive for Multipoint Radio Antennas	Harmonised

EN 302 326 supersedes former harmonised standard EN 301 753 as well as former system specific and antenna specific standards for P-MP systems.

By exception P-MP equipment operating in the frequency range 40.5-43.5 GHz is subject to a specific harmonised standard: EN 301 997, as explained in the following Table 28.

Table 28: EN 301 997 description

Part	Subject	Status
EN 301 997-1	Multipoint equipment; Radio Equipment for use in Multimedia Wireless Systems (MWS) in the frequency band 40.5 to 43.5 GHz; Part 1: General requirements	Not harmonised
EN 301 997-2 (note)	Multipoint equipment; Radio Equipment for use in Multimedia Wireless Systems (MWS) in the frequency band 40.5 to 43.5 GHz; Part 2: Harmonised EN covering essential requirements under article 3.2 of the R&TTE Directive	Harmonised

Note: this EN refers to EN 301 125-1 and EN 301 125-3 for directional parameters

As a consequence specific parts of antenna specific standard EN 301 215 remain valid for the frequency band 40.5-43.5 GHz as listed in Table 29 below.

Table 29: EN 301 215 description

Part	Subject
EN 301 215-1	Fixed Radio Systems; Point to Multipoint Antennas; Antennas for P-MP fixed radio systems in the 11 GHz to 60 GHz band; Part 1: General aspects
EN 301 215-3	Fixed Radio Systems; Point to Multipoint Antennas; Antennas for P-MP fixed radio systems in the 11 GHz to 60 GHz band; Part 3: Multipoint Multimedia Wireless System in 40.5 GHz to 43.5 GHz

System specific standards

In addition to the technology neutral Harmonised Standards for Fixed P-MP systems ETSI has also developed Technical Specifications dedicated to the specific Fixed P-MP technologies HIPERACCESS and HiperMAN.

HIPERACCESS system is designed to operate typically in frequency bands designated for P-MP use typically between 11 and 42 GHz.

HiperMAN system is designed to operate in frequency bands designated for P-MP use below 11 GHz. Nomadic usage is possible in frequency bands below 6 GHz.

The following Table 30 presents the Technical Specifications for HIPERACCESS.

Table 30: Technical Specifications for HIPERACCESS

Specification	Subject
TS 101 999	Broadband Radio Access Networks (BRAN); HIPERACCESS; PHY protocol specification
TS 102 000	Broadband Radio Access Networks (BRAN); HIPERACCESS; DataLink Control (DLC) layer
TS 102 115-1	Broadband Radio Access Networks (BRAN); HIPERACCESS; Cell based Convergence Layer; Part 1: Common Part
TS 102 115-2	Broadband Radio Access Networks (BRAN); HIPERACCESS; Cell based Convergence Layer; Part 2: UNI Service Specific Convergence Sublayer (SSCS)
TS 102 117-1	Broadband Radio Access Networks (BRAN); HIPERACCESS; Packet based Convergence Layer; Part 1: Common Part

Specification	Subject
TS 102 117-2	Broadband Radio Access Networks (BRAN); HIPERACCESS; Packet based Convergence Layer; Part 2: Ethernet Service Specific Convergence Sublayer

The following Table 31 presents the Technical Specifications for HIPERMAN.

Table 31: Technical Specifications for HIPERMAN

Specification	Subject
TS 102 177	Broadband Radio Access Networks (BRAN); HiperMAN; Physical (PHY) Layer
TS 102 178	Broadband Radio Access Networks (BRAN); HiperMAN; Data Link Control (DLC) Layer