ECC Report 173

Fixed Service in Europe Current use and future trends post 2022

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0 EXECUTIVE SUMMARY

The Fixed Service 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.

Developments in the technologies have made available the possibility to improve the efficiency and flexibility of FS use, and the new trends in the FS sectors, expressed by CEPT membership, show the interest to use these new capabilities, including higher modulation schemes (up to 4096 levels) wide bandwidth channels (e.g. 112, 224 MHz, adaptive modulation equipment, Hybrid/Ethernet technology equipment better suited to accommodate different Quality of Service (QoS) levels and high capacity links, and other technological solutions.

The information gathered for developing this Report gives the evidence that the current trends in the FS market place are for an ever increasing need to provide high capacity for the mobile networks infrastructures, using all possible new capabilities which have been made available by technology and by the evolution of regulation (such as the availability of wide channel bandwidth), especially to support the requirement of the 5G technologies by means of high capacity links using the most advanced technologies available today, including the use of wide channels and combination of different channels and band. 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. The need and possibility to migrate FS applications from bands intended to be used in future for mobile applications, such as the 5G, is also considered, also taking into account the aspects related to legacy, including existing licenses.

As a consequence, the report highlights the strategic importance of some frequency bands for the FS. Some of these bands show a growth in terms of number of links (13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz and 70/80 GHz), and on which special attention from administrations should be taken; while others are starting 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 consideration of possible future use of W-band (92-114.25 GHz) and D-band (130-174.8 GHz).

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

This Report also highlights the fact that the CEPT proactively responds to the industry and market 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 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 P-MP (or, in some cases, even mixed FS and other telecommunication service) are permitted.

For millimetric frequencies, although some different licensing regimes exist, the majority of administrations relate to link-by link assignment, while a significant percentage (about 20% of total answers) declare light license or unlicensed regime.

ECO Report 04 [2] 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.

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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
ADM	Add Drop Multiplexer
AM	Adaptive Modulation
ANFR	National Frequency Agency (France)
ARCEP	Autorité de Régulation des Communications Electroniques et des Postes
ATM	Asynchronous Transfer Mode
ATPC	Automatic Transmit Power Control
BCA	Bands and carrier aggregation
BEM	Block Edge Mask
BER	Bit Error Ratio
BFWA	Broadband Fixed Wireless Access
BNetZa	Federal Network Agency (Germany)
BPSK	Binary Phase-Shift Keying
BWA	Broadband Wireless Access
CAGR	Compound Annual Growth Rate
CCDP	Co-Channel Dual-Polarisation
CEPT	European Conference of Postal and Telecommunications Administrations
CES	Circuit Emulation
C/I	Carrier to interferer ratio
CPE	Customer Premise Equipment
CRS	Cognitive Radio System
CS	Channel Spacing or Channel Separation
DBPSK	Dual-Polarisation Binary Phase-Shift Keying
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
ERC	European Radiocommunications Committee
ERO	European Radiocommunications Office
ETSI	European Telecommunication Standard Institute
ESS	Earth satellite station
FDD	Frequency Division Duplex
FM	Fade Margin

FS	Fixed Service
FWA	Fixed Wireless Access
GSM	Global System for Mobile Communications
GSO	Geostationary Satellite Orbit
HDFS	High Density Fixed Service
HDFSS	High Density Fixed Satellite Service
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
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISM	Industrial Scientific Medial
LAN	Local Area Network
LMDS	Local Microwave (or Multipoint) Distribution Service
LOS	Line of Sight
LTE	Long Term Evolution
MVDS	Multipoint Video Distribution *System*
MFCN	Mobile / Fixed Communication Networks
MGWS	Multi Gigabit Wireless Systems
MIMO	Multiple Input Multiple Output
MMDS	Multichannel Multipoint Distribution Service,
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
ODU	Outdoor Unit
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
PSK	Phase-Shift Keying
PSTN	Public Switched Telecommunication Network
PTT	Post and Telecommunication
PW	Pseudo Wire
QAM	Quadrature Amplitude Modulation
QLOS	Quasi Line of Sight
QoS	Quality of Service
QPSK	Quaternary Phase-Shift Keying
RAS	Radio Astronomy Service
RBER	Residual BER
RPE	Radiation Pattern Envelope
RR	Radio Regulations
RRL	Radio Relay Link
RSL	Received Signal Level
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)
VSAT	Very Small Aperture Terminal
WiMAX	Worldwide Interoperability for Microwave Access
WRC	World Radiocommunications Conference
XPIC	Cross Polarisation Interference Cancellation

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The activity of collecting info on FS use and trend in CEPT, by means of specific questionnaires, started in 1997 and several updates of a ECC Report were produced over time. This information is highly appreciated by the administrations and industry.

In 2010, the ECC decided to start the edition of a new Report as an updated version of the ECC Report 3 [1] (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.

In 2017, a new activity was agreed to update the info on effective spectrum use, vision and expectations of frequencies above 50 GHz, also in view of the impact of 5G on FS.

Technology trend and licensing regime were also included; at same time, the possibility to develop a more frequent update of this document was considered useful to keep alignment with the changes in the FS market, due to the speed of evolution of the telecommunication environment.

The activity to finalise current revision was agreed in 2021.Therefore, this Report builds on the results of the original ERO Reports on FS trends post-1998 and post-2002 by revising them and updating the information on FS use.

This version is based on the structure of previous revisions, updated by means of a questionnaire developed in 2021.

In addition, ECO Report 04 [2] 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 service from 1997 up to 2021;
- To provide a useful reference for administrations, manufacturers and telecom operators on issues surrounding the developments of civil[1] 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, are previous version, published in 2016, and the questionnaire on FS use and future trends, conducted through CEPT administrations in 2021. In total, 32 membership, including administrations, network operators and manufacturer companies responded to these questionnaires.

Detailed evaluation of the evolution of FS situation in Europe is done based on the answers of the countries answering 2021 questionnaire (see Table 1), while only trends are shown for older versions, due to the absence of electronic database for the revisions of report earlier than 2011.

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

1.4 CONTRIBUTIONS TO THE STUDY

Table 1 provides the list of administrations answering questionnaires leading to the publications of reports ECC Report 3 [1] (1997, 2002), ECC Report 173 (2012) and its revision (2018) [3].

Table 1: Countries replies to the questionnaires

Country	1997	2001	2010	2016	2021	Country considered for 2021 trends evaluation
Albania				X (Note 1)		
Austria	X	X	X	X	X	X
Azerbaijan					X	
Belgium	X	X			X	
Bosnia and Herzegovina			X	X	X	X
Bulgaria	X			X	X	X
Croatia	X	X	X	X	X	X
Cyprus			X		X	
Czech Republic	X	X	X	X	X	X
Denmark	X	X	X			
Estonia		X	X	X		
Finland	X	X	X	X	X	X
France	X	X	X	X	X	X
Germany	X	X	X	X	X	X
Greece			X	X		
Hungary	X	X	X	X	X	X
Iceland	X		X			
Ireland	X	X	X	X	X	X
Italy	X	X	X	X	X	X
Latvia	X	X	X	X	X	X
Lithuania	X	X	X			
Luxembourg	X	X	X			
Malta				X	X	X
Moldova					X	
Montenegro				X (Note 1)		
Netherlands			X	X	X	X

Country	1997	2001	2010	2016	2021	Country considered for 2021 trends evaluation
Norway	X	X	X	X	X	X
Poland			X			
Portugal	X	X	X	X		
Romania			X	X	X	X
Russia			X	X		
Serbia			X		X	
Slovak Republic		X	X	X	X	X
Slovenia	X	X	X	X	X	X
Spain			X			
Sweden	X	X	X	X	X	X
Switzerland	X	X	X	X	X	X
Türkiye	X	X		X	X	X
United Kingdom	X	X	X	X	X	X
Total	23	23	31	26	26	22

The detailed summary of the responses of national FS use is given in Annex 1 to the Report.

2 DEFINITIONS

Term	Definition
CAGR	The **Compound annual growth rate** is a specific term for the smoothed annualised 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.

3 EUROPEAN FIXED SERVICE MARKET AND ITS REGULATION

This section describes some aspects related to European market trends, including role of Fixed Service, FS assignment methods, frequency band refarming.

3.1 GENERAL MARKET TRENDS

Liberalisation of telecommunications has been taking place and consolidating 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 1990s, 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 PSTN network, national broadcast distribution (feeder links to regional VHF/UHF transmitters) networks, etc.

The most significant increases of 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 increase since 1997. 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 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.

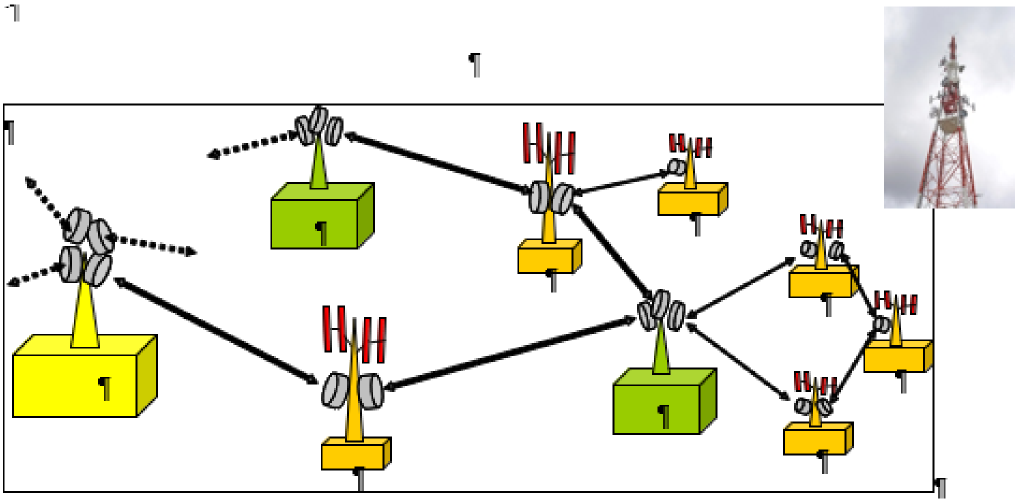


Figure 1: Example of fixed links deployment within the infrastructure of mobile network

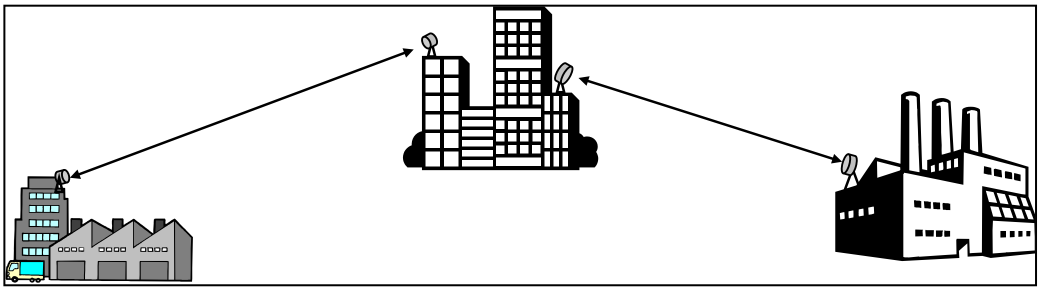


Figure 2: Example of a private radio relay link (e.g. for LAN, PABX inter-connection of premises)

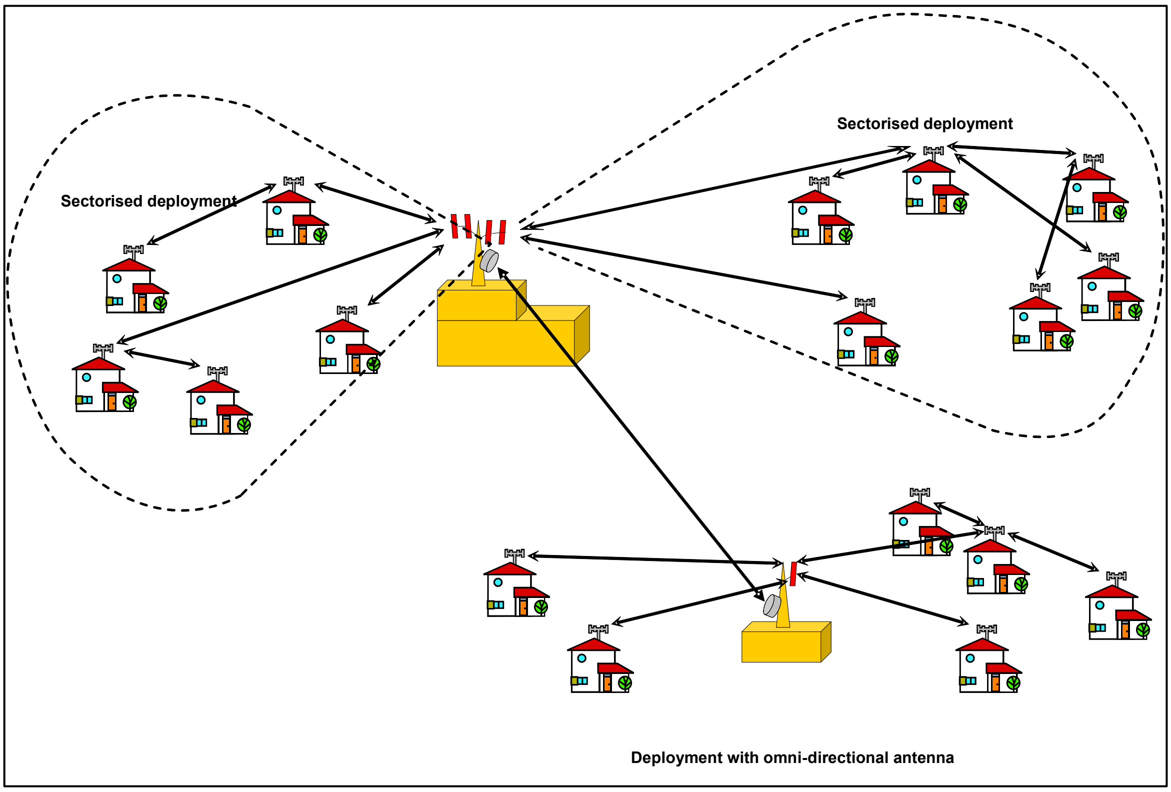


Figure 3: Example of P-MP FWA / BWA network including a P-P infrastructure connection

Fixed radio links 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 of such cases, installation of optical fibre or cable is not deemed to be convenient, so 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 at least over the next 5 years. This is primarily due to the expected growth in data traffic over the coming years.

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. Such growth could be effective, for instance, to counteract possible network congestions due to increased smartphone usage with several new applications running.

3.3 FIXED SERVICE GROWTH AND BANDS STRATEGY

The FS usage figures obtained from 2021 questionnaire, compared with the usage figures obtained in previous studies (see Figure 5), where the overall increment of FS links compared to previous version of the Report is shown), 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 in the order of about 8% for all period (1997 to 2021).

The trend for the period 1997-2010 was calculated based on data from the 19 administrations answering all the first three questionnaires, while the trends for following periods are based on the administrations providing answers to two consecutive questionnaires.

Figure 4 gives the trend of use of FS (reflecting increase of overall number of links in operation), relative to first data provided in 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 2021.

The margin of error, due to a non-homogeneous base of responding administrations in every questionnaire, is estimated to be less than 10%. A detailed comparison of the effective number of links in operation, based on answers from those administrations answering all questionnaires, was not possible, since data from questionnaires in 1997 and 2001 are no more available in an electronic form.

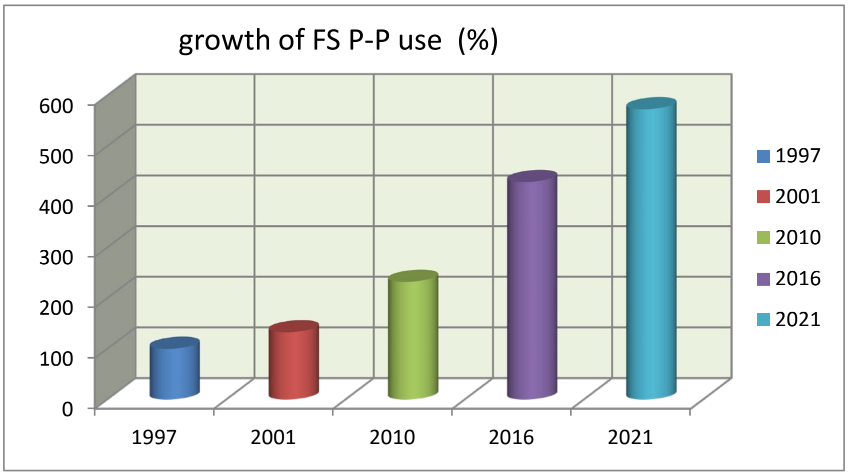


Figure 4: Trend of increase in FS links in Europe based on administrations answering CEPT questionnaires

The major growth in FS usage is reported in the area of infrastructure support (from 73000 in 1997 to about 740000 links in 2016), mainly linked 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 is significantly decreased in time since 1997, but show increase compared to 2016; it is currently indicated to be in the range of 1 to 2% of total number of bidirectional links.

Table 2 provides a summary of total number of links in operation, for each revision of the Report.

Compared to previous versions of the Report, a second column (indicated as “same admins” is made available, since data from one administration providing a significant percentage of links in previous questionnaires was not available for 2021 revision of Report 173.

In order to allow a realistic comparison of data between 2016 and 2021 revisions, in this column only administrations answering both 2016 and 2021 questionnaire are taken into account.

Table 2: Total declared number of FS active links

	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	494449		126459	21195
2016	742820	531966 (Note 1)	4889	34219
2021	738333	721747 (Note 2)	12067	10725
Note 1: 2016 data only for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data only for administrations responding both 2016 and 2021 questionnaires				

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 [78]), 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 [79] 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 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 exemption**: 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 3 [1], 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 1990s.

It is an important tool to optimise 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

This section describes the status of technology currently addressed by FS, in relation to equipment / network specific aspects (such as modulation, availability of wide band channels), and antennas.

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 (see Figure 5a)). 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 (see Figure 5b)).

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.

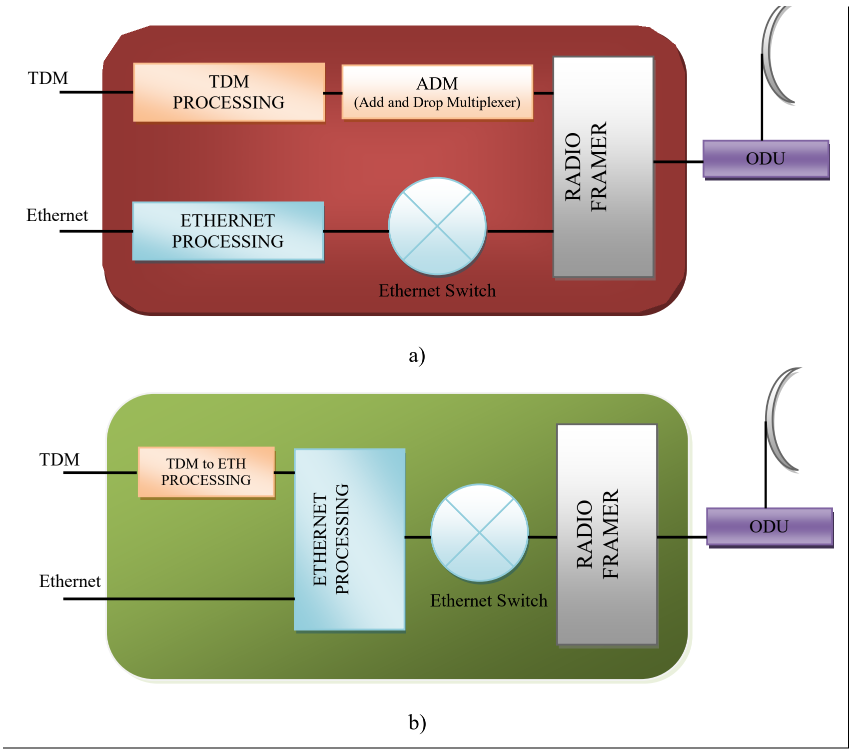


Figure 5: Evolution from Hybrid MW (a) towards Packet MW (b)

4.1.2 Modulation, spectral efficiency and error performance enhancement

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 6.

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.

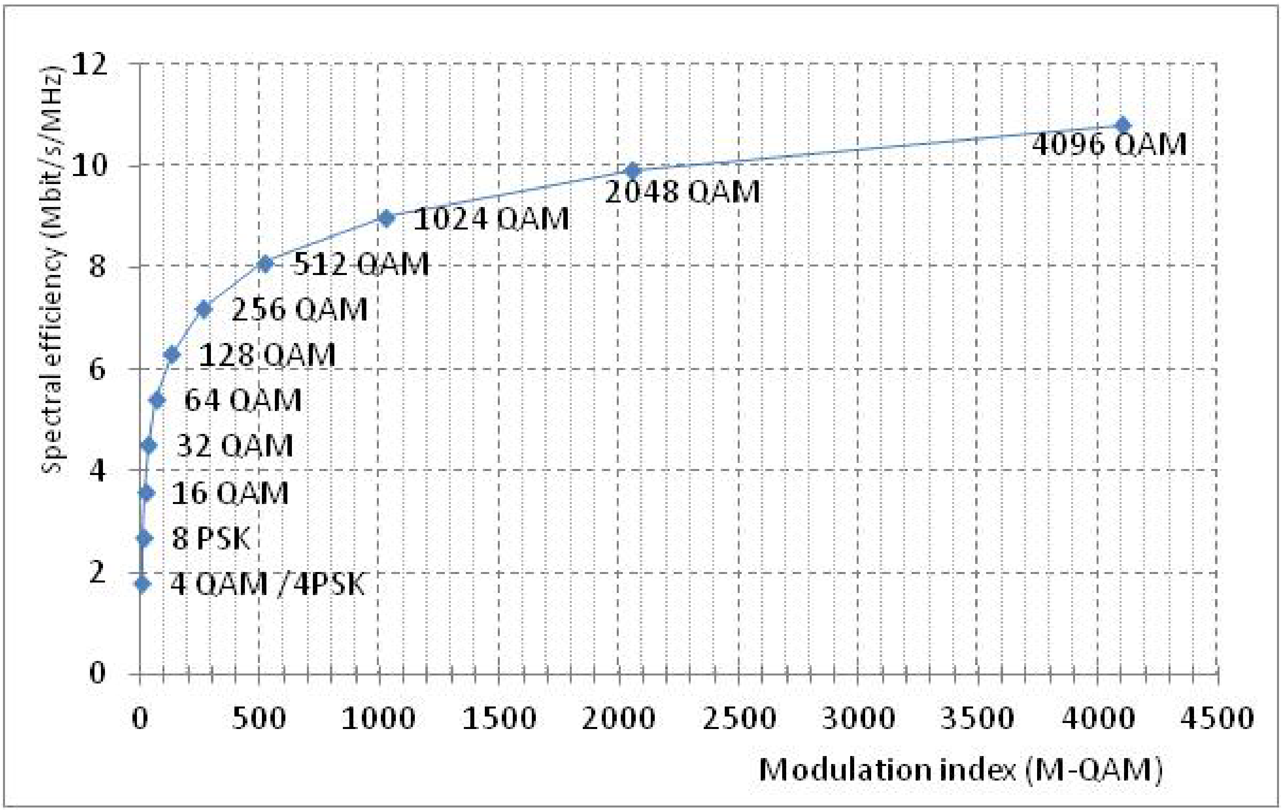


Figure 6: Spectral Efficiency versus Modulation index (example for symbol frequency of around 0.9 CS)

4.1.3 Polarisation

The additional use of Cross-Polarisation Interference Cancellation (XPIC) to double capacity in Co-Channel Dual-Polarisation (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 increased use is declared. Use of MIMO is in phase of initial consideration.

4.1.4 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;
- 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[2];
- 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.

Table 3: Maximum channel width available in ECC/CEPT and ITU-R Recommendation

F (GHz)	CEPT Recommendations	CH BW (MHz)	ITU-R Recommendations
10-7-11.7	12-06 [38]	112	F.387-13 [45]
14.5-15.35	12-07 [39]	56	F.636-5 [46] (also 112)
17.7-19.7	12-03 [40]	220	F.595-11 [47]
21.2-23.6	13-02 [36]	224	F.637-5 [48]
24.5-26.5	13-02 [36]	112	F.748-4 [49]
27.5-29.5	13-02 [36] (also 224)	112	F.748-4 [49]
31.8-33.4	(01)02 [41]	224	F.1520-3 [50]
37-39.5	T/R 12-01 [42]	224	F.749-4 [51]
40.5-43.5	(01)04 [43]	224	F.2005-1 [52]
71-86 (E-band)	(05)07 [44]	N*250	F.2006 [53]
92-114 (W-band)	(18)02 [16]	N*250	
130-174.8 (D-band)	(18)01 [15]	N*250	

4.1.5 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

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

to dynamically increase radio throughput by scaling modulation schemes (e.g. 4 QAM → 64 QAM → 256 QAM) according to the current propagation condition (see Figure 7).

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 [4] 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”.

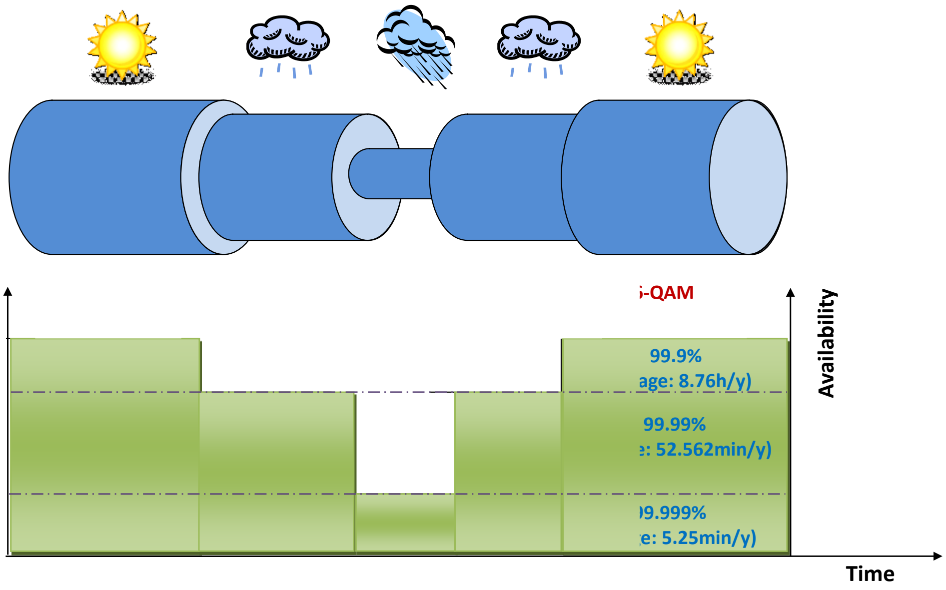


Figure 7: Adaptive Modulation example (availability/outage figures are indicative)

4.1.6 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 8), 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 (see Figure 8). 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.

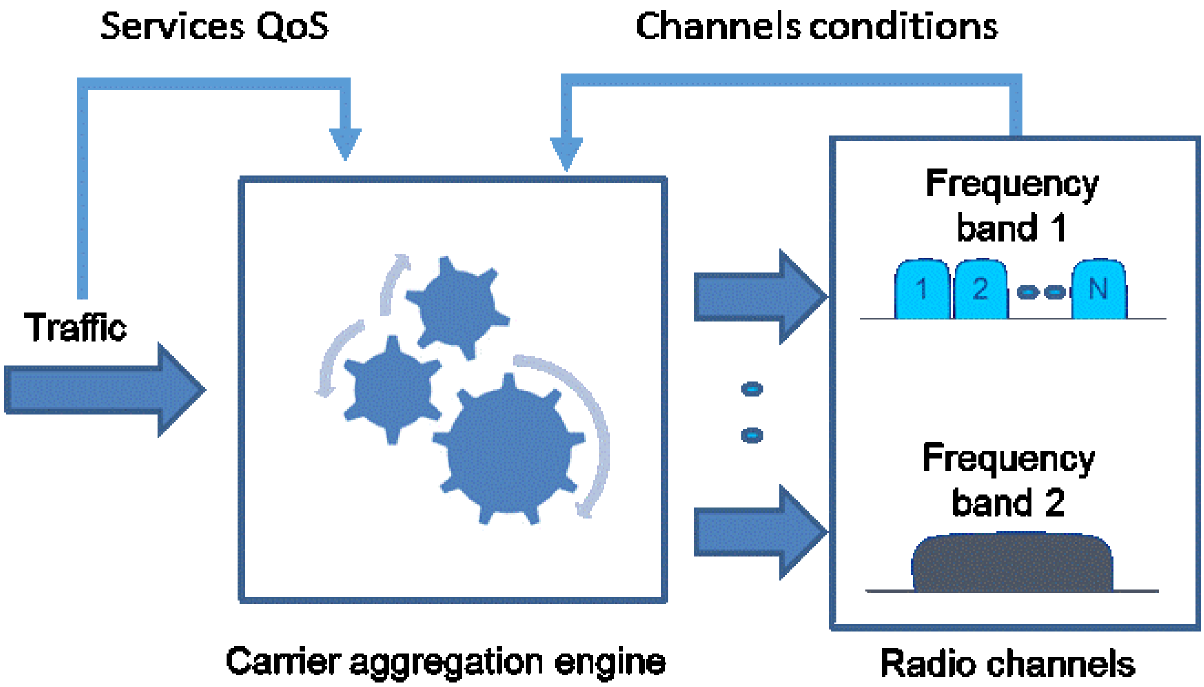


Figure 8: BCA concept

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 9 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.

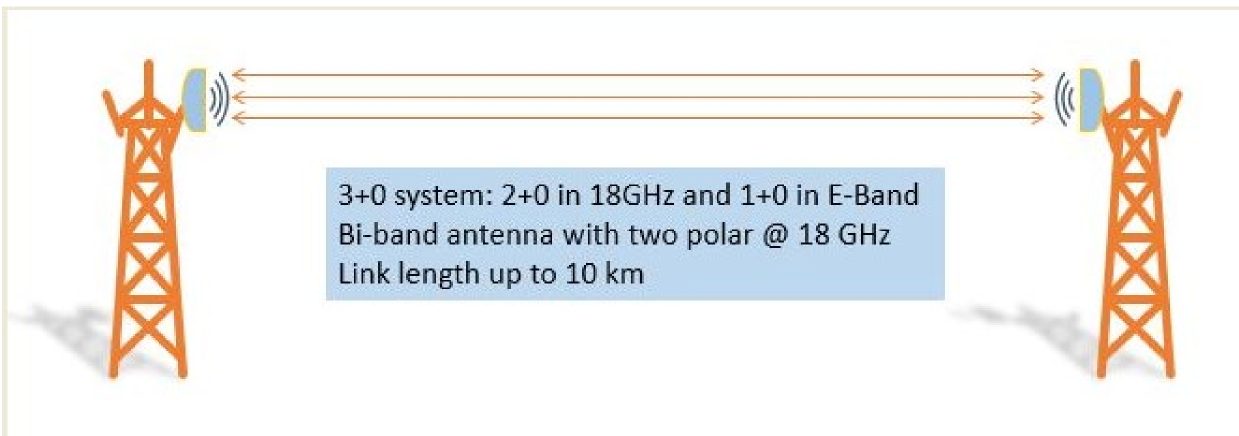


Figure 9: BCA in traditional microwave bands plus E-band

A typical shape of capacity/availability performance for this case is depicted in Figure 10.

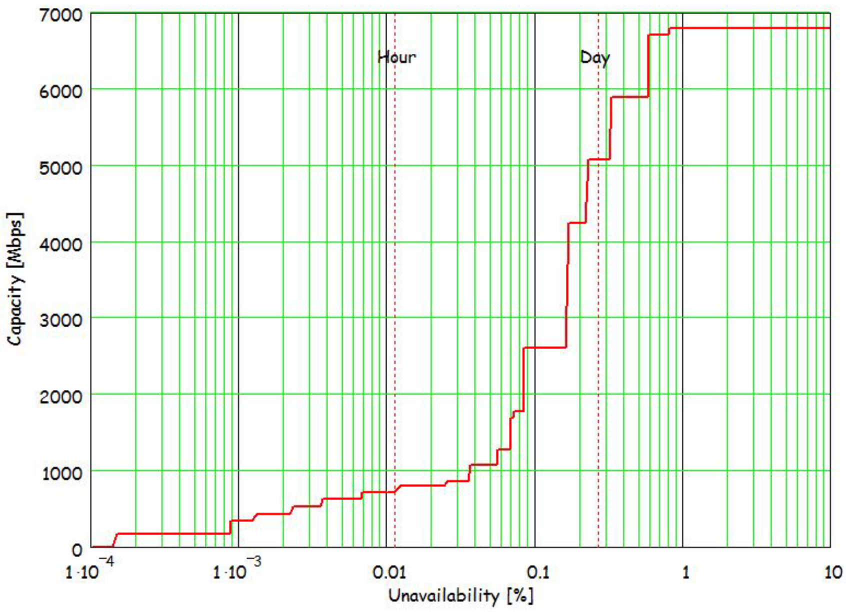


Figure 10: Capacity vs availability with BCA of 18 GHz and E-band

More in general, this specific combination could be used for the following two different use 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.

4.2 ANTENNAS FOR FS

General aspects related to antennas used in FS applications are considered in this section, providing some general aspects on types and characteristics. Few considerations on active antennas, currently not used in field yet by FS, are also given.

4.2.1 Antenna types

4.2.1.1 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 [5], and for frequency range from 1 to about 70 GHz from Recommendation ITU-R F.699 [6] (for peak side lobes) and F.1245 [7] (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 [8].

In addition, for integral and stand-alone P-P link antennas the following conformance specifications are referenced in ETSI EN 302 217-4 [9] for several classes of antennas depending on the potential of interference scenarios. Directive antennas for P-MP terminals are standardised, also subdivided in different classes, in ETSI EN 302 326-3 [11].

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 7). 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 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 (see Figure 11).

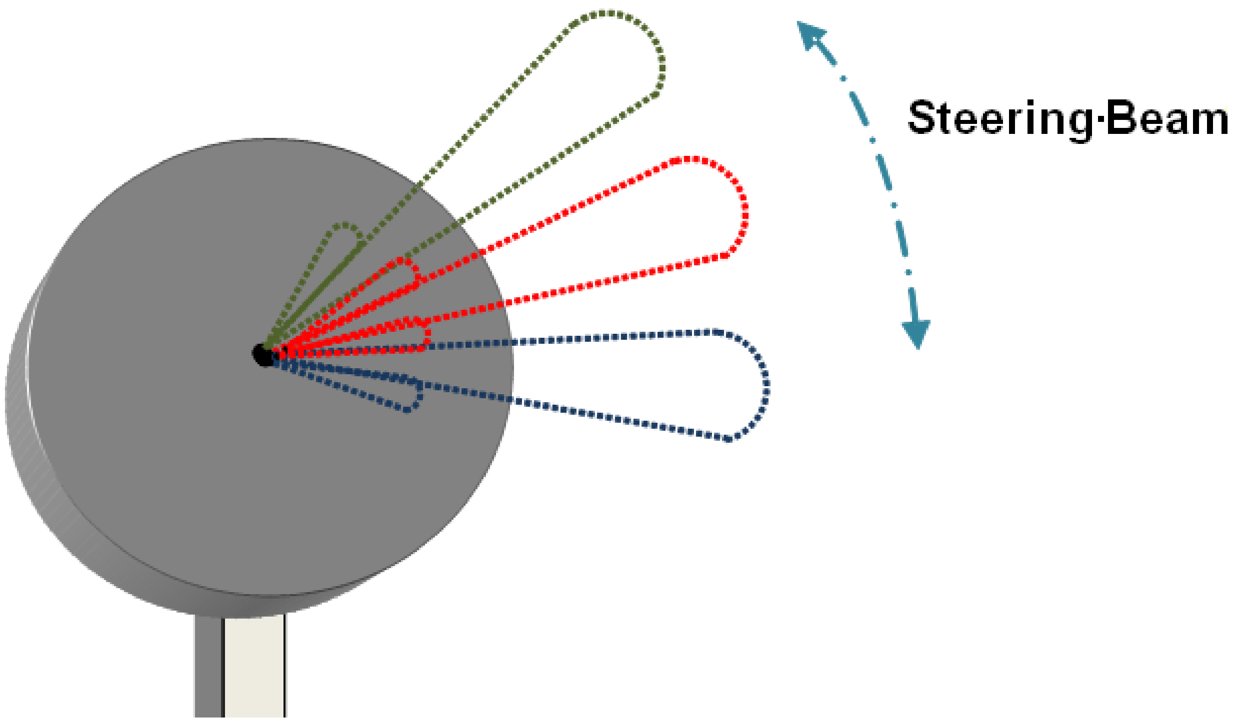


Figure 11: Smart antenna with steering beam (both transmitting and receiving)

4.2.1.2 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 [8]. The conformance specifications for such integral and stand-alone antennas are referenced in the following ETSI standards: EN 302 326-3 [11] for frequency bands between 1 and 40 GHz, EN 301 215-3 [12] for the 40.5-43.5 GHz .

4.2.2 Antenna characteristics and use

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.

4.2.2.1 Required specific conditions.

Most responding administrations require an ETSI Class 2 (Bosnia and Herzegovina, Belgium, Ireland, United Kingdom, France, Norway, Germany, the Netherlands and Switzerland) or a Class 3 (Ireland, Bosnia and Herzegovina, Germany, Switzerland, Bulgaria, the Netherlands, Norway, Sweden, France and Finland) as minimum antenna class.

ETSI Class 1 may be accepted by o responding administrations for all cases (Moldova) or in limited frequency bands (the Netherlands in 1350-1375 MHz and 1492-1517 MHz frequency band), while Class 4 may be required in Finland and France in some frequency bands.

A minimum gain value is required in Hungary.

4.2.3 Active antennas

Within fixed service, the possibility of using adaptive antennas, provided with active devices to optimise performances, could be considered in case of need, due to technological evolution.

An example of such possibility is considered in ECC Report 342 [13], which was developed for the case of a P-MP system, where every network element is at fixed nominal location during operations.

Due to that the antenna pattern is defined at the system configuration and is not changing any more while in operation.

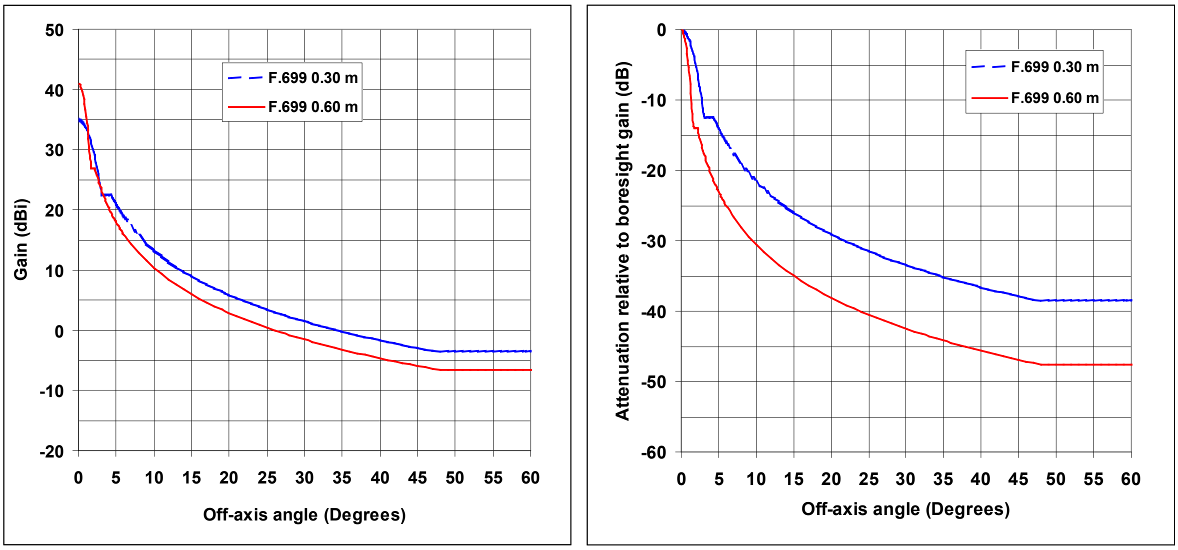
The key technologies in such a system are beamforming and interference cancellation techniques.

4.2.4 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.

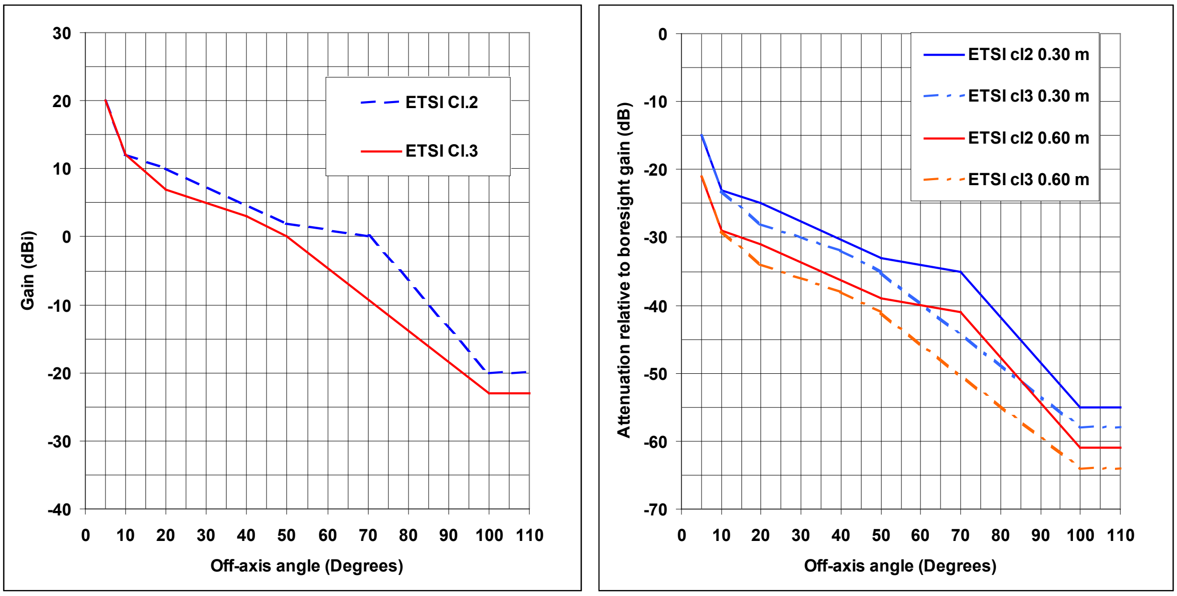
A typical access network could operate at 23 GHz using 0.6 m dish antennas at the central station and 0.3 m dish antennas at the remote stations. For extended coverage 0.6 m dish antennas can also be used at remote stations. As an example, we could assume that 40 dB attenuation is required between co-channel hops in star configuration. Based on the reference radiation pattern described in Recommendation ITU-R F.699 [6] (see Figure 12), 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 13), 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 12: Antenna radiation pattern at 23 GHz, based on Recommendation ITU-R F.699-7 [6]



a) Absolute Gain b) Relative attenuation

Figure 13: Antenna radiation pattern envelope at 23 GHz, based on ETSI EN 302 217-4 [9]

Note 1: Being only a reference, the radiation pattern in F.699 [6] 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 the maximum frequency reuse can be estimated to be 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.

4.2.5 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 [59] 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 EXPECTATIONS OF CHANGES OF THE FS APPLICATIONS AND TECHNOLOGICAL EVOLUTION

This section describes aspects related to possible aspects related to expected use of available technology in networks, not excluding aspects indirectly dependent on technological evolutions, such as the planning methods.

5.1 TECHNOLOGY / DEVELOPMENT EXPECTED IN NEXT FUTURE

The expectation of a high capacity requirement (up to 10 Gbit/s indicated by one responding administration (Austria) to be met is confirmed by several responding administrations; possible use in urban environments has been noted by one responding administration (Italy).

Use of sub millimetre waves is mentioned to cover very high capacities.

It was noted by one responding administration (Ireland) that need for high capacity demand also exists for frequencies lower than 50 GHz, due to possibility to achieve longer distances.

It was noted that FWS use might be driven in sub-6 GHz and 60 GHz frequencies by broadband service where fibre implementation is not possible or not feasible (Türkiye).

The expectation of a widespread use of equipment technical features already available to increase spectrum use, such as high order modulations, wide channels, adaptive modulation, XPIC and Tx power, is confirmed for the next future. One or more of these features have been mentioned by most respondents (including Austria, Croatia, Germany Ireland, Finland, Hungary, Serbia and Sweden); it is however noted by one responding administration (Italy) that the use of modulations of higher order of the highest used today (1028, 2048) is not expected to give a significant advantage in terms of increase of capacity, due to reduction of link budget.

BCA is expected to be adopted on a large scale; in particular, the use of the aggregation of the E-band with some lower frequency is indicated by several respondents (including Bulgaria, Italy, Sweden, Norway, Slovenia as well as Huawei).

The use of LOS-MIMO is considered as a viable solution by some responding administrations (Sweden, Austria, Serbia and Slovenia), even in case of areas with local spectrum shortage/congestions (Sweden), possible limitation of due to installation constraints was noted, together with possibility to use multi-user MIMO for FWA (Italy).

NLOS was also mentioned for low frequencies by one responding administration (Bosnia and Herzegovina).

The possible use of spectrum resources in sub millimetre wave are also considered feasible by some responding administrations, while the availability of other techniques to further improve spectrum use such as full duplex, consisting in using same frequency for simultaneous continuous transmission for both direction of a link, potentially enabling doubling of capacity is under study and not expected on a short time scale (Huawei).

Possibility of implementation of advanced network solutions based on coordination of powers transmitted by a network for optimisation of network performance have also been indicated in the answers (Italy, Huawei).

Possibility of radio equipment capable of dynamic traffic awareness features allowing radio systems to minimise their power consumption, during periods with limited traffic, was mentioned by one responding administration (Sweden).

5.2 EMERGING TECHNOLOGIES AND NETWORK ARCHITECTURES)

CEPT administrations are following technological evolution, and keep regularly contacts with stakeholders to timely detect the evolving needs and solutions under study.

A wide consensus has been confirmed on the need for fixed service to evolve towards applications that, although formally not so different from today's use (network infrastructure for fixed and mobile, infrastructure for broadcast etc.), can allow the management of ever increasing capacity, currently expected to be in the order of 1-2 Gbit/s in short term, to increase to higher than 10 Gbit/s in dense urban use in next future

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.

The increase of interest in the use of multichannel/multiband (BCA and CA) solutions has been expressed or mentioned by some responding administration, one of them expects growing demand in next years (Czech Republic)

In particular, the possible use of a high capacity band aggregated with a band with low capacity and high availability has been noted.

Concerning the possible use of very high frequencies, such as the D-band, it was noted by industry that the small form factor associated to the short wavelength, facilitating the development of small equipment with high capacity of integration, could facilitate the use these bands for high capacity backhaul.

In relation with the possibility of adopting new solutions in network architecture, -reference was made to Integrate Access and Backhaul (IAB) by some answering administrations (Türkiye and Austria).

Although several responding administration expressed interest towards common aspects (such as the use of some frequency bands for 5G and related possibility to offer mobile backhauling), following points have been specifically noted:

- 5725-5875 MHz band was indicated suitable for BFWA by one responding administration (Slovenia);
- 24.5-26.5 GHz band was reminded to be planned for the use of 5G systems by one responding administration (Türkiye);
- 26-28, 42, 60 GHz are declared suitable for 5G backhaul by one responding administration (Austria);
- V-band was indicated for possible use within one responding administration (Austria);
- 71-76 GHz and 81-86 GHz (E-band) one responding administration expressed interest for use of the band for Wireless backhauling and FWA (Malta).

5.3 ATPC USE

Administrations have been asked to provide information related to the use of ATPC in their networks, since this feature was made available from industry more recently than some historical features of P-P and P-MP equipment.

The feature is in general not imposed as mandatory from responding administrations, although some different cases exists; in no case it has been stated that the use is not allowed:

- It was noted by one responding administration (Italy) that the use of ATPC should facilitate sharing with other services; it was also noted by another administration (Slovenia) that ATPC should be used according to ETSI EN 302 217 [14];
- one respondent (Eolo-Italy) expressed view that this feature is fundamental and should be used as wider as possible.

In particular, in most administrations, ATPC is not declared to be mandatory (Ireland, Belgium, Malta, Bulgaria, Azerbaijan, Italy, Moldova, Türkiye, Norway, Cyprus, Romania, Bosnia and Herzegovina, Croatia, United Kingdom, Slovak Republic, the Netherlands and Hungary, Germany and Czech Republic), while in other cases, it is mandatory only in some frequency bands (Serbia in license exempt 5470-5725 MHz, Finland and Austria in 18 GHz band, France between 10 and 40 GHz).

Just in one responding administration, Switzerland ,ATPC have been reported to be mandatory only in some frequency band (between 3.8-40 GHz Band and in E-band).

- Possible difficulties to indicate ATPC as mandatory in regulation have been reported regarding the use in a multi-operator domain, as well as for BCA and high level modulations by one responding administration (Sweden);
- Concerning the use, some responding administrations reported that, even without a specific obligation, ATPC is used on a voluntary basis (Finland, Sweden, Austria and Norway);
- One responding administration (France) also noted that the use of adaptive modulation and the high order modulations now available could make the use of ATPC less relevant.

6 GEOGRAPHICAL CONTEXT OF USE

Depending on the needs, FS links can be used to implement connections within a very wide range of cases, from point of view of geographical topology, covering the case of short connections totally within high densely populated areas of the same municipality, as well as the case of long connections, with terminals lying within or outside high densely populated areas, passing over scarcely populated areas, and an almost infinite variety of intermediate cases and environments.

In the past, where low frequencies were mostly used, greater percentage of links were quite long (>20 to 50 km or more) and the need of a specific classification to describe specific cases was not felt useful for characterizing different technical needs and use cases.

In the recent years, the extension of the frequency range to cover high frequencies, capable to realise higher capacities over shorter links, the need of different performances related to emerging technologies and applications, the need to optimise investments by properly associate the technical requirements and the best technology, the use of specific terms to relate links with the environment of use have become common in different contexts.

In particular, the terms “Urban”, “Suburban”, “Rural” or some similar expressions have gained popularity, even without having been defined at a worldwide bases.

Sometimes other terms are also used for more specific conditions (such as “dense urban” for very short links expected to provide capacities > 10 Gbit/s in future):

- In about 20 responding administrations, the classification of urban, suburban, rural environment is not used (Ireland, Belgium, Malta, Bulgaria, Azerbaijan, Serbia, Austria, Norway, Cyprus, Latvia, Romania, Switzerland, Bosnia Herzegovina, Slovenia, Croatia, France, Slovak Republic, Hungary, Germany and Czech Republic);
- One responding administrations provides a general view on the use of the term “urban” to indicate radio links in densely populated areas, with short typical lengths and very high capacities, while the term “rural” is applicable to longer links in less densely populated areas; the definition is not applied to FS in Italy;
- Some administrations use the concept of “urban” in general case, since in urban cases higher threshold degradation is allowed (Finland, Sweden under study), and some kind of indicator of density (economic development factor) is used to establish fees (Türkiye);
- In the United Kingdom - for certain authorisation products e.g. shared access FWA within the 3.8-4.2 GHz band different types of licences are permitted depending on the location ‘rural’ or ‘urban’;
- In one responding administration only the term “urban” is used, to be applied to the entire country (the Netherlands);
- Classification appears "under study" in some administrations, where some operators use a classification in their networks (Sweden) and other operators consider that such classification could be useful, even if not currently used in their country (Eolo-Italy);
- One respondent (Huawei) noted that general views exists that the use of term “urban” should indicate radio links in densely populated areas, with typical lengths not longer than 3 km and very high capacity is expected, to be achieved by E-band or higher bands in future, while the term “rural” should be used for longer links in less densely populated areas, to be supported by BCA systems, capacities up to 2 Gbit/s, possibly in addition to wide channels (e.g. 112 MHz).

7 LINK PLANNING

While link planning is well consolidated for frequency ranges below 50 GHz, since most of them are available since few decades, there is the need to check the application of these methods to higher frequencies, since new frequency ranges (up to about 86 GHz) became recently available due to the evolution of technology, while others, even higher (up to about 170 GHz), are expected to be made available in few years from now.

Concerning link planning methods adopted for frequencies above 50 GHz, several respondents note that planning is performed according to relevant ITU and ECC Recommendations. It is also noted by some respondents that some lack of information is affecting frequency bands above 50 GHz.

In particular the following Recommendations are indicated:

- Recommendation ITU-R P.530 [17] (prediction methods) by Bulgaria, Finland, Türkiye, Slovak Republic, the Netherlands and Germany;
- Recommendation ITU-R P.525 [18] (free space propagation) by Bulgaria and Switzerland;
- Recommendation ITU-R P.452 [19] (prediction for interference evaluation) by Austria, Finland, Moldova and the Netherlands.

Other complementary Recommendations are addressed by other responding administrations, e.g. Recommendation ITU-R P. 838 [20] for rain fading, and Recommendation ITU-R P.676 [21] on atmospheric gas attenuation (Italy) and Recommendation ITU-R F.699 [6] on antennas (Slovak Republic and Italy))

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

Some specific tools have been indicated such as Pathloss 5 (Latvia) in addition to few proprietary tools (United Kingdom and Slovak Republic).

Some interference criteria are reported by responding administrations: I/N= -- 6 dB for 1 dB threshold degradation (Sweden); threshold degradation < 1 dB single / or < 2 dB cumulative / ITU-R P.525 [18] / P.526-11 [22] (Switzerland); C/I or TD (Bosnia and Herzegovina)¸ T/I (Germany).

7.1 FREQUENCIES BELOW 86 GHZ

In some responding administrations, no calculation is done by the administrations (Belgium, Ireland, Serbia, Hungary, Romania and Croatia up to 86 GHz, Czech Republic above 86 GHz) due to the adoption of simplified licensing regimes, (the operators make link planning); in case of interference, the last registered user changes frequency (Ireland); some responding admins use link-by-link up to 86 GHz (United Kingdom).

One responding administration (Sweden) notes that for frequencies above 50 GHz systems, accurate knowledge of antenna characteristics and site location are required for accurate link planning. Same respondent notes that the interference criterion is for the time being the same as in the traditional bands 6-38 GHz, I/N= -- 6 dB for 1 dB threshold degradation (single entry).

Another administration (Norway) uses standard software and standard methods for interference calculations, including latest propagation and attenuation models.

Czech Republic informs that in the 60 GHz, where two technologies are allowed – (RLANs and FS), basic technical parameters of each station (e.g. location, bandwidth, power, required C/I based on modulation) are registered and simple calculation is executed using free space.

7.2 FREQUENCIES ABOVE 50 GHZ

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

In several responding administrations there is no use nor request for these bands yet.

One responding administration (Sweden) notes that above 86 GHz, the situation is basically the same as for 50-86 GHz, possibly even with higher requirements due to higher frequencies.

Some respondents note that existing prediction models need consolidation for frequencies above 86 GHz (Italy, Austria, Huawei and United Kingdom).

One responding administration (Italy) notes that activities are ongoing to evaluate the effectiveness of existing methods for rain attenuation in D-band, since current methods could overestimate the attenuation, while United Kingdom notes the there is a need for propagation models and antenna patterns for bands above 50 GHz to be updated and extended in frequency.

The following ETSI documents are noted by some individual respondents:

- ETSI EN 302 217 series [14] (Ireland);
- ECC Recommendation (18)01 [15] and ECC Recommendation (18)02 [16] channel plans for W-bands and D-bands);
- Recommendation ITU-R P.530 [17] (prediction methods) and Recommendation ITU-R P.525 [18] (free space propagation) (Austria).

7.2.1 Link quality criteria – error performance and availability

Common view exists that error performance and availability are expected to still play a significant role in future networks and technologies, including 5G.

Latency is also indicated as important by some respondents.

Recommendation ITU-T G.826 [60] and Recommendation ITU-T Y.1563 [61] are used for reference by some respondents.

A widely used parameter for link planning is the availability, based on the 10 consecutive SES criteria, defined many years ago for PDH (ITU-T Recommendation G.821 [23]), extended later for constant-bitrate digital connections (ITU-T Recommendation G.826).These criteria were developed many years ago, and an analyses could be carried on, to check their 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.

7.2.2 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 in future 5G from rural to dense urban environment (see an example in Figure 14). 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 also implies 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).

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).

7.2.3 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[3] 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 [24])[4]. In such short hops, this obviously means that, for fulfilling also the other “error performance objectives” (Recommendation ITU-R F.1668 [80]), 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.

[3] See EN 302 217-2-1 [10]

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

Figure 14: Urban area backhauling example

7.2.4 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 [83]); 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 Report 258 [25], including planning guidelines, and in ETSI TR 102 311 [26];
- Introduction of more complex “Cognitive Radio System (CRS)” capability[5];
- Asymmetrical traffic point-to-point links as described in ECC Report 211 [27].

[5] According ECC Report 159 [28] and Report ITU-R SM.2152 [29], 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.”*

7.3 P-MP AND MP-MP NETWORKS

This section provides some overview on FS topologies other than P-P, including FWA and BWA.

7.3.1 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 15.

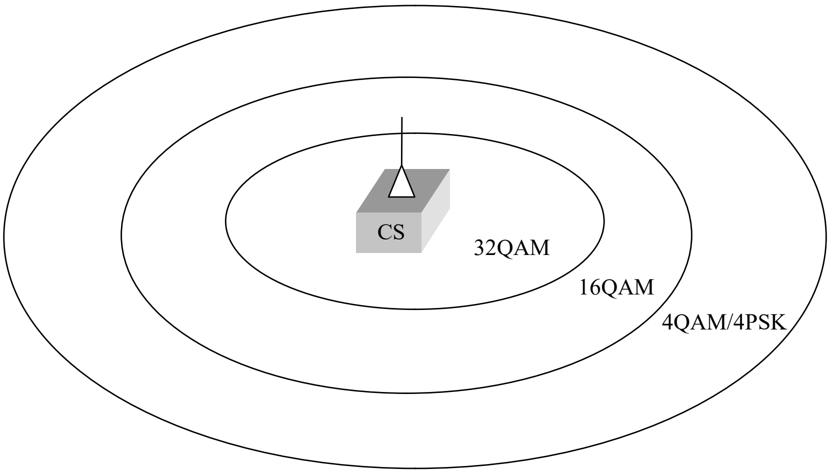


Figure 15: Example of using adaptive modulation in a P-MP network, serving terminals with different link budgets (CS= central station)

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 nodes may be later converted into repeaters with the further growth of the network (see Figure 16).

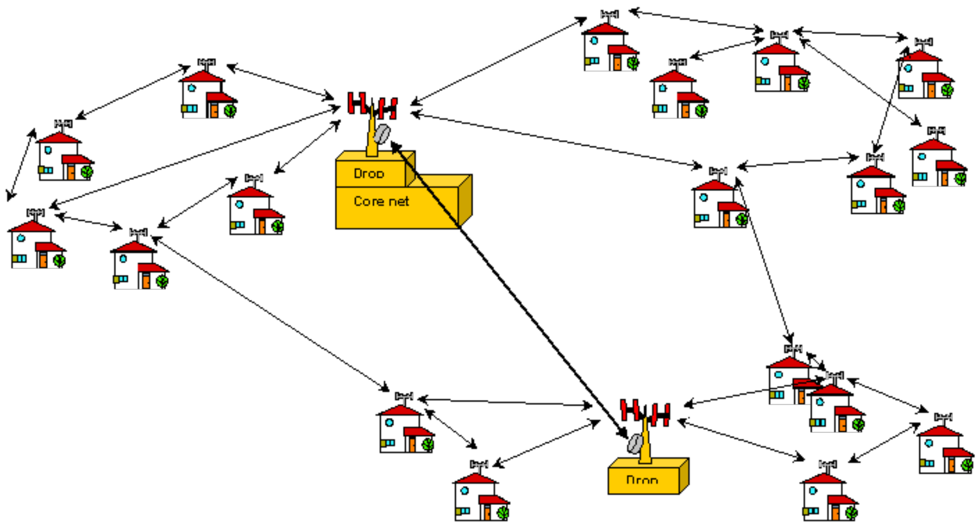


Figure 16: Topology example in a mesh network

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 17). This allows the traffic to be merged so that the peaks from one mast 'cancel out' the troughs of another which improves system efficiency.

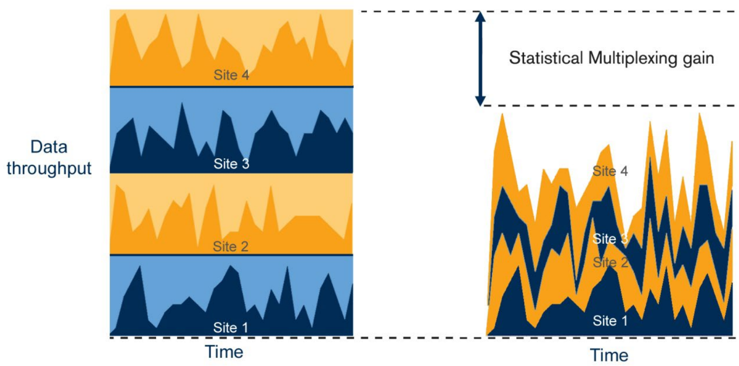


Figure 17: Example of statistical multiplexing gain

7.3.2 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. Section 7.3.3 describes in detail the current situation in the field of BWA.

7.3.3 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 [30].

Standardisation activities for broadband FWA included the development of the IEEE 802.16 [31] 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 11 GHz 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 Wireless MAN OFDM PHY specification targeting the 3400-3600 MHz band.

7.4 FORESEEN USE OF RF BANDS

7.4.1 Frequency bands below 10 GHz

Intention to continue using frequency ranges below 10 GHz was expressed by most responding administrations, substantial stability of number of existing links is expected by several of them, or even a small reduction, possibly related to the adoption of wider channel for active links.

Generic information on a continuity of use or moderate increase of use has been provided by other responding administration mainly to accommodate the high capacity connectivity requirements between point of concentration sites (Ireland), especially in rural areas where optical fibre is not available, and the inter-site distance is large (Türkiye), need for high backhaul capacities for IMT services in rural areas (Sweden).

Increase of channel BW and capacity was mentioned by several responding administrations, while some of them expressed expectation for a possible reduction.

Use channel BW to 56 MHz has been mentioned, as well as possibility of link aggregation of 7/8 GHz together with 18/23 GHz with 112/224 MHz channels in case of congestion (Sweden), possible reduction of number of links was reported in this case by one responding administration (Cyprus)

XPIC and/or high order modulations have also been reported by some respondents, including Malta, Moldova, Romania and Slovenia.

Increasing demand for security backbone networks was mentioned by one responding administration (Switzerland).

Presence of SDH links have been reported by one responding administration (Austria).

Expectation was expressed by Germany that on the long term the lower frequency ranges could become less import due to growing infrastructure of fibre optics.

7.4.1.1 Below 3.4 GHz

Few information has been provided and low use is reported, without particular interest for the future few years above 2021.

One responding administration (Ireland) expressed plan to use and monitor existing links for applications already in use (probably till 2023), military use was noted by one responding administration.

Reduction of use was reported by one responding administration (Norway).

One responding administration declared that 2 GHz band is not used (Hungary).

The 1.4 GHz band (1350-1374.5 MHz and 1498.5-1517 MHz) is no longer available for new fixed wireless links or technical variations in some administrations (United Kingdom). This is for the introduction of mobile.

7.4.1.2 3.4-4.2 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 Decision (07)02 [32] and EC Decision 2008/411/EC [33] and 2014/276/EU [34].

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 Decision (11)06) [66] 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 Decision (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.

Use for MFCN have been announced by one responding administration (Serbia), specific use and assignment to BWA (WiMAX) till 2013 are present in Italy, where LTE and 5G will be allowed after 2013.

Possible reallocation of band 3.6 to MS was indicated by one responding administration (Slovak Republic), where IMT is deployed gradually. The Slovak Republic also intends to use the band 3.8-4.2 GHz for MFCN as well.

Information that 3400-3800 MHz band is not used for FS anymore, due to the 5G mobile applications, is indicated by one responding administration (Hungary).

Use of band 3.6-4.2 GHz only for 5G is indicated by one responding administration (Germany) where decrease of use of 3.8-4.2 band is also expected, due to growing infrastructure of fibre optics or local mobile use in the band (Hungary).One responding administration is going to reallocate 3.6 GHz the band to mobile (Slovak Republic), while another respondent notes that migration of some fixed links from the band 3.6-3.8 GHz to the band 3.8-4.2 GHz was undertaken (RAI, Italy).

7.4.1.3 6-7 GHz

An increase in number of P-P links in 6_GHz bands for long haul links in rural areas is expected by some responding administrations (including Bulgaria), and an increased use of P-P links in 6 GHz bands, mostly associated with the increase in the capacity, channel BW, use of higher-order modulation is also expected by one responding administration (Serbia).

Increased use of 6L due to congestion of 6U was indicated as possible by one responding administration (Finland).

Other views on possible trend of increase of use have also been expressed, showing no expectation of growth by some responding administrations (including Hungary), or possible reduction of number of links in 5925 - 6425 MHz, as it is foreseen by other responding administrations (including Germany, Norway, France, Slovenia). This possible reduction could be justified by the introduction of RLAN, IMT or sharing with other Services.

Possible reduction of use in 6.4 to 7.1 GHz is also mentioned by some respondents (Bosnia and Herzegovina, Slovenia, Germany for 6.8 GHz as well as Huawei). A possible decrease of link number associated mainly to links using narrow channels (28 MHz) is expected by Germany.

Increase of number of channels on existing links, possibly using both polarisations, is expected by one responding administration (France), while others inform about the interest for the availability of 56 MHz channel BW in 7 and 8 GHz bands (Finland and Sweden).

Expected use of 6.4-7.1 GHz for IMT is indicated by some responding administrations (including Germany, Italy, Slovak republic), possibly with a transition period. It is also noted that in same band, in Italy there is use of FS for radio/TV broadcasting.

Possibility of use of 7/8 GHz together with 18/23 GHz, in case of congestion, is expressed by one responding administration (Sweden).

Same responding administrations noted that the introduction of sharing between FS and WAS / RLAN in the L6 GHz, and initiation of studies for possible sharing with WAS/RLAN or IMT also in the U6 GHz, leads to FS operator uncertainty and unwillingness to invest in the L6 / U6 GHz bands. If the 6 GHz frequency bands will not be used for FS this may lead to lack of spectrum for long distance radio link.

In the administrative domain of one responding administration, some frequency bands in the 6425-8500 MHz range are used for non-civil applications.

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 (06)04 [57] and ETSI EN 302 502 [58]. 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.

7.4.2 Frequency bands from 10 to 26 GHz

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 commercialisation of new infrastructures in multipoint technology in these frequencies.

Several widely used frequency bands with different characteristics are included in this frequency range, which was noted by one responding administration as being a dynamic frequency range (the Netherlands).

Expectation of increased use of some of these frequency range, especially improving spectral efficiency, was indicated by several answering administrations, increasing modulations index and channel bandwidths (Moldova, Sweden, Austria, Slovenia and Croatia), capacity (Türkiye), adopting wide channels (Sweden, France, Italy, Czech Republic and Malta), XPIC (Malta and Slovenia) and /or using combination of them.

Possible increase of use of some sub-band due to future use of IMT, also in rural/semirural areas, was identified by several responding administrations (including some frequency range above 26 GHz) (Sweden and Hungary).

The number of links may increase or is considered stable, depending on Administrations (including Slovenia and Italy) and frequency bands, but in any case, more efficiency is required by most respondents.

Provision of backhaul for 5G has been indicated and need for high traffic have also been noted; continuation of use of this RF range for other sectors besides the mobile sector (such as water/ energy/ broadcasting) is noted by one respondent (Sweden).

BCA use has also been indicated by several answering administrations, with the E-band or 7/8 GHz.

The use of this frequency range for long and medium distances in urban and rural areas is noted by one answering administration (Türkiye), use for last mile is also addressed by others (Austria), as well as public services and TV (RAI, Italy).

Very high demand for co-use by FSS is reported by one responding administration (Switzerland) in parts of this frequency range.

Wide channels recently adopted by CEPT in some frequency bands are increasingly used or requested by several administrations. It is noted by one responding administrations (the Netherlands) that replacement of existing channels with wide channels in order to support 5G backhaul, reducing the number of available channels, could lead to scarcity of available frequencies, in more densely populated areas.

Some responding administrations note that the request for low channels in RF bands where wide channels are available is decreasing.

Use or requests for high modulations (2048 and 4096 QAM) are reported by three responding administrations (Austria, Czech Republic and Sweden).

Congestion in some sub bands has been noted by some answering administration (including Italy).

7.4.2.1 10-10.7 GHz

This band has been mentioned by some responding administrations (including Hungary, Italy) for a possible increase of use. In addition, regional licenses are used (Türkiye).

One responding administrations declares that frequent use of unidirectional links for TV uses are allowed (Hungary).

7.4.2.2 10.7-11.7 GHz

A possible increase of use is expected by two responding administrations Serbia, France, which also indicates possible use of 80 MHz channels.

One responding administrations (Hungary) informs that a minimum antenna gain of 40 dBi is required, in order to minimise the possible interference between FS and to satellite Earth stations. Also info is given that the use of 80 MHz channel BW is allowed and that the band is only partly congested.

Another responding administrations (Germany) informs that no FS licenses are given because of Astra Sat.

Coexistence issues with satellites in populated areas are also noted in Italy.

7.4.2.3 13 (12.75-13.25) GHz

An intensive use of the band is noted by some responding administration (Hungary and Ireland).

Increased use is expected by some responding administrations (Serbia, Finland, Türkiye, Bosnia and Herzegovina and limited in the Netherlands)

Possibility of some congested areas for 13 GHz band due to the using of wider channels (56 MHz) is foreseen by Bulgaria, while congestion is already experienced or expected by four administrations (Germany, Italy, Serbia and Türkiye).

Individual licenses for FS have been confirmed in one responding administrations (Sweden), where there is a market demand for wide channels also in this RF band.

Request for wide channels is reported by one responding administration (Sweden), while possible use for last mile and mobile backhaul in noted by another (Austria).

56 MHz channels are or will be available in short time in the administrative domains of some responding administration (Austria, Finland and France), while their use is becoming more relevant in Germany.

In Ireland, the band was closed due to heavy use in some areas and its reopening for new FS links is under decision.

7.4.2.4 15 (14.5-14.62 and 15.23-15.35) GHz

An intensive use of the band is noted by Ireland, where it was closed due to heavy use in some areas and its reopening for new FS links is under decision.

Increase of use is expected (Serbia), decrease or stability in number of links was indicated by some responding administrations (Hungary, Germany and Sweden).

Request for wide channels is reported by one responding administration (Sweden).

In Germany, the 14 GHz band is the most relevant (14.25-14.5 GHz band is reserved for PPDR applications) while in 15 GHz band a reduction of use is expected.

Individual licenses for FS have been confirmed in one responding administrations (Sweden).

Congestion is experienced by some respondents (Türkiye and TIM-Italy)

7.4.2.5 18 (17.7-19.7) GHz

Increase of use is expected by some responding countries (Serbia, Slovenia, Hungary, the Netherlands, Bosnia and Herzegovina), intense use is noted in some respondents (including Hungary).

Decrease or stability of number of links was indicated by one responding administration (Sweden), while the channel size (CS) is expected to increase significantly and typically be close to the maximum channel size available, thus increasing the overall spectrum use of the band.

Possible future higher usage of spectrum due the migration from 26 GHz band for the introduction of IMT in same areas is expected by some answering administrations (including Sweden).

Requests from customers for channels widening to 110/220 MHz is reported by three answering administrations (Finland, Austria and Germany).

Multiple band applications have been noted by some responding administrations with E-band (Sweden, the Netherlands), to offer both high capacity to support 5G backbone and robustness to heavy rain influences, or with or 7/8 GHz (Sweden).

It is noted by some respondents (including Sweden), that the overall number of links may not increase, but the channel BW should increase.

110 MHz channels are or will be available in short time in the administrative domains of some responding administration (Finland, Hungary), where they are replacing 55 MHz Channels; use of 110 MHz channels is becoming more relevant in Germany, with stable number of links, 220 channels BW are available in Italy and Sweden.

Individual licenses for FS have been confirmed by one responding administration (Sweden), use by for TV exists in Italy.

Some congestion, or partial congestion, is experienced on the band by at least two respondents (Germany, TIM-Italy).

7.4.2.6 21-23 GHz

Intense use is noted in one Country (Hungary), the high importance of this band for mobile backhaul is specifically indicated by the Netherlands.

Increase of use is expected by some responding administrations (Bosnia and Herzegovina, Germany for 56/110 MHz BW, Hungary, Serbia and Türkiye); stability is expected by other responding administrations (Slovak Republic), future use is planned in Austria.

Possible future higher usage of spectrum due the migration from 26 GHz band for the introduction of IMT in same geographical is expected by some answering administrations (Hungary, the Netherlands, Sweden).

Widening channel BW, even up to 224 MHz, is reported by some responding administrations (Austria, France, Finland, Germany, Italy, the Netherlands and Slovenia).

Use of the band for long and medium distances in urban and rural is noted by Türkiye.

It is noted by some respondents (including Sweden), that the overall number of links may not increase, but the channel BW should increase.

Individual licenses for FS have been confirmed in one responding administrations (Sweden).

Carrier aggregation with 7/8 GHz (Sweden) or E-band (the Netherlands and Sweden).

Some congestion, or partial congestion, is experienced on the band by some respondents (Germany, Hungary, TIM-Italy); intense use is reported by some responding administrations.

A number of responding administrations (including Hungary and the Netherlands) indicate that the band is one of the main bands to support backbone capacity for public networks, especially in not congested areas).

7.4.2.7 26 GHz

Intense use up to now of the band for FS is noted by some responding administrations (including Ireland, where P-P licenses expire in 2028). Possible evaluations upon future use are indicated (Italy, Sweden and Cyprus).

Individual licenses for FS have been confirmed in one responding administrations (Sweden).

No particular use of P-MP is declared by respondents (no harmonisation of the band is noted by Slovak Republic, no new licenses in Germany).

Block licensing regime is used in band 24.5-26.5 GHz by a responding administration (Hungary), where links can be migrated by other congested bands; current FS licenses will be retained till they expire, at that point the operators will decide when they intend to introduce mobile applications in the band, if the unused spectrum portion of the extended range of 26 GHz is not sufficient for such use.

This band has been allocated to 5G applications for next years, and is already open in some countries, so some existing links in this band will need to be reallocated to other frequency bands, with times and methods according to the decision of national administrations. Till complete migration, the band will be shared with FS in many administrations, with decreasing FS use and growth of mobile.

Also due to this need, future reduction of use for FS in this RF band is expected by a large number of responding administrations (including Bosnia and Herzegovina, Germany, Hungary, Italy, the Netherlands, Norway, Serbia, Slovenia, Sweden and Türkiye). Migration of current FS links in operation to other bands are indicated by several respondents.

Potential adjacent channel co-existence issues with IMT in the 26 GHz band are under study in Sweden, with possible increase of use of FS in other bands.

Request for 56 MHz channels has been noted by some answering administrations.

The 26 GHz (24.5-26.5 GHz) band has been recently closed in the UK to new Fixed link applications and technical variations. This is in preparation for the introduction of mobile 5G.

7.4.3 Bands from 26 to 50 GHz

The importance of this frequency range for backhaul is confirmed by some responding administrations, (including Malta, Cyprus and Romania) who foresee an increase of use, with support of technical available options, such as wide channels, high modulations, XPIC (Croatia, Czech Republic, France, Germany, Malta, Moldova, the Netherlands, Norway, Slovenia and Sweden).

Other Admins foresee a possible use reduction of some sub-bands (Sweden and Austria).

Use of parts of this frequency range by FSS was noted by two responding administration (Switzerland and Czech Republic).

Information that the adoption of high order modulations (2048 QAM and higher) as reference is used by some operator, for frequencies below 38 GHz, is provided by some responding administration (Austria and Sweden).

Support of Carrier aggregation is also expected in this frequency range, even with wide channels (Czech Republic).

7.4.3.1 28 GHz

Heavy use of the band is indicated by some respondent (TIM-Italy), no designation for FS is available in Hungary.

Possible increment of use of the band is foreseen by five administrations (Bulgaria, Italy, the Netherlands, Malta and Sweden); increasing demand for the 112 and 224 MHz channels is noted by one responding administration (Sweden), who also informs about a possible use of the band by other users and a possible reduction of number of FS links.

The band has been indicated for possible migration of FS links from 26 GHz band, due to IMT allocation, by some answering administration (the Netherlands and Germany).

Possibility to extend the use of WLL till 2029 is under consideration by one responding administration where 224 MHz channels are available (Italy), and where a check on the use may be carried on in future.

Recent opening for FS (shared with FSS) was done by Czech Republic, possible opening of band 27.5 - 29.5 GHz (or 31.8-33.4 GHz) for migration of links from the frequency band 24.5-26.5 GHz is under study in one responding administration (Serbia).

The band is open to all applications after 2021, when just mobile use was allowed, in another responding administration (Germany), where 112/224 MHz channels are allowed, the requests for 28 MHz channels are decreasing.

Possible use of this band for backhaul due to migration from the 26 GHz is indicated by the Netherlands.

National licenses for FS have been confirmed in one responding administrations till end of 2024 (Sweden).

Use of the E-band to replace FS applications in this frequency bands is reported by one responding administration (Finland).

Possible multi-band applications using this band in combination with the 80-90 GHz are considered by one answering administration (the Netherlands), to support backbone capacity for public networks.

Use of frequency block allocation is noted in Slovak Republic for the 29 GHz band, with licenses valid till 2026, and no expectation exists for significant increase of FS use.

7.4.3.2 32 GHz

Use of this band by FS is indicated by respondents (the Netherlands, Slovak Republic, Sweden, TIM-Italy); with some possibility or limited expectation for growth.

Such concepts are also noted by one responding administration, with possible increase due to migration of systems currently in 24-26 GHz (Slovenia), a possible opening of band 31.8-33.4 GHz (or 27.5-29.5 GHz) for migration of links from the frequency band 24.5-26.5 GHz is under study in one responding administration (Serbia).

Individual licenses for FS have been confirmed by one responding administrations (Sweden).

Another responding administration (Germany) allows 112/224 MHz channels; expectation of growth exists, limited to 112/224 MHz channels.

Recent increase of use was indicated by one administration (Slovak Republic).

The band has been indicated for possible migration of FS links from 26 GHz, due to IMT allocation, band by some answering administration (Hungary and Germany).

Use of the E-band to replace FS applications in this frequency bands is reported by one responding administration (Finland).

Wider channels are also expected to be made available by some responding administrations (including the Netherlands); in Italy, 224 MHz channels are allowed.

7.4.3.3 38 GHz

Confirmation of use of this frequency range for FS is given by some respondents (Hungary, the Netherlands, Serbia, Slovak Republic as well as TIM-Italy).

Possible increment of use is foreseen by some responding administrations (Bulgaria, Hungary, Italy, Serbia and Bosnia and Herzegovina), possible replacement by E-band is indicated by one responding administration (Finland).

One responding administration (Sweden) noted that possible reduction of use might happen when the mobile 3G networks are taken out of service.

Individual licenses for FS have been confirmed as still being active in one responding administrations (Sweden).

Recent increase was indicated by one administration (Slovak Republic).

One responding administration (Germany) expressed an expectation of growth for 112 MHz channels, stable interest for 56 MHz, decrease for 28 MHz channels; same administration foresees use of modulations higher than 512 in future.

Wider channels are expected by one administration (the Netherlands).

7.4.3.4 40 GHz

Monitoring of the situation is reported by one administration (Ireland), FS use is reported by one administration, with possible decrease for IMT (Italy). Also, a reduction is expected in Germany.

7.4.3.5 40- 60 GHz

42 GHz frequency band, originally designated for exclusive Multimedia Wireless Systems (MWS) use (ERC Decision (99)15 [69]) in 2009, was not exploited anywhere in Europe. 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.

Difficulty to provide links with high reliability was expressed by one Administration (Hungary), together with an indication of no use of 49 GHz, 52 GHz, 56 GHz and 58 GHz bands.

7.4.4 Frequency bands above 50 GHz

In 2016, ECC approved “CEPT roadmap for 5G” [82], 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.

In the 57-66 GHz band, one responding administration expects an increase of use, as it seems to be an attractive alternative frequency range for providers (Slovak Republic).

The 71-76 GHz band, associated with the 81-86 GHz, experienced a very fast growth from the previous revision of this Report, and the use is expected to continue with a significant growth in the next years.

7.4.4.1 60-70 GHz

In some administrations, this frequency range is under study (Italy).

Information is given by one responding administration (Italy) that the 57-71 GHz frequency band is identified for wideband data transmission systems operating on a non-interference basis (required not to produce harmful interference) according to provisions in ERC Recommendation 70-03, annex 3 [55].

7.4.4.2 71-76 and 81-86 GHz (so called E-band)

Most Administrations foresee a significant increase of Fixed Service links; use for backhaul is indicated by (Bulgaria, Austria, Norway, Switzerland, IMT service for urban/suburban areas (Sweden).

Stable situation is expected by two administrations (Azerbaijan and Italy).

RF channels up to 2000 MHz are indicated to be possible by some administrations (Austria, Italy), increase of channel BW, modulations, capacity have also been indicated (Romania, Slovenia, France, the Netherlands and Germany).

Use of E-band as part of multi band applications was also noted (Czech Republic).

In Italy, these frequency bands can be used for both point-to-point or point-to-multipoint fixed links. Channels may be used to form either TDD or FDD systems and, when extremely high bit rate system is required, a flexible aggregation of those 250 MHz basic channels for composing wider channels may be allowed.

7.4.4.3 92-114.25 GHz (so-called W-band)

A situation of monitoring was declared by some administrations (Ireland), and expectation of use is possible for some administrations especially for cases where E-band is becoming congested (Türkiye), or a possible additional alternative to E-band itself (Sweden and Italy).

No expectation of use in next years was provided by (Serbia), possibility of limited increase of use in next 5 years is indicated by four administations (Austria, Norway, Cyprus and Croatia).

Unavailability of equipment was noted, as well as lack of requests from operators in 2021.

7.4.4.4 130-174.8 GHz (so-called D-band)

Answers from administrations are quite similar to the ones submitted for the W-band, with similar expectations in term of possible use and provision of equipment.

Ned of wide channels, in the order of 2000 MHz, for future high capacity mobile related applications, has been expressed (Austria)

The foreseen important potentiality for this band to convey very high capacity (in the order of 100 Mbit/s per connection) by grouping multiple 250 MHz channels, with MIMO implementation, was noted by some respondents. Possible trial activity is expected by Türkiye.

7.4.4.5 Frequencies higher than 175 GHz

No indications of effective use or requests have been provided by responding administrations, only the indications of first studies, and activities of research and development have been provided by manufacturers. Possibility to provide sufficient capacity for next generation wireless and FWA has been indicated.

7.4.5 Congestion

Congestion can arise as long as the density of applications in some band increases. A specific question was addressed in 2021 to CEPT members.

The interpretation of the term is dependent on each administration, since no widely used definition is available; some indications have been provided by respondents:

- Condition where less than 20% channels are free (Serbia);
- No available frequency resource to establish connectivity (Croatia);
- No new license possible due to interference calculation (Germany);
- Difficulties in finding free channels, no new license possible due to interference calculation (Germany);
- Definition depends on various factors (Italy, topology-environment- length).

Concerning congestion, it was noted by some 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.

It was further noted by one responding administration that congestion in point to point links can occur mainly where operators seek the same or a similar link route on a particularly popular route. e.g. cross channel routes can be challenging in a number of the lower bands (United Kingdom).

Concerning current use, condition of congestion has been reported by responding administrations for following specific RF bands:

- 1.5 GHz band (Slovenia);
- 2400-2483.5 MHz – license exempt- in high urban areas (Serbia);
- 5470-5725 MHz and 5725-5875MHz – license exempt- in high urban areas (Serbia);
- 5.9-6.4, 6.4-7.1 GHz band (Bulgaria near the capital, Serbia, Cyprus, Switzerland);
- 6U (Finland and Slovenia);
- 8 GHz (Bosnia and Herzegovina, Cyprus till 12 GHz);
- Most RF bands below 10 GHz (Croatia);
- 13 GHz band (Serbia, Slovenia, Croatia, Hungary and Germany);
- 15 GHz (Austria and Slovenia);
- 18 GHz band (Austria, Croatia, Finland, Germany, Ireland, the Netherlands and Slovenia);
- RF bands below 20 GHz (France - some bands);
- 23 GHz band, (Austria, Croatia, Cyprus, Hungary, Germany, Ireland and Slovenia);
- 28 GHz (Slovenia);
- 38 GHz (Hungary and Germany);
- 80 GHz(Slovenia).

No congestion is reported by a number of responding administrations (Malta, Azerbaijan, Türkiye, Latvia, Romania and Slovak Republic).

Possible congestion due to the use of wide channels is mentioned by one responding administration, in 18, 23, and 32 GHz bands (Sweden).

Cohabitation issues with uses other than FS have been noted by one responding administration (France) for 11 GHz band (TV satellite), 18 GHz, 32 GHz (aeronautical).

High density use, which could give raise to some congestion in case of increase, are reported by some responding administrations in following RF bands:

- 10-13, 18 GHz, 80 GHz (Switzerland);
- 18 and 23 GHz bands by (Italy and Croatia).

8 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.

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.

8.1 DEVELOPMENT OF FS BETWEEN 2001 AND 2021

A comparison of the data recorded in 2001 with those derived from the questionnaires after 2001 allows an evaluation of the overall FS developments between 2001 and 2021. 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 4 of Chapter 3 are representative of 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 experienced the highest positive growth, apart the 71-86 GHz band, which showed a very fast increase since 2016 are shown in Figure 18 (normalised to 1997 data) and Figure 19.

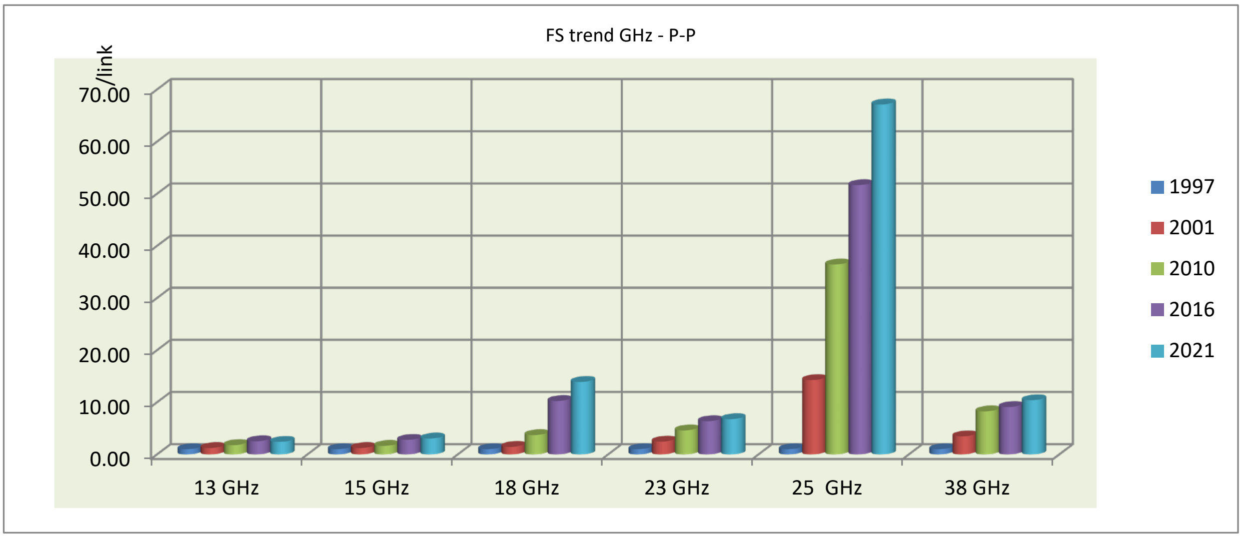


Figure 18: Historical (normalised to 1 link in 1997) trends for P-P links in CEPT in frequency bands which showed the highest FS growth between 1997 and 2021 (P-P only)

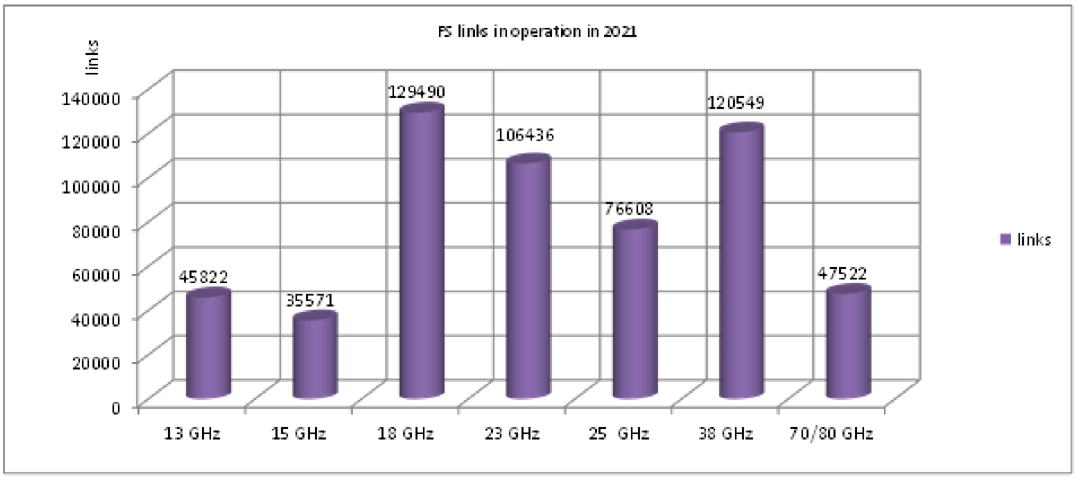


Figure 19: Active P-P links in 2021 declared by responding administrations in frequency bands which showed the highest FS growth since 1997

It is to be noted that Figure 18 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 10.0-10.68 GHz had a negative trend in the period 1997-2001, after that it experienced an 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.).

8.2 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 [2].

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 20 show the number of CEPT administrations committing or planning to commit to ERC/ECC Decisions addressing specific frequency bands, which are most relevant for the planning of FS services. These data are based on the ECO implementation records, as valid for 2022. In Figure 23, the implementation status, expressed as number of countries, throughout CEPT, for RF channels with bandwidth of about 14 MHz and higher are shown for some of most used frequency bands.

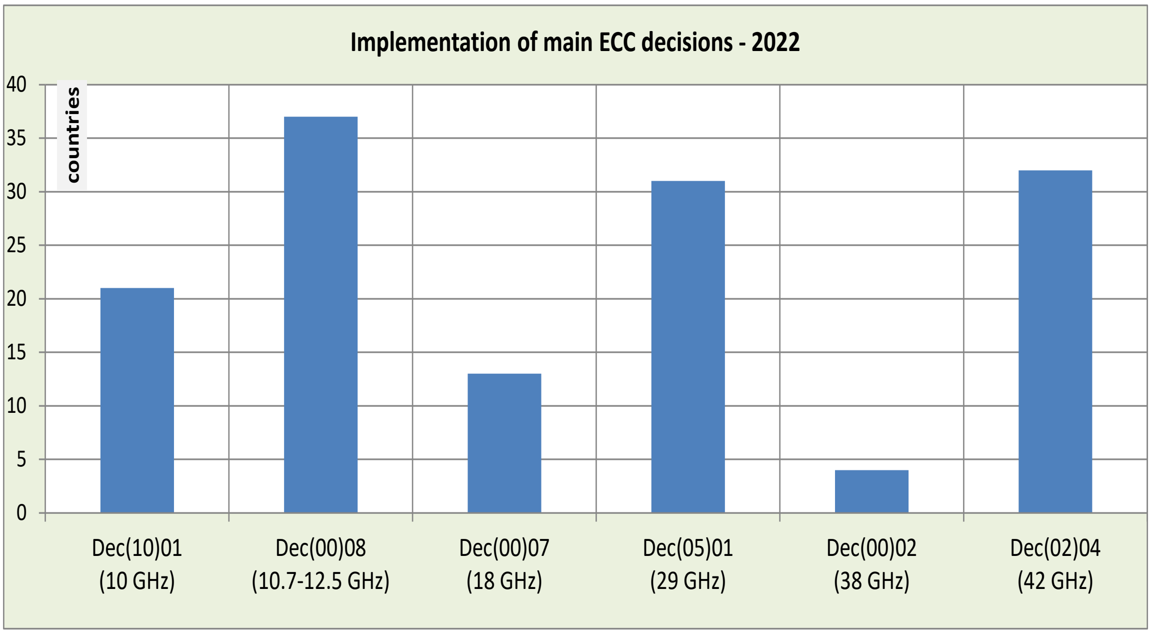


Figure 20: Implementation of some major ERC/ECC Decisions in the field of FS as of November 2022 (source: http://test.ecodocdb.dk/docdb)

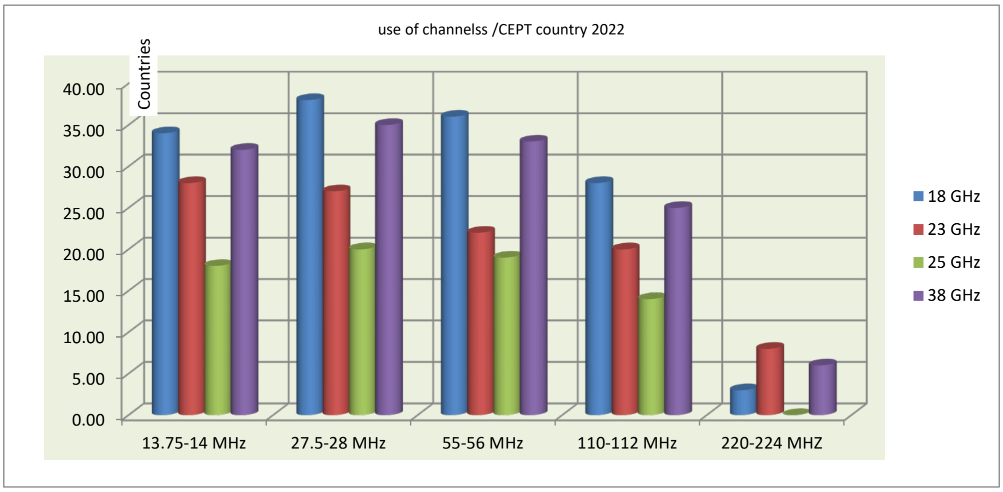


Figure 21: Statistics of number of countries implementing channel bandwidth of at least 13.75 MHz for some most used frequency bands)

8.3 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).

The diagrams in the following paragraphs report the number of links declared in operation at the date of publication of current revision of the Report, 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.

8.3.1 Number of active links for each band

Figure 22 and Figure 23 show the number of active links for each specific frequency band.

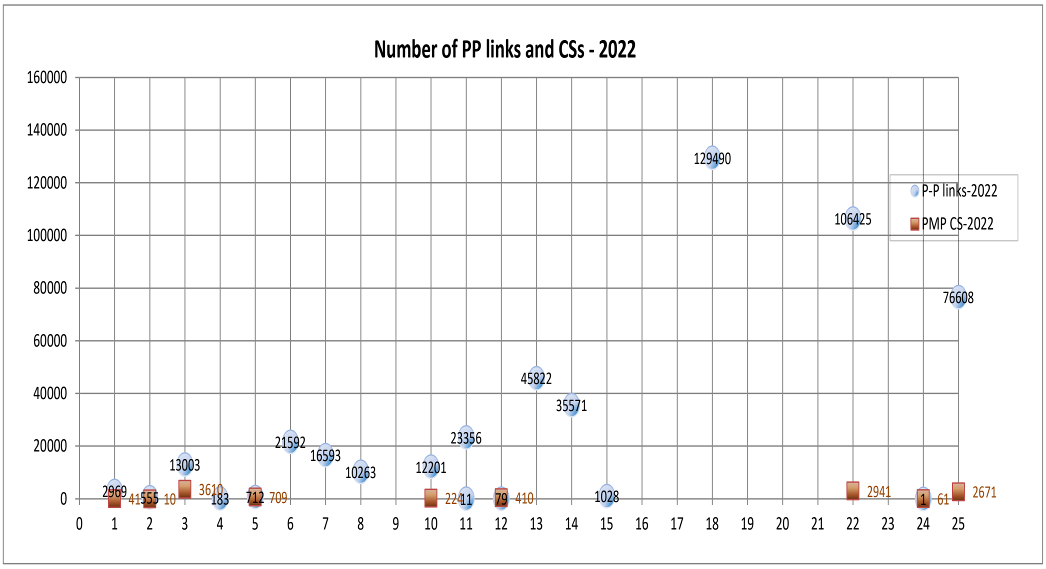


Figure 22: Distribution of links for the frequency bands from 0 to 25 GHz

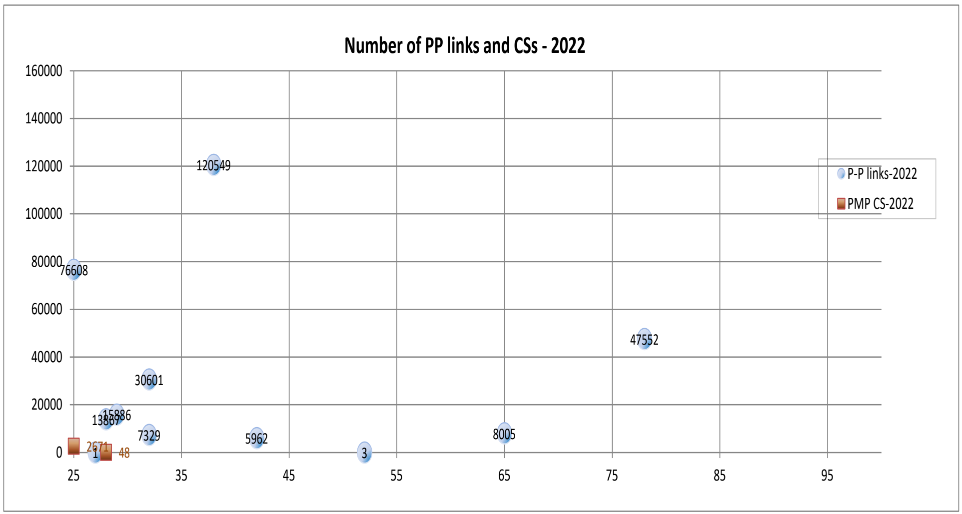
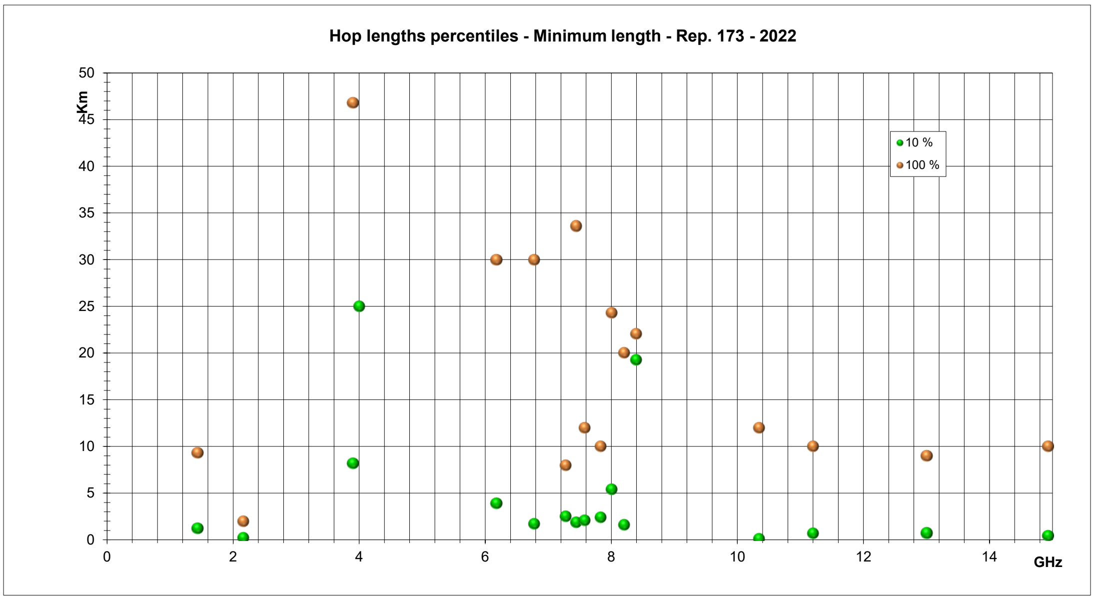


Figure 23: Distribution of links for the frequency bands from 25 to 105 GHz

8.3.2 Hop length distribution

Figure 24, Figure 25 and Figure 26 show the 10 and 100 percentiles of hop length, in the overall used frequency range.

Figures have been drawn for the hop lengths defined as minimum, typical, maximum from responding administrations.



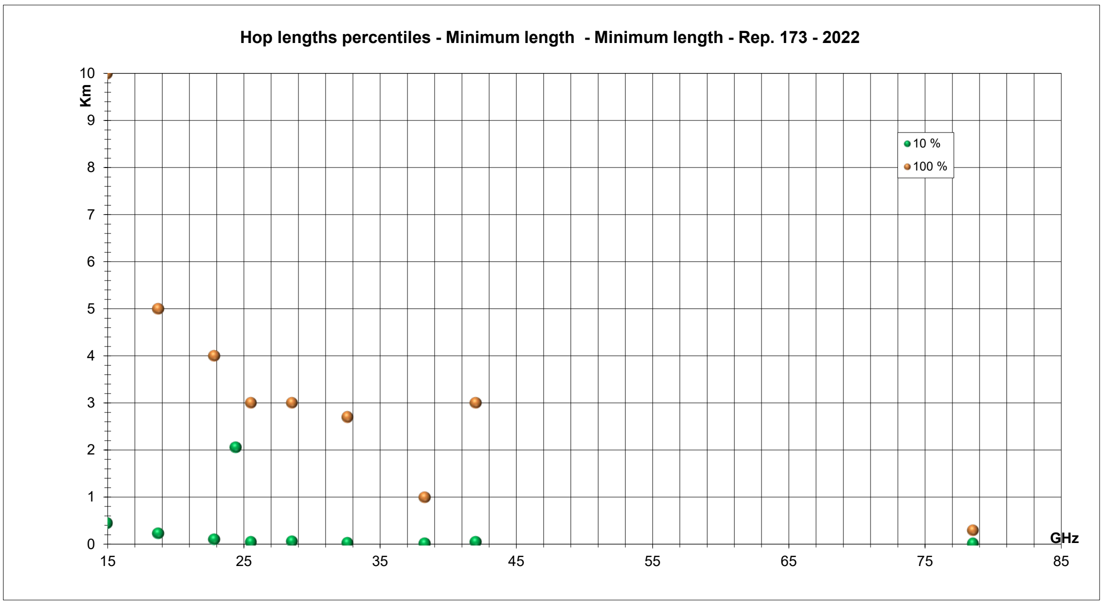
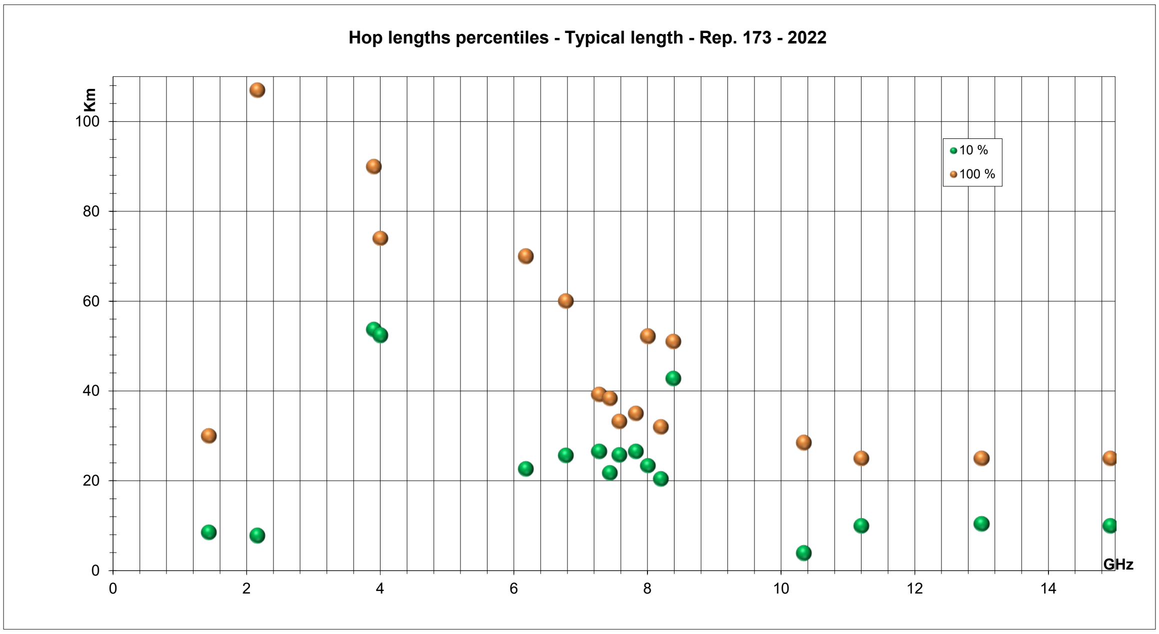


Figure 24: Hop length percentile for frequency bands from 0-15 GHz and 15-80 GHz (Distribution of hop length defined as “Minimum” by CEPT responding administrations)



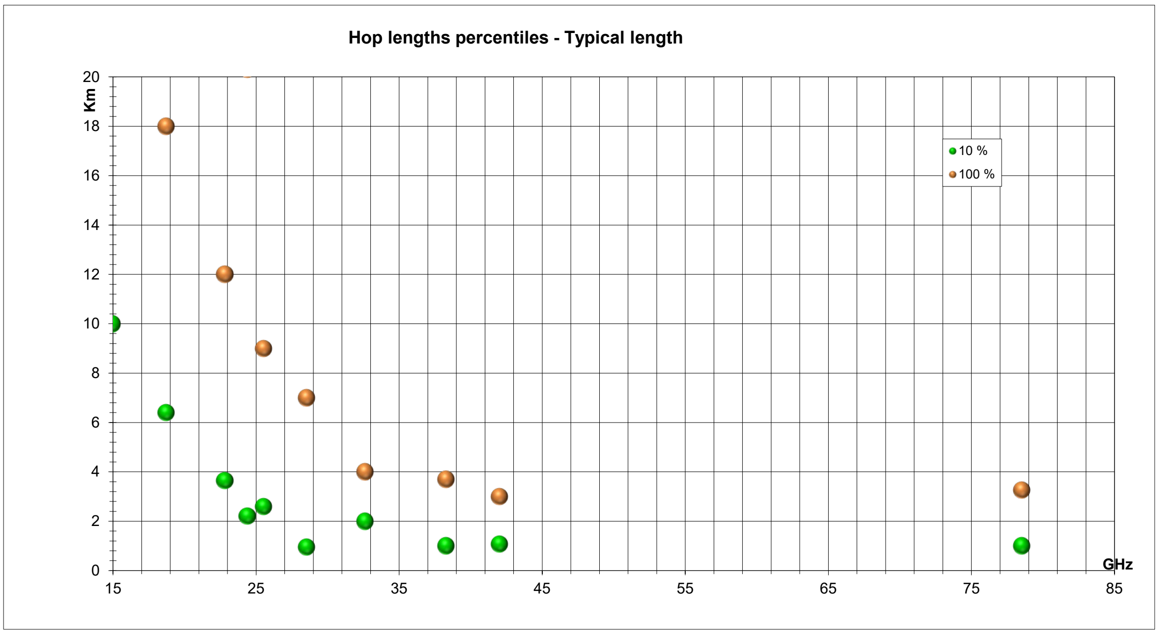
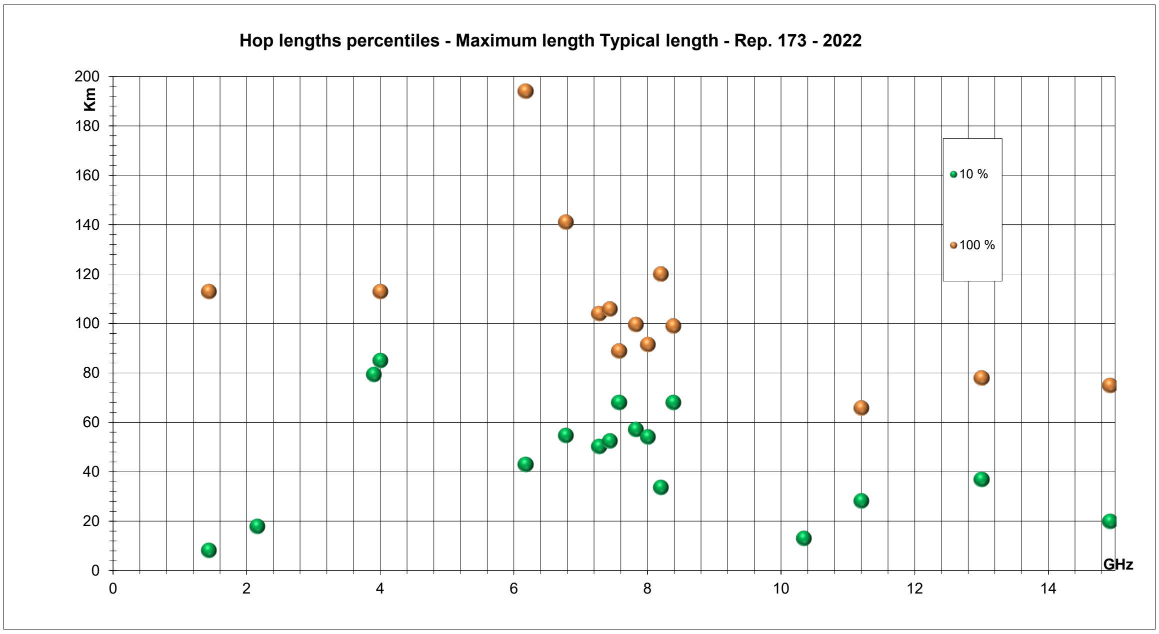


Figure 25: Hop length percentiles for frequency bands from 0-15 GHz and 15- 80 GHz (Distribution of hop length defined as "Typical" by CEPT responding administrations)



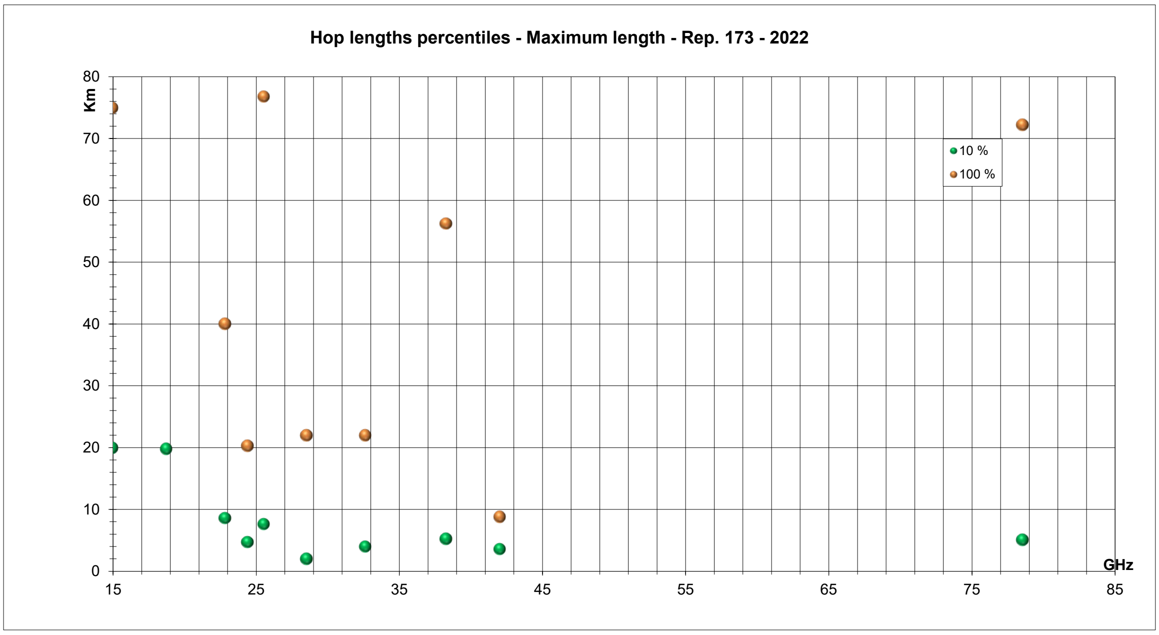


Figure 26: Hop length percentiles for frequency bands from 0-15 GHz and 15-80 GHz (Distribution of hop length defined as "Maximum" by CEPT responding administrations)

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 value closest to the (X,Y) point.

The upper points for each frequency have probability as high as 1.

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.

8.4 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.)

8.4.1 Long-haul trunk/backbone networks

As reported in the 2002 in the ECC Report 3 [1], 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 8.4.2) 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.

8.4.2 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.

8.4.3 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 Decision (07)02) [32].

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 ERC Decision (99)15 [69] which were revised in 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.

8.5 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.

Need for high capacity system is indicated by most respondents.

Capacity range from 1 to 10 Gbps is expected, requiring proper technological capabilities: wider channel bandwidth (up to 224 MHz), adaptive modulation, higher order modulation (up to 4096 QAM), XPIC have been mentioned by a very high percentage of answers.

MIMO and ATPC are also noted. Possibility of use of multiband solutions, adopting two different radio streams on same frequency, with one stream at much higher frequency range than the other (example: E-band + 18/23 GHz), such as the Band and Channel aggregation (BCA) has been indicated to offer challenging peak throughput and high capacity.

Line of Sight (LOS) links are required, Non Line of Sight (NLOS) is also mentioned.

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.

8.6 BANDS STRATEGY AND TRENDS

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

The answers to 2021 questionnaire on FS use confirm the need to achieve the high capacity required by 5G backhaul, but also to continue the uses currently supported by FS.

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:

- Bands traditionally used by FS , currently used for applications such as backbone and long distance links, for rural coverage, in particular bands lower than 18 GHz will retain their strategical relevance, also for important infrastructure needs, backhaul of mobile network, provision of services for power related uses (electricity, oil etc.), They are also important for high capacity in rural areas, and to relieve existing congestion in certain bands (e.g. 38 GHz);

The introduction of 5G in previously used FS bands, such as the 26 GHz, will imply migration of several FS applications to other bands, which then could become strategically important in the next few years following 2021. In some countries, sharing between MS and FS will be considered, at least in the transition period, since the introduction of 5G migration could require few years to be completed, also waiting the expiration of FS licences already active.

- E-band (71-76 GHz/81-86 GHz) has grown fast in last years and is considered to be strategically important due to the potential for high capacity dense networks for small cell backhaul. Use of this band to improve transport capability by means of aggregation with lower bands (BCA) is expected to increase. Flexible channelling and low cost licensing are particular benefits;
- The possible use of W-bands and D-bands for mobile backhaul, including rural and suburban areas, was envisaged by some administrations, but on a longer time bases.
- Unlicensed or Light licensed bands are expected to become increasingly important.

It is also noted that not every frequency band assigned to FS in 24-50 GHz range, 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.

Importance of bands which may became shared with other services or are subject to change of radiocommunication service were also mentioned, within the bands that are expected to become strategically important. Among them, 3400-3800 MHz, 6L band and some higher frequency bands (18-32 GHz) necessary to assist the transition of 24.5-26 GHz for 5G in near future, have been indicated by many administrations.

Some bands have been generically indicated to be still considered important for backbone networks and long distances by some administrations, and indications regarding continuation of FS use in next years have been given regarding wide frequency bands, as follows:

- One responding administration (Czech Republic) reminds that all bands above 1 GHz are heavily used and remain important;
- Bands 6-8 GHz will continue to be important for long distance links where optical fibre is not a viable solution (Sweden);
- RF bands <10 GHz are indicated by three responding administration (Finland, Türkiye and Croatia), for their characteristics to allow long links, even for rural deployment;
- 10-12 GHz band was indicated for mobile backhaul by one administration (Austria);

- RF bands below 13 GHz have been declared important for long distance in rural areas by one administration (Norway);
- RF bands below 17 GHz for long distance rural have been indicated by one answering administration (Moldova), while all bands above 17 GHz have been referred to by another (Germany) due to availability of wide channels;
- RF bands 11 to 18 GHz are assumed to retain their importance, due to good combination of channel widths and number of channels by one administration (France);
- Frequency bands 11 to 23 GHz are reported to be expected to retain their relevance as most used frequency bands for FS by Ireland;
- RF bands above 30 GHz are indicated to become more and more important for FS (Romania);
- One responding administration (Sweden) noted that the use of the bands between 18 to 50 GHz, capable to provide 112/224 MHz, will probably be increased, for urban/suburban use;
- RF bands between 50 and 100 GHz for 5G rollout (Cyprus).

Other more specific bands, narrower frequency ranges have also been directly indicated by one or more respondents due to their future importance for improved use, including possible migrations of links from frequency bands to be used for 5G /MFCN. They are provided as follows:

- 3400-3800 MHz band is expected to possibly become important after introduction of 5G (Serbia);
- 6L band was reported to be important due to migration from 6U (Bosnia and Herzegovina);
- 5925-7725 MHz bands was noted by two administrations (Serbia and Sweden);
- 13 GHz is indicated for governmental use by one responding administration (Switzerland), and is indicated to be growing fast by another (Serbia);
- 11 GHz is indicated to be heavily used and to remain strategically important by one responding administration, due to the good tradeoff between capacity and hop length (France, also for 18 GHz);
- 18 GHz band is confirmed to be the core band for FS, and remains important, for some answering administration (Finland, France), and it is indicated by other respondents (Sweden and Eolo-Italy), for urban / suburban connections, due to availability of wide channels, also for possible FS migration from 26/28 GHz;
- 23 GHz is mentioned by some respondents (the Netherlands and Huawei) as a possible band to be used for FS migration from 26 GHz; in addition one responding administration (Sweden), notes the possible use in urban /suburban use and increased importance due to availability of wide channels;
- 24.5-26 GHz (or 31.8-33.4 GHz) is indicated by one responding administration (Serbia) to be possibly used after 2026 for migration of links from 24.5-26.5 GHz; other respondent (Eolo-Italy) notes the possible strategical importance to enable the provision of high-capacity radio links in next future, due to wide channel bandwidth up to 224 MHz;
- 26 GHz: several responding administrations consider possible migration of existing FS links in this band to other bands, due to the foreseen future extensive use this band for 5G (Bosnia and Herzegovina, Czech Republic, France, Hungary, the Netherlands, Serbia, Sweden, Switzerland, United Kingdom);
- 28 GHz is indicated for migration of FS from 26 GHz to support back-bone capacity by some responding administration (the Netherlands, possibly Serbia), while another respondent (Eolo-Italy) notes the possible strategical importance to provide high-capacity radio links in next future, due to wide channel bandwidth up to 224 MHz. The appropriateness of this band to be used as one of the candidate bands for multi band applications with 80 GHz and higher bands are also noted (the Netherlands);
- 32 GHz is indicated by three administrations (France, Hungary and Serbia), for FS migration or also to be used as possible fallback solution for the shorter links initially foreseen in the 26 GHz, while another respondent (Eolo-Italy) notes some position expressed for the 28 GHz;
- 38 GHz is indicated by two responding administrations (Bosnia and Herzegovina and Ireland);
- 42 GHz a respondent (Eolo-Italy) presents the same position expressed for the 28 GHz;
- 60 GHz band may become important where fibre is not available (Türkiye);
- E-band (71-76 GHz/81-86 GHz) GHz band is indicated by some responding administrations (Austria, Bosnia and Herzegovina, France, Ireland, Italy, Malta, Moldova, Norway and Türkiye) and other respondents (including Huawei), as a higher capacity alternative to the realisation of new links in 38 GHz / 42 GHz bands;
- 80 GHz was indicated for backhauling mobile by Switzerland;

- W-bands and D-bands might become important in a longer time perspective (Austria, Türkiye and United Kingdom).

8.6.1 Frequency band selection criteria

Selection of a specific band to be used for FS applications implies the consideration of several factors, in relation with expected use, specific technical characteristics of equipment and RF band, regulatory and economical aspects.

Involvement of stakeholders is often a part of this process.

In some case, administrations leave users or licensees the freedom to propose a specific frequency band, but, before agreement, provide a guidance about a list of criteria to be taken into account, including minimum criteria, where applicable.

Evaluation of technical parameters has been indicated as an important factor for the selection of the proper RF band by several respondents (Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Finland, Ireland, Italy, Malta, Moldova, Norway, Romania, Slovenia, Sweden and Türkiye).

following parameters have been specifically indicated:

- Link length, (also in relation with geographical scenarios);
- Required capacity (high for mobile backhauling or limited);
- Channel spacing;
- Propagation;
- Error performance and objectives;
- Antenna characteristics (gain, size);
- Status of use of the band;
- Available channels;
- Band congestion.

Among technical factors, attention is also given to some installation constraints , such as tower locations, wind load, power supply, as it is noted by one responding administrations (Sweden).

The proper value of one or more parameters involved in these considerations are strongly dependent on specific needs and context; as an examples of such variability, it was specified that in some cases, link length is assigned as a minimum value in relation with geographical location; capacity considered for the assignment can also be subject to a widespread from case to case, since it can be quite high, in case mobile backhaul is required, or be accepted to be more limited, in other cases.

Economic factors, such as license fees and equipment and antenna costs, have also relevance in band selection, as specifically mentioned by some responding administrations (Austria, Italy, Moldova, Serbia, Slovenia and Türkiye).

Policy and licensing regime were also indicated by respondents to 2021 questionnaire among factors to be considered. (Austria, Italy, Romania and Slovenia).

Among regulatory aspects used to determine the possibility of use a specific RF band for FS, possible need to refarm bands already used by FS or to rearrange / move the FS frequencies to another portion of the spectrum due to coexistence problems with other services have been indicated by some administrations.

Finally, availability of proper technology is a fundamental element to consider.

8.7 LICENSING REGIMES

While most historically bands used by FS are mainly associated to the use of link-by-link licensing regime, other frequency ranges recently made available by the evolution of technology towards higher RF frequencies are under study to allow more flexible licensing regimes.

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 deemed 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 and antenna proper RPE) are standardised.

8.7.1 Band suitability for license exemption/block assignment

While the licensing appears well consolidated for traditional applications of the fixed service, the identification of the most appropriate regime to be used for emerging needs, mainly requiring the transfer of signals with much higher capacity than what has been required by most applications up to now, is under evaluation by several actors in the field of telecommunications.

One administration noted that that there is a request from market for block license with wide bandwidth (Norway).

Most administrations consider that the most appropriate bands to allow less stringent licensing regimes than the widely adopted individual licensing, such as the block license, or without license at all, can be identified within the higher frequency bands allocated to FS, typically including and exceeding the E-band, at least for block assignment.

Observation that license exemption is considered only for the frequency ranges where the absorption loss is high enough was offered by one administration (Germany).

Some responding administrations are open to consider bands in the range 20 to 30 GHz as possible lower frequency limit for this licensing regime, possibly under specific conditions.

Few indications have been given for use of this licensing regime in lower frequency bands.

8.7.1.1 Block assignment

Block assignment is in deemed applicable mostly to mid and high frequency ranges, when applied.

It was noted by one administration (Sweden) that block licenses are typically not wide enough to support the use of multiple wide channels (112/224 MHz) in the same geographical area. Another administration (Austria) noted that licensing regime is good when many links are used.

In particular, different views are expressed on frequency ranges to be subject to these simplified licensing regimes. Following cases have been addressed:

- Preference for block assignment as a general approach (Malta);
- RF bands above 5.9 GHz, on a non-exclusive basis, was indicated by one administration (Romania);

- 13 GHz band has been indicated by one answer (Eolo-Italy) to provide dedicated point-to-point services;
- 23-32 GHz band: block assignment is generally applied by one administration when spectrum usage rights can be gained through competitive procedure (Hungary);
- 26-71 GHz range is indicated by one administration (Türkiye);
- 40-43.5 GHz band is indicated for a possible auction by one administration (Norway);
- 71-76 and 81-86 GHz band is indicated by one administration (Türkiye);
- 80 GHz band is used with block assignments by one administration (Switzerland).

8.7.1.2 Light license or license exemption

Light license or license exemption have been in general deemed applicable to frequencies at or above 60 GHz from some administrations, although it was reminded that in some administrations the license exemption regime is not used (Romania, France and the Netherlands).

In particular, different views are expressed on frequency ranges to be subject to these simplified licensing regimes. Following cases have been addressed:

- RF bands above 20-30 GHz, scarcely used, can be suitable (Croatia);
- RF bands above 50 GHz are indicated by three administrations (Moldova, Germany and Czech Republic);
- 60 GHz band (V band) is deemed suitable for license exemption by some respondents to 2021 Questionnaire (Malta, Switzerland, TIM, Slovak Republic and Türkiye); light license is also used in one administration (Hungary); it was noted that this band does not guarantee QoS;
- RF band 71-76/81-86 GHz is already used on simplified licensing schemes (license exempted (Serbia) or light licensed(Hungary and Czech Republic));
- RF bands above 74 GHz are considered suitable for licence exemptions and block assignment by one administration (Latvia);
- RF band 90-130 GHz range possible for light licensing by two administrations (Norway and Türkiye);
- W-bands and D-bands are under examination by one administration (Ireland), for license exemption / block assignment (Finland and Austria);
- RF band 100-200 GHz is indicated for license exemption by one administration (Cyprus).

8.7.2 Stability of spectrum management/licensing approach

Review of FS licensing regime is expected by two administrations (Ireland and Norway) or deemed feasible in few years (Cyprus).

General authorisation is under evaluation in RF bands other than 57-66 GHz (Slovak Republic).

One administration consider the advantage of the adoption of block allocation in terms of time (Türkiye).

Evaluation of band use in relation with bands open to IMT use is also ongoing (Italy) Block allocation and a new fee approach is under study in some responding administrations (Austria).

Licensing for 40 and 86 GHz bands are under review (Malta).

Bands above 57 GHz will probably go under light licensing (Bosnia and Herzegovina).

Use of 60 GHz band is under consideration, due to recent standardisation activities in 57-71 GHz (Italy).

Some responding administrations do not see changes in short time (Latvia, Romania, Switzerland, Slovenia, Croatia, France, the Netherlands, Hungary and Germany), at least in short time (Czech Republic).

Contacts with stakeholder are held by some administrations, to detect any request and need in due time (Sweden, Romania and United Kingdom).

8.7.3 Coexistence/ Spectrum Sharing between FS backhaul and mobile access

Several administrations have no such experience or plan (Ireland, Malta, Bulgaria, Azerbaijan, Finland, France Türkiye, Austria, Norway, Cyprus, Romania, Switzerland as well as Bosnia and Herzegovina).

Others responding administrations have no experience at the moment (Slovenia and Croatia), or have very limited experience, with specific tests (Sweden) or studies.

Coexistence analyses have been made on some bands, based on I/N, leading to possibility of exclusion zones in areas where base stations cannot be installed around incumbents, or some restriction is necessary (Italy).

One responding administration notes that such sharing of FWS backhaul will complicate the mobile applications (Netherland), other noted that operators do not tend to mix two types of applications (Hungary).

In Italy, FS links in 3600-3800 MHz have been migrated, and 6.4-7.125 GHz band is under consideration.

One administration declared that in 3.8-4.2 and in 26 GHz bands sharing can be facilitated by a new shared license product (United Kingdom).

In the 6 GHz band, sharing between FS and 5G is considered (Germany), based on interference calculations on a link-by-link/area licence; for the 8 GHz, in same administration, medium/ long-term reallocation for 5G is foreseen with possible transition period for FS with sharing between both services.

For the 26 GHz band, some administration do not expect 5G till '26 (Serbia), and plan to migrate existing links (Serbia and Italy).

For the 26 GHz, possibility of study is indicated for future (Türkiye).

For the 42 GHz, one responding administration (Germany), is open to foresee an allocation for 5G, depending on a sufficient demand, with same licencing approach as the 26 GHz band.

9 CONCLUSIONS

The Fixed Service (FS) is and remains a key service for telecommunication infrastructure development. Current revision of this Report continues the activity of CEPT, initiated in 1997, to provide public information on the FS deployment in Europe, with the intention that it can be used as a reference and for guidance purposes for administrations, operators and manufacturers.

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; at same time, evolution of the regulatory framework allows the provision of wide bandwidth channels, in the order of 100 MHz and above.

In several CEPT administrations, the use of frequencies for strategic use, as well as the continuation of use for specific applications used up to now, is still considered actual and is foreseen to be continued.

The information gathered for developing this Report gives the evidence that, in addition to some use of FS service to continue support of some existing applications, the current trends in the FS market place are for an ever increasing provision of high bandwidth capacity for the mobile networks infrastructures. The need and possibility to migrate FS applications from bands intended to be used in future for mobile applications, such as the 5G, is also considered, also taking into account the aspects related to legacy, including existing licenses. 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 show a growth in terms of number of links (13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz and 70/80 GHz), and on which special attention from administrations should be taken; while others are still preparing to take off (32 GHz, 50 GHz and, 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 also highlights 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 responses to the 2021 questionnaire.

It should be noted that sections related to frequencies lower than 50 GHz (clause A1.25 included) have been addressed by all questionnaires since the beginning, while sections for higher frequencies are considered only in the last three surveys (2010, 2016 and 2021).

In analyses of answers, two major constraints need to be taken into account:

- Specific answers for 1997 and 2001 revisions are not available in an electronic format;
- Different countries answered the questionnaires from time to time.

As a consequence, in accordance with the approach already used in previous versions of the Report, following assumptions have been made:

- Information related to the overall number of links / band are based on the data provided by all the answering Administrations, without any filtering;
- Information related to trends are based on comparison of data submitted by the countries answering two consecutive questionnaires; in particular trends for the 2016 to 2021 period are based on data provided by all Administrations answering both these questionnaires.

At the end, for more comprehensive visualisation of variation of number of links in field, the cumulative trend for all period has been shown as the ratio between the number of active links in a band in a specific year to the number of declared active links in that band 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 (7 different sub-ranges are indicated); about 3000 P-P active links are reported

Two harmonised bands for FS below 2 GHz: 1350-1375 MHz paired with 1492-1517 MHz and 1375-1400 MHz paired with 1427-1452 MHz, which are described in Recommendation T/R 13-01, annexes A and B [63] and are used in the majority of countries.

Three responding administrations (Romania, Slovenia and Croatia) adopt national channel plans in this frequency range.

The possible use of band 1375-1400 MHz, paired with 1427-1452 MHz, is declared by five responding administrations, one of them (France) shows a significant number of active links (about 2000), the great majority being bidirectional.

Concerning the 1350-1375 MHz band, paired with 1492-1517 MHz, answers were provided by about 15 responding administrations, for an overall number of about 800 active links. In one responding administration (United Kingdom), where about 500 links are still in operation, the band is no more open for new fixed links.

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

All subranges are open for P-P applications, P-MP is open and used by one responding administration (Finland).

However, these bands, even if providing limited bandwidth, might be potentially suitable for NLOS backhauling applications for which the regime, in general, appears to be link by link authorisation; few administrations allow block assignment.

Intention to decrease the use of these frequencies has been declared by some respondents, similarly to possible allocation to other services / applications; unavailability of subrange 1427-1452 MHz and 1492-1517

MHz for FS is reported by one responding administration(Slovenia), while a consultation in the 1.4 GHz range is indicated by Ireland (one other administration).

In sub-band 1350-1375 paired with 1492-1517 MHz, intention to decrease is declared by (Croatia and Ireland) while reallocation in the range is anticipated by Latvia and Norway.

Possible growth in the 1518-1530 MHz subrange is indicated by Slovenia.

The number of active links reported is indicated in Table 4, while trend can be seen in Figure 27.

Table 4: Number of active links operating in RF range below 2 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	4655		2291	154
2016	3998	3367 (Note 1)	908	44
2021	2969	2907 (Note 2)	295	41
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

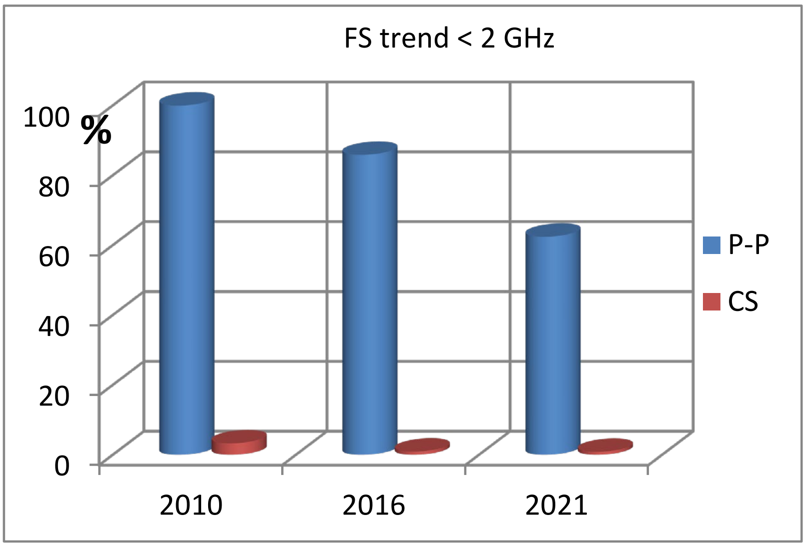


Figure 27: Trends for the P-P links in the band below 2000 MHz in CEPT

Hop length: 95% percentile of “typical” length is about 30 km in different sub-ranges (10 for those indicated as “minimum”) 70 km is the 50% percentile of the “maximum” indication.

A1.2 2.025-2.4 GHZ BAND

This frequency range is available for many applications, mostly related to mobile service (including ENG/OB) and MSS.

The harmonised 2025-2110 and 2200-2290 MHz is described in Recommendation T/R 13-01, annex C [63], which is the most frequently referred channel plan.

Some national plans (Romania, Serbia and Croatia) are indicated in this frequency range.

Three sub-ranges have been indicated for FS by 2021 questionnaire; among them, the range 2025-2110 and 2200-2290 MHz is open by about 25 administrations, but used by only four with limited density and unidirectional links.

About 560 P-P links have been indicated to be in operation, in addition to about 10 base stations.

Low capacity links are generally implemented, with a low percentage of medium capacity. Licensing regime is mostly link-by link based, with few administrations indicating possibility of block licensing (Romania, Norway, Croatia).

Use appears mostly for broadcasting infrastructure, ENG and defence systems are also reported.

A trend for increased use is not indicated.

The use of this band for the fixed service seems to be stable or in reduction in almost all countries. However, the 2 GHz band (CEPT Recommendation T/R 13-01, annex C [63]), 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 7.2.2).

Hop length: it appears to be significantly long: 95% percentile of “typical” length is in the range of about 90 km in different sub-ranges; 150 km is the 50% percentile of the “maximum” indication.

A1.3 3400-4200 MHZ BAND

This frequency range is available for IMT (3400-3600 MHz as established by WRC-07) and P-MP applications (3400-3800 MHz), including WiMAX, as well as Fixed Service P-P traditional applications.

5 different sub-ranges have been indicated by responding administrations in 2021 questionnaire, among which the 3400-3600 and the 3600 to 4200 MHz bands are used by most administrations.

The 3400-3800 MHz band is also addressed by the European Commission Decision 2008/411/EC [33] where neutrality with regard to technology and service is required.

ERC Recommendation 14-03 [64] provides channel plan for the 3400-3600 MHz frequency range, while CEPT/ERC/Recommendation 12-08 [65] covers the 3600-4200 MHz range.

The results of the questionnaire indicate that more than 3610 base stations are in operation, in addition to about 13150 P-P links. The number of base stations is underestimated, as block and link based licenses are foreseen in many countries.

The great majority of countries refer, for channel plan, to ERC Recommendation 14-03 and ERC Recommendation 12-08; one administration (Finland) adopts a national frequency plan.

P-MP use is indicated by five responding administrations in 3400-3600 MHz frequency range P-P use is referred by two administrations in 3400-3600 MHz frequency range, ten administrations in 3600-4200 MHz frequency range.

Band 3400-3600 GHz (also 3600-3800 MHz) is intended to be used for MFCN in one responding administration (Finland); in the 3800 to 4200 MHz band coexistence with low power IMT is indicated by other (Slovenia) or for use of local mobile (Hungary).

Broadband Wireless Access (BWA) and IMT are also indicated to be planned in Bosnia and Herzegovina and Czech Republic are also indicated by some administrations (Latvia and Italy) to be possible in some parts of the band. .

It should also be taken into consideration that the portion 3800–4200 MHz (ERC/Recommendation 12-08, annex B part 1 [65]), providing up to 6 $\times$ 29 MHz paired channels, might be potentially suitable for NLOS backhauling applications (see section 7.2.2). However, sharing with FSS should be carefully considered.

Possible use of ATPC and ACM is indicated by Serbia, MIMO is indicated by Slovenia. Minimum antenna Class 3 is required by responding administrations.

Link-by-link (about 15 administrations in various bands) and block licensing regimes (about ten responding administrations) are used.

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

In 2021 questionnaire, in 3400/3800 MHz band, increase of use is indicated by one responding administration (the Netherlands), while one (Slovak Republic) declared a possible reduction.

In some parts of the band, stability or scarce use is indicated by Austria and Romania.

Concerning 3.6-4.2 GHz band, possible increase of use in next years is indicated by three responding administrations (Bosnia and Herzegovina, the Netherlands and Switzerland), decrease of use is expected in five countries (Croatia, Germany, Hungary, Slovak Republic and Türkiye).

Some administrations indicate possibility to reallocate part of the band to other services (3 for the 3.4-3.6 GHz, 6 for the 3.6-4.2 GHz).

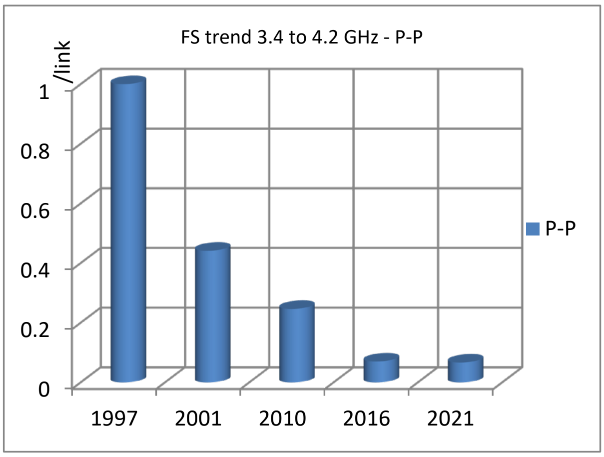
In the 3600-4200 band, possibility of ATPC use is indicated by Switzerland (also ACM) and Germany. Requirement for Class 3 antennas is indicated by three responding administrations (Bosnia and Herzegovina, Germany and Switzerland).

In the 3800-4200 band, possibility of ATPC and ACM use is indicated by Serbia, MIMO is considered by Slovenia and requirement for Class 3 as a minimum antenna class is indicated by Bulgaria.

Number of active links reported is indicated in Table 5, while trend is reported in Figure 28.

Table 5: Number of active links in operation declared in RF range 3400-4200 MHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	5252		624	12664
2016	1790	1046 (Note 1)	285	8735
2021	13150	995 (Note 2)	518	3610
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				



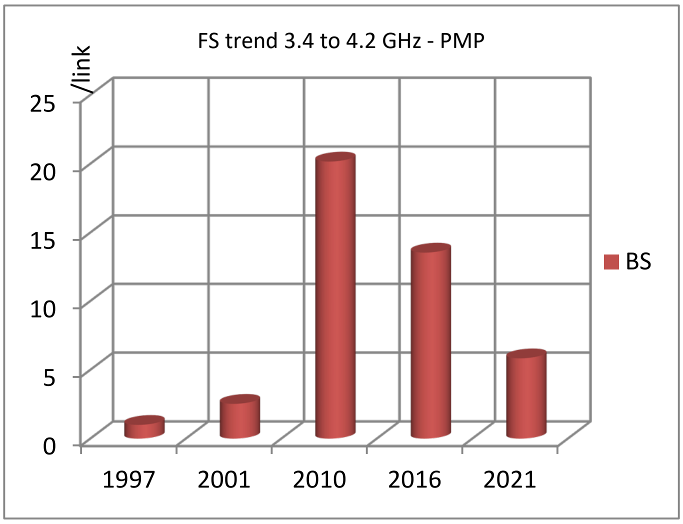


Figure 28: Historical trends for P-P and P-MP links in band 3400-4200 MHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is in the range of about 70 to 80 km in different sub-ranges (40 km for those indicated as “minimum”) about 100 km is the 50% percentile of the “maximum” indication.

A1.4 4.4-5.4 GHZ BAND

This band appears scarcely used for P-P and P-MP links. It is declared to be in use just by three administrations (Austria, Cyprus and France), for P-P only.

It is not covered by any CEPT frequency plan Recommendations.

The band is used mainly for low capacity links, licensing regime is link-by-link.

Possible increase of use is reported by one responding administration (Cyprus).

A1.5 5.65-5.9 GHZ BAND

This frequency range is open for P-P and P-MP applications by seven administrations, some allowing both uses.

No specific CEPT/ECC Recommendation indicates a channel plan for FS, while ECC Recommendation (06)04 provides guidance for the implementation of Broadband Fixed Wireless Access (BFWA) systems in frequency band 5725-5875 MHz.

Use of ECC Recommendation (06)04 for the 5850-5925 MHz range is possible in some responding administrations (including Italy and Hungary).

Two sub-ranges are indicated (5725-5875 MHz, 5850-5925 MHz); among them the 5850-5925 MHz range is indicated by most administrations for possible use. Active links are indicated in Austria and Greece.

The band has some use in (Serbia) , while appears scarcely used elsewhere in Europe.

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

Link-by-link regime is used by one administration (Italy); unlicensed use is noted by four administrations (Norway, Hungary, Ireland and Serbia).

No expectation for increase of use is indicated. Congestion in band 5725-5875 MHz is reported by one administration (Serbia).

Number of active links reported is indicated in Table 6.

Table 6: Number of active links declared in RF range 5650-5950 MHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010 (Note 3)	1568		187	623
2016	3071	13 (Note 1)	-	4977
2021	712	77 (Note 2)	77	709
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires Note 3: (5650-5850 MHz no info)				

Hop length: no accurate indication was given, to allow percentile determination, however the frequency band allows significantly long links; a minimum length of about 20 km have been indicated, together with maximum length in the range on 100 km.

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. Band is open in all responding 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. 3 different sub-ranges are indicated (5925-6425 MHz, 5925-7125 MHz, 6425-7125 MHz) as being open by all administrations and are used for P-P by the great majority of them.

Used frequency plans are in accordance with ERC Recommendation 14-01 [67] (5925 to 6425 MHz) and ERC Recommendation 14-02 [68] (7425-7125 MHz). No national frequency plans are noted.

About 22000 P-P active links are indicated as active in total by administrations, about one third is operating in 5925-6425 MHz frequency range. The use of unidirectional links is quite limited, apart in one country (Italy). No P-MP has been reported.

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

Licensing regime is mostly link-by-link; block assignment is foreseen in Slovenia (5925-6425 MHz).

In the 5925-6425 MHz frequency range, trend to increase the use of the band is indicated by six administrations (Bosnia and Herzegovina, Finland, the Netherlands, Norway, Switzerland and Türkiye), while possible reduction has been indicated by five (Bulgaria, Croatia, Cyprus, Germany and Hungary). Stability was indicated by other administrations.

Possible reallocation has been indicated by one administration (Croatia). Other indications have been given towards a possible impact of WAS/RLAN (Sweden). Congestion in some parts of the network is referred by four administration (Bulgaria, Norway, Serbia and Switzerland).

In the 6425-7125 MHz frequency range, trend to increase the use of the band is indicated by 6 Administrations (Bulgaria, Croatia, Finland, Moldova, the Netherlands, Slovak Republic, Sweden, Switzerland and Türkiye), while possible reduction has been indicated by 3 (Cyprus, France and Germany). Stability was indicated by other administrations. Possible reallocation has been indicated by one administration (Germany). Other indications have been given towards a possible coexistence with IMT (Slovenia) and for the strategic importance of the sub-band (Sweden). Congestion in some parts of the network is referred by six administrations (Bulgaria, Croatia, Finland, Serbia, Sweden and Switzerland):

- Use of ATPC and ACM are specifically indicated by ten responding administrations (Croatia, Czech Republic, France, Germany, Moldova, Norway, Serbia, Slovak Republic, Sweden and Switzerland) and six responding administrations (Croatia, Ireland, Norway, Serbia, Sweden and Switzerland) respectively; possibility of BCA and MIMO is indicated by some responding administrations (Croatia and Sweden for BCA, Croatia, Norway and Sweden for MIMO);
- Most used minimum antenna Class is 3 (about nine administrations, depending on frequency range, while Belgium and United Kingdom (also France and Norway for 5925-6425 MHz band) allow Class 2 and Finland requires Class 4.

Number of active links reported is indicated in Table 7, while trend is reported in Figure 29.

Table 7: Number of active links declared in RF range 5900-7100 MHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	17663		4253	1942
2016	23027	16752 (Note 1)	80	5370
2021	21592	21012 (Note 2)	1146	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

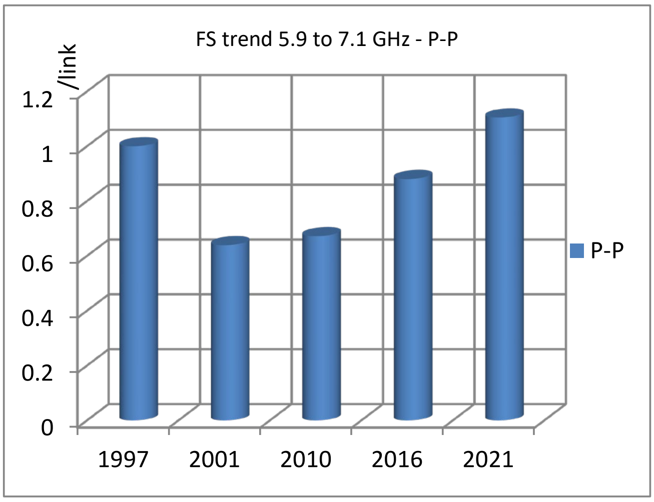


Figure 29: Historical trends for P-P links in band 5900-7100 MHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is about 50 km for 5.9-6.4 GHz for both ranges, (about 20 km for those indicated as “minimum”); 70 km is the 50% percentile of the “maximum” indication.

A1.7 7.1-8.5 GHZ BAND

This range is also an historical and widely used band for P-P applications, the use started quite long time ago, when systems were still analogue and many countries adopted national plans at that time, without coordination with other countries. In 2011, ECC Recommendation (02)06 [70] was revised with a view to harmonise the use of the band in Europe for countries planning to refarm it, and most used channel plans are included.

A high percentage of answers (60%) refers to the adoption of this Recommendation, but the total range of different sub-bands is still significant (9); three of them are widely used.

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

Frequency range 7125-7750 MHz is open and used in almost all countries, frequency range 7750-7900 MHz is open in about 20 administrations and used by 6, while frequency range 7900-8500 MHz is open in more than 20 countries and used by about 15.

Use is only for P-P, licensing regime is link-by-link, even if some countries (Belgium, Finland, Latvia and Malta) block license is also allowed in some portions of the band; no P-MP is allowed.

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

Significant number of responding countries (including Hungary, Malta, Moldova, Slovak Republic, Croatia, Serbia, Sweden, Türkiye, Bosnia and Herzegovina and Finland) plan to increase the usage of this range (a possible growth in the 10-20% range is indicated by some of them), possible reduction is declared by some responding countries (Bulgaria, Germany, Switzerland, France and Cyprus) 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 some responding countries (Türkiye, Malta, Slovenia, Croatia, Norway and Sweden):

- In the overall set of frequency ranges indicate by respondents, Use of ATPC and ACM are indicated to be possible by several responding administrations respectively; possibility of BCA and MIMO is also indicated by some responding administrations;
- Most used minimum antenna Class is 3, while some administration allow Class 2 and Finland requires Class 4.

Number of active links reported is indicated in Table 8, while trend is reported in Figure 30.

Table 8: Number of active links declared in RF range 7100-8500 MHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	36036		5166	-
2016	52670	27385 (Note 1)	181	-
2021	26856	25670 (Note 2)	75	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

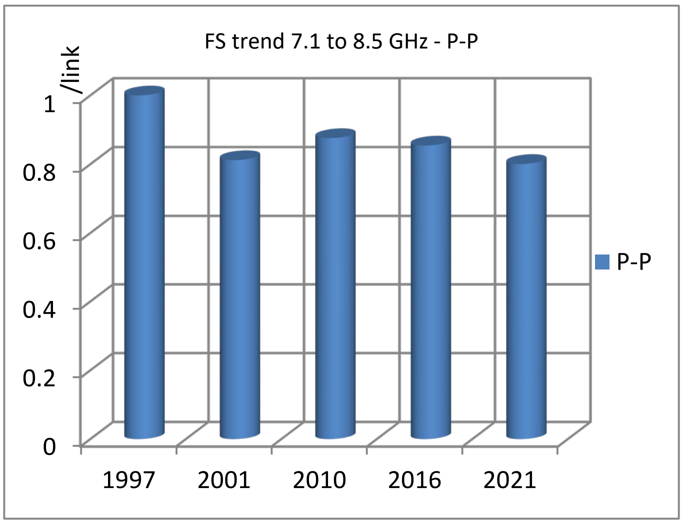


Figure 30: Historical trends for P-P links in band 7100-8500 MHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is in range 30 to 50 km (about 20 km for those indicated as “minimum”); 80 km is the 50% percentile of the “maximum” indication in the band.

A1.8 10-10.68 GHZ BAND

Use of this RF band has been declared by almost all responding administrations (Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Finland, France, Germany, Hungary, Ireland, Italy, Malta, Moldova, the Netherlands, Norway, Romania, Serbia, Slovak Republic, Slovenia, Sweden, Switzerland, Türkiye and United Kingdom), with three different declared sub-ranges, two of them have been reported to be applied within just one country.

Channel use is practically based on ERC Recommendation 12-05 (and annexes) [71] (while the ECC Decision (10)01 [72] regulates the sharing condition between FS, MS and EESS); in addition, some national plans (Serbia, Slovenia and Czech Republic) exist.

Band is used mostly for P-P, P-MP applications are allowed in four responding administrations (Croatia, Serbia, Slovak Republic, Slovenia), two of them (Slovak Republic and Slovenia) allow both applications.

BWA, MMDS are also used in some responding administrations (including Slovenia), together with some use on P-P subscribers with unidirectional connections with UL to CS (about 1000 subscribers, over a total number of subscribers of about 8000). Most licensing regimes are based on individually licensed links; block assignment is also referred (Croatia, Malta, Serbia, Norway, Sweden, Slovak Republic, Slovenia, United Kingdom and Türkiye), license free use is indicated in Czech Republic.

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

All range of capacities (low, medium and high) is reported in this band.

Need for growth has been indicated by few responding countries (, Norway, Switzerland, Slovak Republic and Türkiye); few others indicate a trend to decrease (Cyprus, Serbia, Bulgaria). Possible reallocation is indicated by two responding administrations (Cyprus and Norway).

The band is not congested in average, although some congestion is declared by some administrations (Malta, Norway, Switzerland and Türkiye):

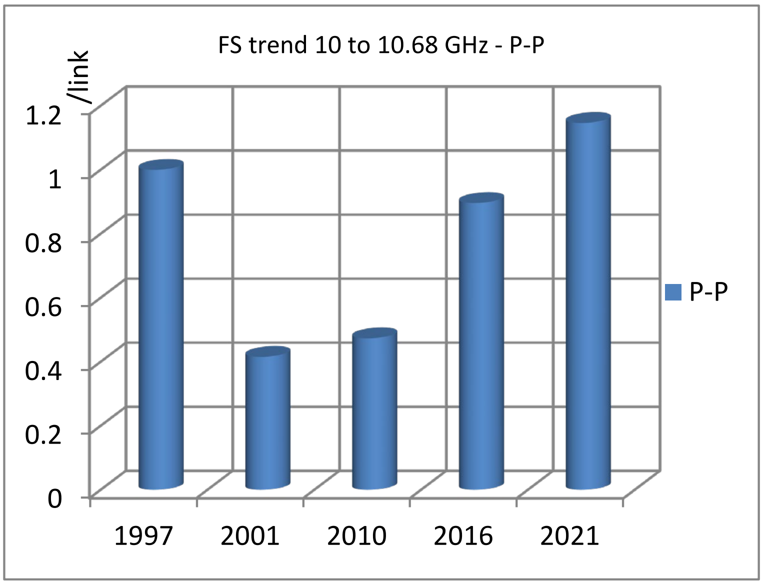
- Use of ATPC and ACM are specifically indicated by four (Czech Republic, Norway, Slovak Republic, Switzerland) and by three (Norway, Slovak Republic and Switzerland) responding administrations, respectively; possibility of BCA and MIMO is indicated by Norway;
- Most used minimum antenna class is Class 3 (four administrations: Bosnia and Herzegovina, Finland, Norway, and Switzerland), while Belgium allows Class 2, and Finland requires Class 4.

The band has been declared important by one responding administration (Norway).

Number of active links reported is indicated in Table 9, while trend is reported in Figure 31.

Table 9: Number of active links declared in RF range 10-10.68 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	3803		2662	1760
2016	6195	5891 (Note 1)	287	890
2021	12201	7562 (Note 2)	6121	224
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				



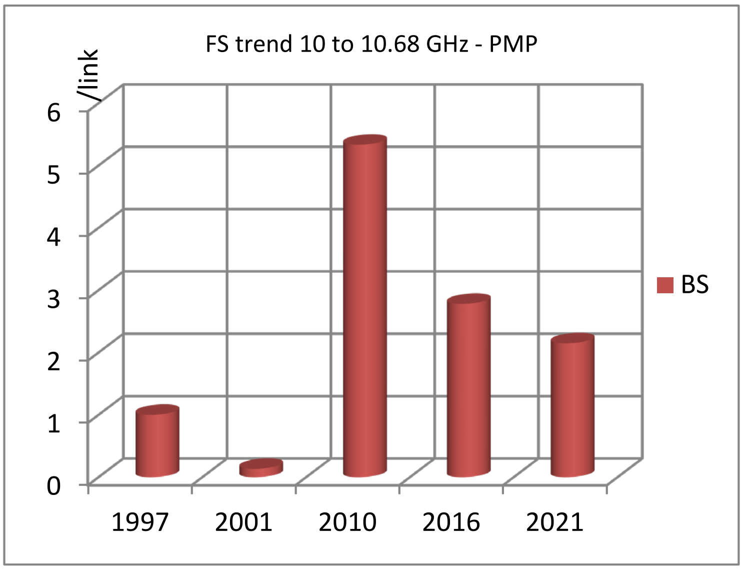


Figure 31: Historical trends for P-P and P-MP links in band 10 to 10.68 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is 26 km (9 km for those indicated as “minimum”); 36 km is the 50% percentile of the “maximum” indication in the band.

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. Two sub-ranges are used (10700-11700 MHz and 11700-12500 MHz).

In 10.7-11.7 GHz band, channel plans are based on ERC Recommendation 12-06 [38], while few national plans are indicated for the other subrange.

The most used is the 10.7-11.7 GHz band, where only P-P use is reported (about 23000 links); the band is open in almost all responding countries and used by more than 15 of them P-MP links are used, only for the 11.7-12.5 GHz in Bosnia and Herzegovina, Hungary, Slovak Republic (restricted MVDS use only in the 12.3-12.5 sub-band) and Slovenia with a limited number of CS (about 400 in total), while P-P use is indicated by three administrations (Italy, Malta and Moldova).

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 Decision(00)08 [62]).

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 Malta, Norway, Bosnia and Herzegovina, and Slovenia in the 11.7-12.5 GHz band.

In 10.7-11.7 GHz band, some responding countries (Croatia, France, Serbia, Latvia, Switzerland, Slovak Republic, Bulgaria, France and Malta) intend to increase the use in next years; congestion is reported by Hungary, Malta, Slovak Republic and Switzerland.

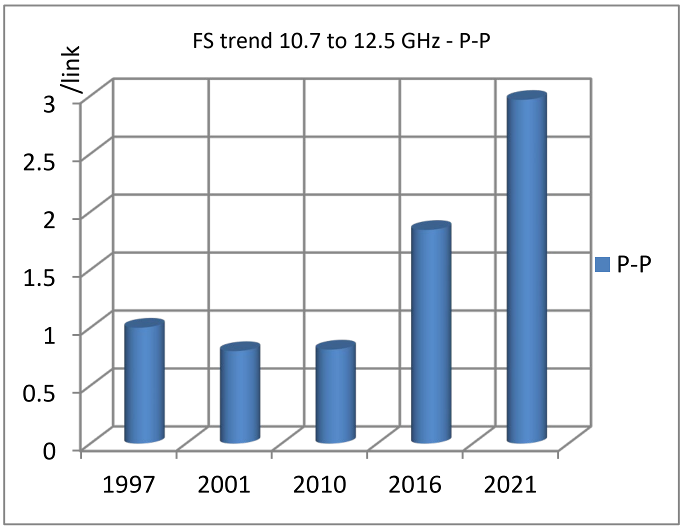
Cyprus declared trend to reduce usage and reallocate the band, no use is reported in Germany; more than 1000 links are declared by France, Czech Republic, Italy, Ireland in the 10.7-11.7 GHz band:

- In the 10.7-11.7 band, Use of ATPC and ACM are specifically indicated by six responding administrations (Croatia, Czech Republic, France, Moldova, Serbia and Switzerland) and by five responding administrations (Croatia, Ireland, Italy, Serbia and Switzerland) respectively; possibility of BCA is indicated by Croatia;
- In same frequency range, most used minimum antenna class is 3 (five administrations: Bosnia and Herzegovina, Bulgaria, France, Ireland and Switzerland), while Belgium allows Class 2.

Number of active links is indicated in Table 10, while trend is reported in Figure 32.

Table 10: Number of active links declared in RF range 10.7-12.5 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	7271		196	2025
2016	16770	14296 (Note 1)	58	252
2021	23435	23001 (Note 2)	710	410
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				



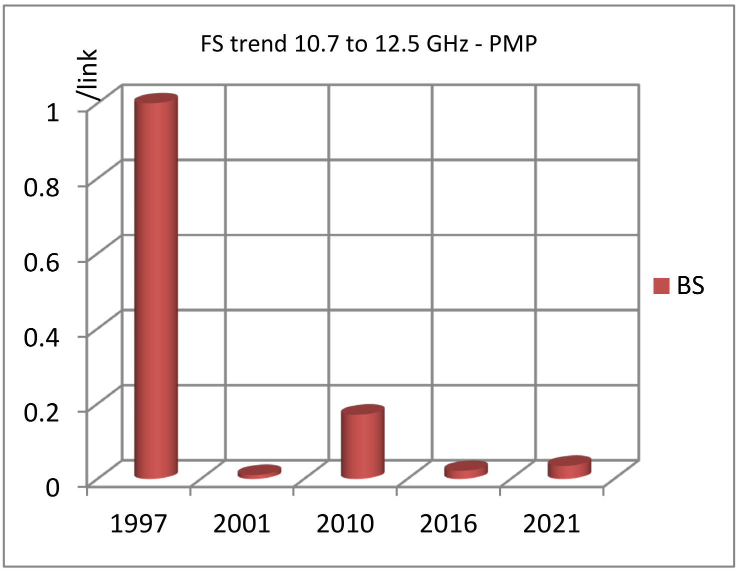


Figure 32: Historical trends for P-P and P-MP links in band 10.7 to 12.5 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of "typical" length is 25 km (10 km for those indicated as "minimum"); 50 km is the 50% percentile of the "maximum" indication in the band.

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 (more than 40000 links) by all responding administrations.

The frequency usage has high a harmonisation level; all answers refer to ERC Recommendation 12-02 [73] (or Recommendation ITU-R F.1492 [74][6], with same channel plan).

The major utilisation 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 Malta and Norway.

Regarding the usage, Bosnia and Herzegovina, Bulgaria, Croatia, Latvia, Malta, Moldova, the Netherlands, Romania, Slovak Republic, Sweden, Switzerland and Türkiye indicate expectations of a moderate increase in coming years (a possible growth up to 20% range is indicated by some of them) . Expectation to decrease is declared by Cyprus, Finland and Germany.

Congestion exists in Croatia, Germany, Hungary, Latvia, Norway, Serbia, Slovenia, Sweden and Switzerland.

Stable link amount was noted by Cyprus, Hungary, Ireland, Latvia and Norway:

- Use of ATPC and ACM are specifically indicated by about 9 and 6 responding administrations respectively; possibility of BCA and MIMO is indicated by two responding administrations (Croatia and Sweden for BCA, Norway and Sweden for MIMO);
- Most used minimum antenna class is 3 (nine administrations: Bosnia and Herzegovina, Bulgaria, France, Germany, Ireland, the Netherlands, Norway, Sweden and Switzerland), while Belgium and United Kingdom allow Class 2 and Finland requires Class 4.

Presence of more than 2000 links are reported by Romania, France; Germany, Hungary, Italy and United Kingdom.

[6] This Recommendation has been replaced by Recommendation ITU-R F.1703

Number of active links is indicated in Table 11, while trend is reported in Figure 33. The trend chart shows a continuous increase since 1997.

Table 11: Number of active links declared in RF range 12.75-13.25 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	51313		7951	7
2016	72200	46635 (Note 1)	41	-
2021	45822	44249 (Note 2)	84	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

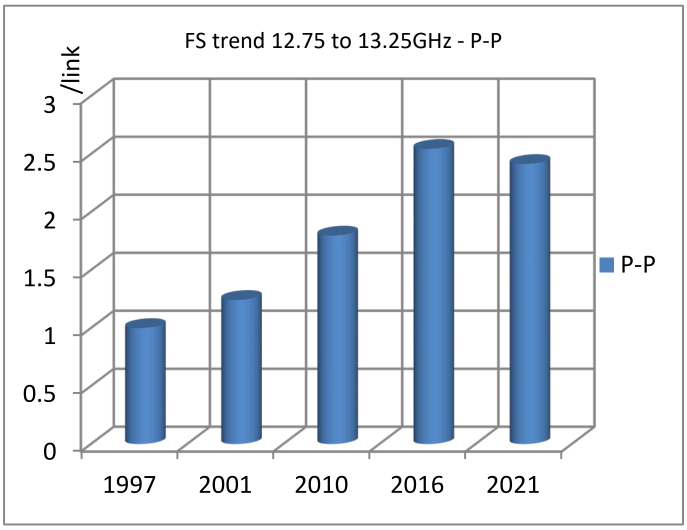


Figure 33: Historical trends for P-P links in band 12.75 to 13.25 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is 25 km (3.3 km for those indicated as “minimum”); 50 km is the 50% percentile of the “maximum” indication in the band.

A1.11 14.25-15.35 GHZ BAND

Three sub-bands (14.25-14.5 GHz, 14.4-15.350 GHz, 14.5-14.62 GHz coupled with 15.23-15.35 GHz) have been indicated in this range, for P-P links.

In the RF band 14.5-14.62 GHz, paired with 15.23-15.35 GHz, which is widely and densely used all over Europe (about 25 responding countries with about 3000 links in operation), possibility to use P-MP is indicated by Türkiye.

- Channel are mostly used according to ERC Recommendation 12-07 [39] (or Recommendation ITU-R F.636 [46])¸Sweden indicated a national channel plan;
- Links appear mostly individually licensed; block licence is possible in Belgium, Norway and Türkiye;
- 14.25-14.5 GHz frequency range is used for FS by some lower number of countries (Austria, Estonia, United Kingdom, Italy and Latvia), with about 500 active P-P links overall. In the United Kingdom and France, the 14.25-14.5 GHz band is closed to new fixed links;
- In the RF band, 14.5-14.62 GHz, paired with 15.23-15.35 GHz, anticipated growth is indicated by several responding administrations (Ireland, Latvia, Moldova, the Netherlands, Serbia, Slovak Republic, Sweden and Türkiye), while in Cyprus, Finland, Germany a possible reduction is anticipated;
- In few countries some congestion is experienced;

- Major utilisation 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;
- Use of ATPC and ACM are specifically indicated by about five responding administrations each one; possibility of BCA and MIMO is indicated by one responding administration (Sweden);
- Most used minimum antenna class is 3 (six responding administrations: Bosnia and Herzegovina, Finland, Ireland, the Netherlands, Sweden and Switzerland), while Belgium, Germany and United Kingdom allow Class 2.

Number of active links reported is indicated in Table 12 while trend is reported in Figure 34.

Table 12: Number of active links declared in RF range 14.25-15.35 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	46996		12239	-
2016	57228	31266 (Note 1)	362	-
2021	35571	34197 (Note 2)	374	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

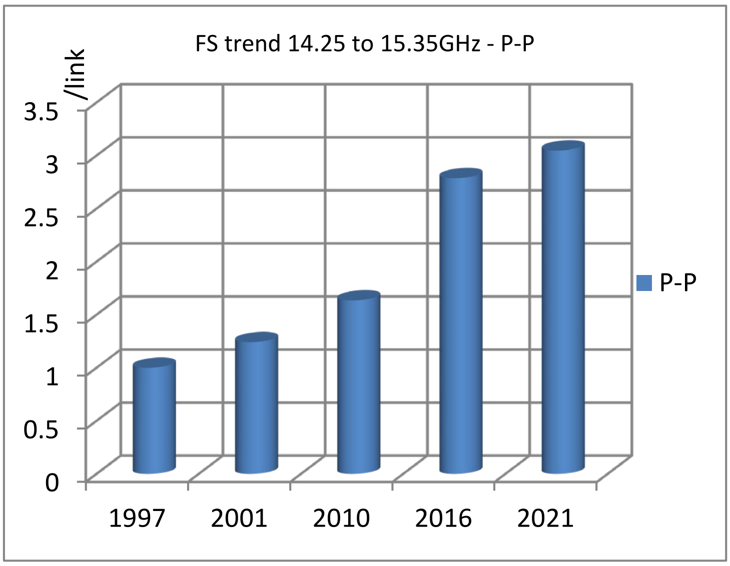


Figure 34: Historical trends for P-P links in band 14.25 to 15.35 GHz in CEPT (normalised to links operating in 1997)

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

A1.12 17-17.7 GHZ BAND

Band is practically not used for FS P-P.

Former version of ERC Recommendation 70-03 [55] 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 links is unknown. License-exempt regime is specifically reported by Ireland.

A1.13 17.7-19.7 GHZ BAND

17.7-19.7 GHz band is a heavily and widely used historical FS band, only for P-P (all administrations indicated the band open and used). About 130000 active links have been reported.

Band usage is highly harmonised: the channel plan is based on the ERC Recommendation 12-03 [40] (F.595 [47] is also indicated); no national arrangements are used.

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

The major utilisation 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 (20 countries) and broadcasting infrastructure (11 countries). Use in different contests and utilities (including oil, gas, electricity) is also indicated by about 15 responding administrations.

Concerning the usage, significant increase is expected in next years (a possible growth up to 20% range is indicated by some of them) in 20 responding countries (Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Finland, France, Germany, Hungary, Ireland, Latvia, Malta, Moldova, the Netherlands, Norway, Romania, Serbia, Slovak Republic, Sweden, Switzerland and Türkiye).

A moderate situation of congestion is already reported in 10 responding countries (Croatia, Finland, Germany, Hungary, Latvia, Malta, Norway, Sweden, Switzerland, Slovenia and Hungary).

Strategic importance of the band is noted by one responding administration (Sweden).

Future possible reduction is not reported:

- Possibility to utilise 220 MHz BW channels are reported by ten responding administrations (Bulgaria, Cyprus, Finland, Ireland, Latvia, Malta, Norway, Slovak Republic, Slovenia and Sweden);
- Use of ATPC and ACM are specifically indicated by 11 (Croatia, Czech Republic, Finland, France, Germany, Moldova, Norway, Serbia, Slovak Republic, Sweden and Switzerland) and eight responding administrations (Croatia, Ireland, Italy, Norway, Serbia, Slovak Republic, Sweden and Switzerland) respectively;
- Possibility of use in BCA is indicated by five responding administrations (Bulgaria, Croatia, Latvia, Sweden, and Switzerland). Possibility MIMO is indicated by two responding administrations (Norway and Sweden);
- Class 3 is required as minimum antenna class by responding ten administrations (Bosnia and Herzegovina, Bulgaria, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, Switzerland), while Belgium and United Kingdom allow Class 2.

Number of active links reported is indicated in Table 13, while trend is reported in Figure 35. The trend chart shows a continuous increase since 1997.

Table 13: Number of active links declared in RF range 17.7-19.7 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	50833		71	-
2016	140320	93810 (Note 1)	544	-
2021	129490	127262 (Note 2)	275	-

Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires
Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires

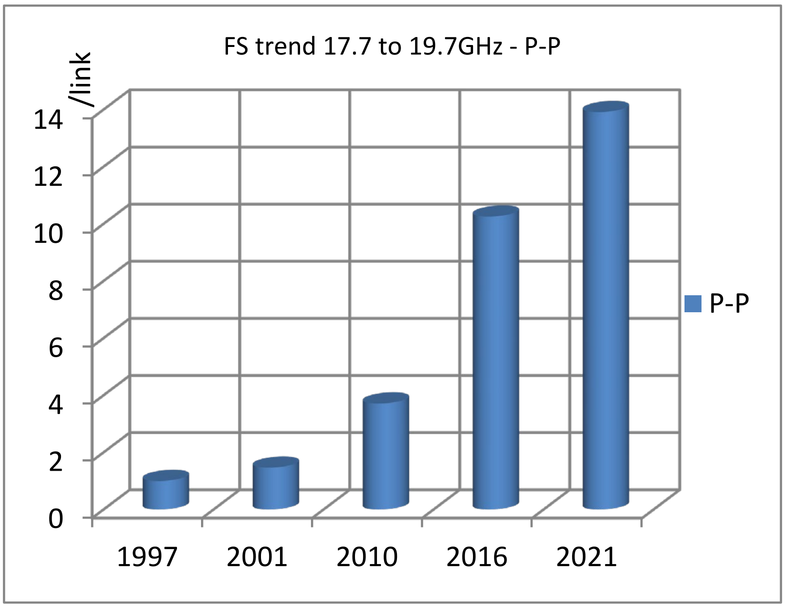


Figure 35: Historical trends for P-P links in band 17.7-19.7 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is about 17 km (4 km for those indicated as “minimum”); about 32 km is the 50% percentile of the “maximum” indication in all sub-bands.

A1.14 21.2-23.6 GHZ BAND

This is a heavily used historical P-P FS band, where indications of use of two frequency sub-bands (21.2-22 GHz and 22-22.6/23-23.6 GHz) have been given. P-MP is used in Czech Republic (about 2000 links) and is also possible in Moldova.

Frequency band 22-22.6 and 23-23.6 GHz appear as the most widely adopted (open and used in all responding administrations), with more than 100000 P-P links in operation. No P-MP application is indicated.

Use of channel plan is well harmonised, all administrations indicate use of Recommendation T/R 13-02 [36], no national plan is indicated. This Recommendation was updated in 2010 to introduce additional channel arrangements in the centre gap.

Licensing regime is substantially link-by-link (24 responding countries in the 6 indicated sub-ranges). Belgium, Malta, Norway and Türkiye indicate possibility of link-by-link and block based license.

High/medium capacity use is more frequently indicated (about 15 responding administrations each), but significant use for low capacity links is still present (about ten responding administrations).

The majority of links are addressed to fixed and mobile infrastructure. Most responding administrations (Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Finland, France, Germany, Hungary, Italy, Latvia, Malta, the Netherlands, Norway, Romania, Serbia, Slovenia, Sweden, Türkiye and United Kingdom) declare that the band is used for mobile backhaul.

Broadcasting infrastructure is addressed by ten responding administrations (Belgium, Bulgaria, Croatia, France, Italy, Latvia, the Netherlands, Norway, Romania and United Kingdom), and other different uses are also indicated by 15 responding administrations (Belgium, Croatia, Cyprus, Finland, France, Germany, Hungary, Italy, Latvia, Norway, Romania, Serbia, Slovenia, Sweden, Türkiye and United Kingdom).

In current revision, trend for increase was declared by more than 15 responding administrations , including Italy, Croatia, Germany, Bosnia and Herzegovina, Bulgaria, Finland, France, Hungary, Ireland, Latvia, Malta, Moldova, the Netherlands, Norway, Romania, Serbia, Slovak Republic, Sweden and Türkiye.

Congestion or possible congestion is declared in Croatia, Latvia, Norway, Hungary and Slovenia; reduction is expected in Cyprus and Switzerland. Possible reallocation to other services is declared by Norway, although the band is still considered an important band.

The band is considered strategic by Sweden:

- Possibility to utilise 224 MHz BW channels are reported by ten responding administrations (Bulgaria, Cyprus, Finland, Ireland, Latvia, Malta, Norway, Slovak Republic, Slovenia and Sweden);
- Use of ATPC and ACM are specifically indicated by 11 responding administrations (Croatia, Czech Republic, Finland, France, Germany, Moldova, Norway, Serbia, Slovak Republic, Sweden and Switzerland) and eight responding administrations (Croatia, Ireland, Italy, Norway, Serbia, Slovak Republic, Sweden and Switzerland) respectively;
- Possible use of BCA is indicated by five responding administrations (Bulgaria, Croatia, Latvia, Sweden and Switzerland). Possibility of use of MIMO is indicated by two responding administrations (Norway and Sweden);
- Class 3 is required as minimum antenna class by eight responding administrations (Bosnia and Herzegovina, Bulgaria, Finland, France, Ireland, Norway, Sweden and Switzerland), while Belgium, Germany and United Kingdom allow Class 2.

Number of active links reported is indicated in Table 14, while trend is reported in Figure 36. The trend chart shows a continuous increase since 1997.

Table 14: Number of active links declared in 2010 and 2016 in RF range 21.2-23.6 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	98881		24321	-
2016	130969	98297 (Note 1)	562	-
2021	106436	103211 (Note 2)	51	2941
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

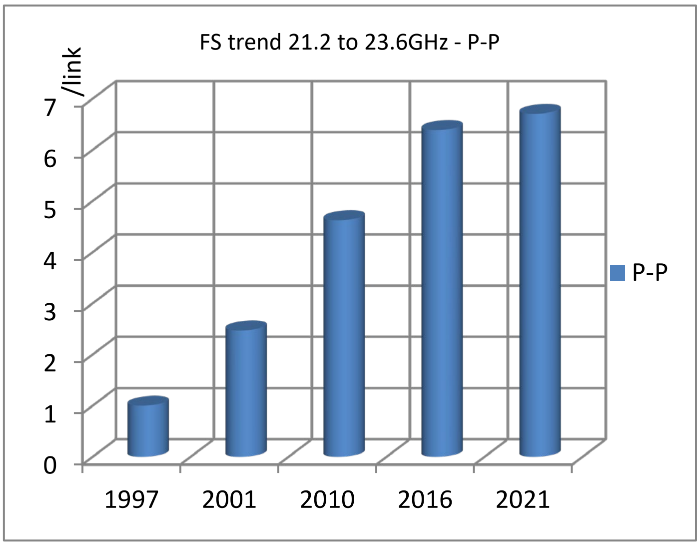


Figure 36: Historical trend for P-P links in band 21.2-23.6 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is about 8 km (3 km for those indicated as “minimum”), 20 km is the 50% percentile of the “maximum” indication.

A1.15 21.2-22 GHZ BAND

This is a poorly used P-P band. About 10 overall link have been declared to be active in this frequency range, although 5 countries indicate the possibility to use it with link-by-link regime.

Links appear mostly low-medium capacity. Frequencies are used according to Recommendation ITU-R F.637 [48] is indicated for channel plan.

No expectation to increase is reported, nor congestion. Intention to reallocate the band is expressed by Cyprus.

A1.16 24.2-24.5 GHZ BAND

This band is declared open by some countries, including Italy, the Netherlands, Ireland, but very poorly used (< 100 links, mostly CS in one country). ENG/OB use is noted by Czech Republic, MFCN by Serbia.

P-P use possibility is indicated, with link-by-link regime. P-MP is available in the Netherlands.

Unlicensed use is declared in Ireland.

ECC Decision 18(06) [81] has been indicated by one administration as reference.

A1.17 24.5-26.5 GHZ BAND

The band is open in most countries (apart from the UK where no new fixed links assignments are allowed) for P-P, where it is largely utilised (around 70000 links in operation) while P-MP use is reported to be allowed by four administrations (Bosnia and Herzegovina, Germany, Hungary and Italy).

In more than 20 responding administrations , significant use is reported; in more than ten responding administrations the number of P-P in operation exceeds 1000, in 6 of them the number exceeds 5000.

Link–by-link regime has been declared by 19 responding administrations (Belgium, Bosnia and Herzegovina, Bulgaria, Cyprus, Czech Republic, France, Germany, Ireland, Latvia, the Netherlands, Norway, Romania, Serbia, Slovak Republic, Slovenia, Sweden, Switzerland, Türkiye and United Kingdom), block allocation is possible in 7 (Belgium, Bosnia and Herzegovina, Hungary, Ireland, Italy, Norway and Türkiye), five of them (Belgium, Bosnia and Herzegovina, Ireland, Norway and Türkiye) allow both licensing regimes.

Use appears well harmonised. Indicated P-P channel plan follows the Recommendation T/R 13-02 [36] while no national plans are indicated. Licenses are assigned by link (19 administrations) or by blocks (seven administrations) according to the use.

Due to presence of block assignment, the declared number of links can be lower than the effective number of links in operation.

Medium and high capacity links are declared, minor use of low capacity is also noted; the majority of links is allocated to mobile backhaul and broadcasting infrastructure. MFCN (Finland) and usage until TRA-ECS (Slovenia) use are also indicated.

Possible trend to decrease and reallocate the band is noted by eight responding administrations (Bulgaria, Germany, Ireland, Norway, Slovak Republic, Sweden, Switzerland and Türkiye); possible increase is indicated by Cyprus, Ireland, Romania. Possible congestion is indicated by Slovenia:

- Use of ATPC and ACM are specifically indicated by seven responding administrations (Norway, Serbia, Slovak Republic, Sweden and Switzerland) and five responding administrations (Croatia, Ireland, Norway, Slovak Republic and Switzerland) respectively;
- Possible use of BCA is indicated by two responding administrations (Norway and Switzerland). Possibility MIMO is indicated by two responding administrations (Norway and Slovenia);

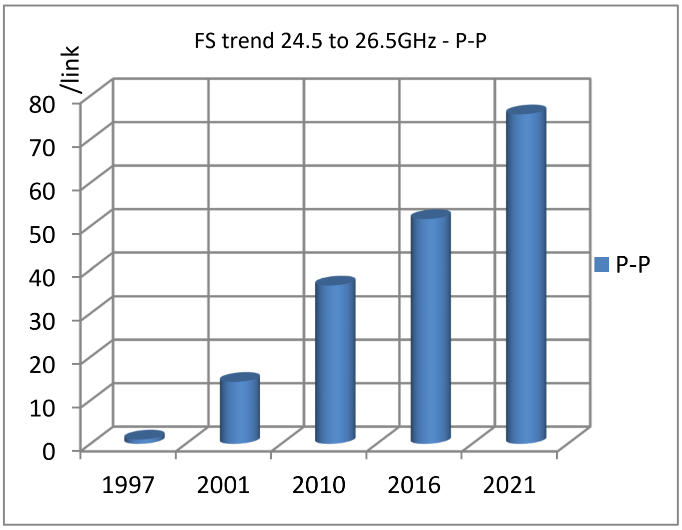
- Class 3 is required as minimum antenna class by six responding administrations (Bosnia and Herzegovina, Bulgaria, France, Ireland, Sweden and Switzerland), while Belgium, Germany, the Netherlands and United Kingdom allow Class 2.

Number of active links declared is indicated in Table 15 while trend is reported in Figure 37. The trend chart shows a continuous increase since 1997.

Table 15: Number of active links declared in 2010 and 2016 in RF range 24.5-26.5 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	37158		19453	1646
2016	51728	51711 (Note 1)	17	4277
2021	76608	76216 (Note 2)	13	2671
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

Hop length: 95% percentile of “typical” length is about 7 km (2.3 km for those indicated as “minimum”), 15 km is the 50% percentile of the “maximum” indication.



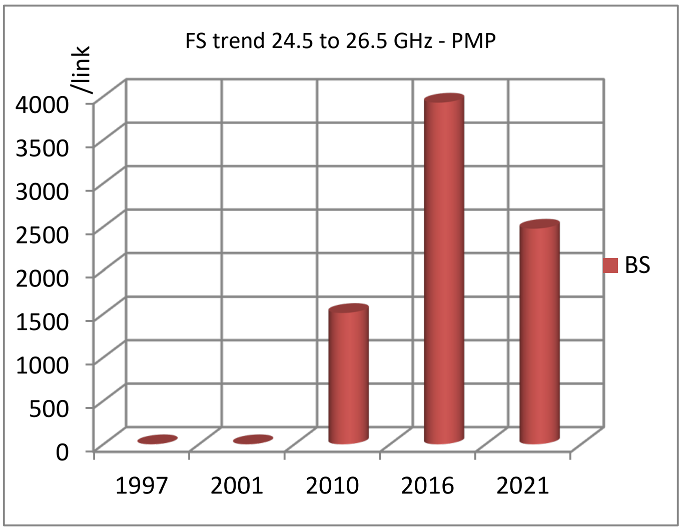


Figure 37: Historical trends for P-P and P-MP links in band 24.5 to 26.5 GHz in CEPT (normalised to links operating in 1997)

A1.18 26.5-27.5 GHZ BAND

This band is not used for P-P or P-MP applications. Indication of possible use for MFCN use is given by one responding administration (Serbia) and indication of use for IMT from 2024 is given by one responding administration (Latvia).

No expectation to increase the use in next years is envisaged.

A1.19 27.5-29.5 GHZ BAND

This band has been segmented between FS and uncoordinated FSS usage with the ECC Decision (05)01 [35]. The majority of CEPT administrations have implemented this Decision.

The band is well harmonised, the P-P channel plan follows the Recommendation T/R 13-02 [36],the block assignment guidance for P-MP links is provided in the ECC Recommendation (11)01 [37], no national frequency plan is indicated.

The band is open in about 20 CEPT responding countries and used in about 15, with limited density of use in most countries; only in Italy and Germany, the number of active links is higher than 1000. Overall number of links is about 13000.

P-P (15 responding administrations) and P-MP (six responding administrations) applications are allowed; Czech Republic, Ireland, Italy, Serbia allow both use.

Licensing regime is mostly link-by-link (14 responding administrations – Belgium, Bulgaria, Croatia, Czech Republic, Finland, Germany, Ireland, Latvia, the Netherlands, Norway, Romania, Serbia, Slovak Republic and Switzerland), but 7 responding countries (Belgium, Italy, Norway, Serbia, Slovenia, Sweden and United Kingdom) allow block assignment; in 3 of them (Belgium, Norway, Serbia), both licensing regime are allowed. 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 cases are for other uses including broadcast infrastructure.

Bulgaria, Germany, the Netherlands, Croatia, Switzerland, Ireland, Norway and Romania indicate expectations to increase the use in next years (mostly below 10), Finland indicates possible reduction of use, the Netherlands and Norway indicates possible reallocation of the band usage, no congestion is reported.

- Possibility to utilise 224 MHz BW channels are reported by seven responding administrations (Bulgaria, Czech Republic, Germany, Ireland, Slovak Republic, Slovenia and Switzerland);
- Use of ATPC is specifically indicated by seven responding administrations (Czech Republic, Germany, Norway, Slovak Republic, Switzerland) and ACM is almost noted by seven responding administrations (Ireland, Norway, Serbia, Slovak Republic, Sweden and Switzerland);
- Possible use of BCA is indicated by two responding administrations (Sweden and Switzerland). Possibility MIMO is indicated by two administrations (Norway and Slovenia);
- Class 3 is required as minimum antenna class by six administrations (Bosnia and Herzegovina, Bulgaria, France, Ireland, Sweden and Switzerland), while Belgium, Germany and the Netherlands allow Class 2.

Number of declared active links is indicated in Table 16, while trend is reported in Figure 38.

Table 16: Number of active links declared in RF range 27.5-29.5 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	2471		1424	183
2016	5869	5869 (Note 1)	-	363
2021	13867	6543 (Note 2)	32	48
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

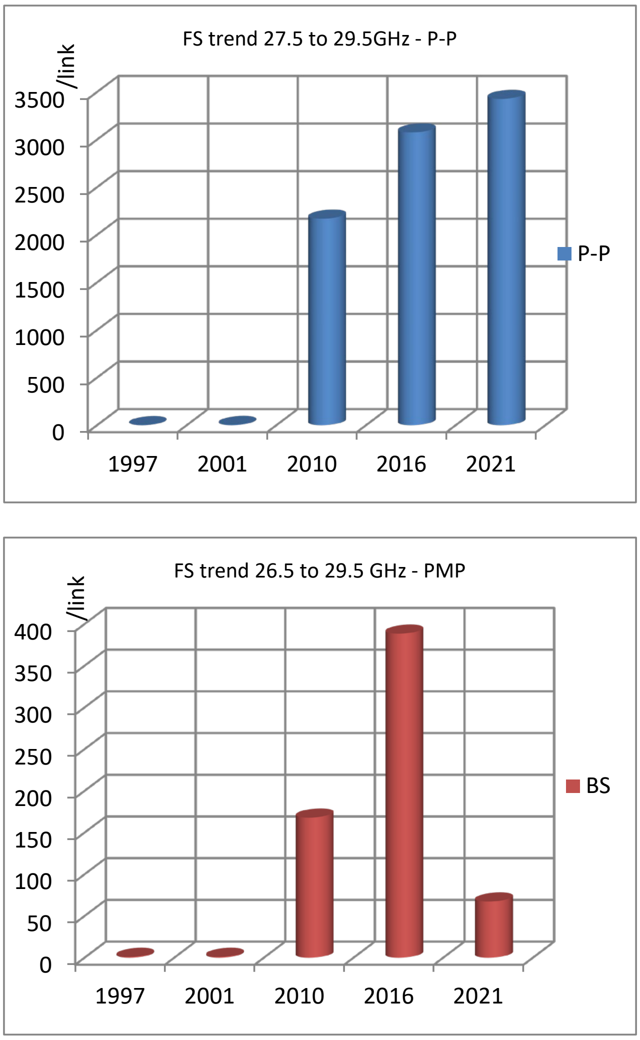


Figure 38: Historical trends for P-P and P-MP links in band 27.5 to 29.5 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of "typical" is about 5 km (3 km for those indicated as "minimum"), 6.5 km is the 50% percentile of the "maximum" indication.

A1.20 31-31.8 GHZ BAND

Very limited use is indicated for this band, with very few indications (in eight responding administrations the band is open). About 1000 P-P links are used in Slovak Republic in the 31-31.3 GHz frequency band, where possible growth for next years is indicated. No use nor demand is indicated by Hungary.

Where the band is used, all capacities are indicated, (possible use for broadcast infrastructure is indicated by one responding administration (Finland)), mostly for links below 8.5 km, with possibility of ACM and ATPC.

Licensing regime appears link-by-link, for only P-P topology.

The channel plan follows ECC Recommendation (02)02 [75], in addition to national plan adopted by United Kingdom (in the overall 31-31.8 GHz band).

No significant expectations to increase the use in next years are reported by most responding administrations.

A1.21 31.8-33.4 GHZ BAND

This band is declared open and used for an overall number of active links of about 30000 links in operation, in about 15 responding administrations, some of them with more than 1000 active links (Czech Republic, France, Germany, Italy, the Netherlands and Sweden).

The P-P channel plan follows the ERC Recommendation (01)02 [41], no national plan is indicated.

P-P and P-MP applications are possible, in 17 and 2 responding administrations respectively, but no active P-MP is indicated; Serbia allow both use.

Use appears mostly for medium and high capacity and for mobile backhaul. Some uses for fixed and broadcast infrastructure are declared; the indication for other uses is also given by few responding administrations, in addition to main uses.

Licenses are assigned mostly by link (15 countries: Belgium, Bosnia and Herzegovina, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Latvia, the Netherlands, Norway, Serbia, Slovenia, Sweden and Switzerland), although block assignment has been reported by five responding administrations (Belgium, Hungary, Serbia, United Kingdom and Norway), three of them (Belgium, Norway and Serbia, allowing both regimes. Hungary indicates planned competitive procedure (block licensing).

Hungary, Latvia, Netherlands, Norway, Slovenia, Sweden, Switzerland, Türkiye expect an increase in the usage in coming years (10-20% and more). Finland and France indicate trend for reduction of use. Congestion is reported by Latvia, Norway and Sweden. Norway indicates possibility of reallocating the band.

Possibility to utilise 224 MHz BW channels are reported by five administrations (Bulgaria, Germany, Norway, Slovenia and Sweden);

Use of ATPC is specifically indicated by seven responding administrations (Czech Republic, France, Germany, Italy, Norway, Sweden and Switzerland) and ACM is almost noted by four responding administrations (Italy, Norway, Sweden and Switzerland);

Possible use of BCA is indicated by three responding administrations (Norway, Sweden and Switzerland). Possibility MIMO is indicated by two of them (Norway and Sweden);.

Class 3 is required as minimum antenna class by five responding administrations (Bulgaria, Finland, Norway, Sweden and Switzerland), while Belgium, the Netherlands allow Class 2. It should be noted that one administration requires Class 4.

The number of declared active links is indicated in Table 17, while trend is reported in Figure 39. The use of the band became effective after 2001.

Table 17: Number of active links declared in 2010 and 2016 in RF range 31.8-33.4 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Station
2010	3177		1466	-
2016	16947	16919 (Note 1)	-	-
202	30601	29976 (Note 2)	8	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

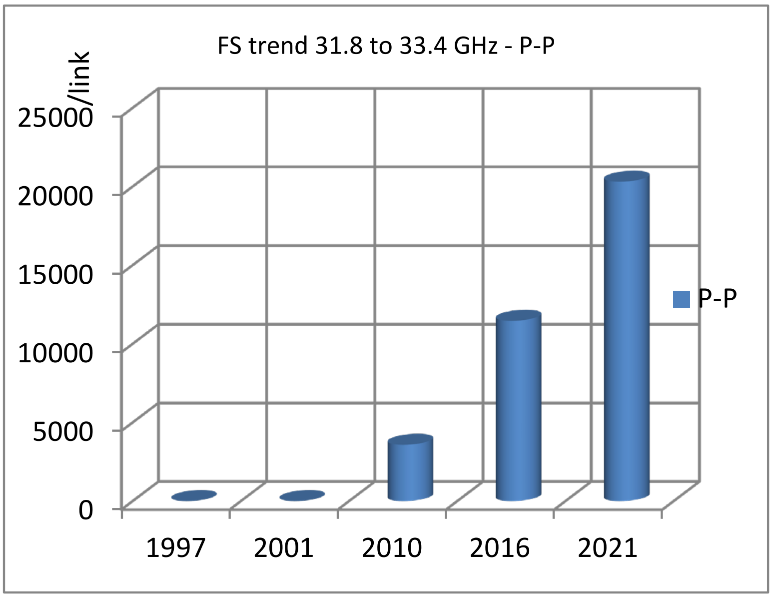


Figure 39: Historical trend for P-P links in band 31.8 to 33.4 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of "typical" length is about 4 km (1 km for those indicated as "minimum"), 6 km is the 50% percentile of the "maximum" indication.

A1.22 36-37 GHZ BAND

No P-P or P-MP active links are indicated by any responding country, nor licensing regime applicable to FS.

A1.23 37-39.5 GHZ BAND

This band is open and widely used historically for P-P FS by most of the CEPT countries with high density, the number of active P-P links id about 120000. Almost All administration responding to questionnaire declared this band opened and used (apart Cyprus). No P-MP use is allowed.

Individually licensed links are declared by the great majority of responding administrations (24); Belgium, Norway, Malta and Türkiye indicated that block licenses can be also used in their administrations domains.

High and medium capacity are mostly indicated, but low capacity is also used.

Great majority of links is used for mobile backhaul and fixed infrastructure, limited use for broadcasting infrastructure is declared, other uses are also indicated, without specific explanation.

Band is widely harmonised; frequencies are utilised according to Recommendation T/R 12-01 [42], no national plan is indicated.

Concerning trends, increase in the use of the band is reported in coming years (a possible growth in the 10-50% range is indicated by some of them)by 14 responding countries (Bulgaria, Croatia, France, Hungary, Latvia, Malta, Moldova, the Netherlands, Norway, Romania, Serbia, Slovak Republic, Switzerland and Türkiye), two indicate possible decrease (Finland and Sweden). Congestion is reported by Hungary, Norway and Slovenia. Possible reallocation to other application is indicated by Norway.

In France, a new regulation was put in place in 2013 in order to offer more capacity to backhaul needs with higher bandwidth. Possibility to utilise 224 MHz BW channels are reported by seven responding administrations (Bulgaria, Ireland, Malta, Norway, Slovak Republic, Slovenia and Sweden).

Use of ATPC specifically indicated by 11 responding administrations (Croatia, Czech Republic, France, Germany, Italy, Moldova, Norway, Serbia, Slovak Republic, Sweden and Switzerland) and ACM is almost noted by eight responding administrations (Croatia, Ireland, Italy, Norway, Serbia, Slovak Republic, Sweden and Switzerland).

Possible use MIMO is indicated by Norway.

Class 4 antennas are required by one responding administration (Finland), Class 3 are used as minimum antenna class by seven of them (Bosnia and Herzegovina, Bulgaria, France, Ireland, Norway, Sweden and Switzerland), while Belgium, the Netherlands and United Kingdom allow Class 2.

The number of declared active links is indicated in Table 18, while trend is reported in Figure 40. Trend shows continuous increase since 1997.

Table 18: Number of active links declared in RF range 37-39.5 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	119923		42646	-
2016	132182	103976 (Note 1)	226	-
2021	120549	118682 (Note 2)	3	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

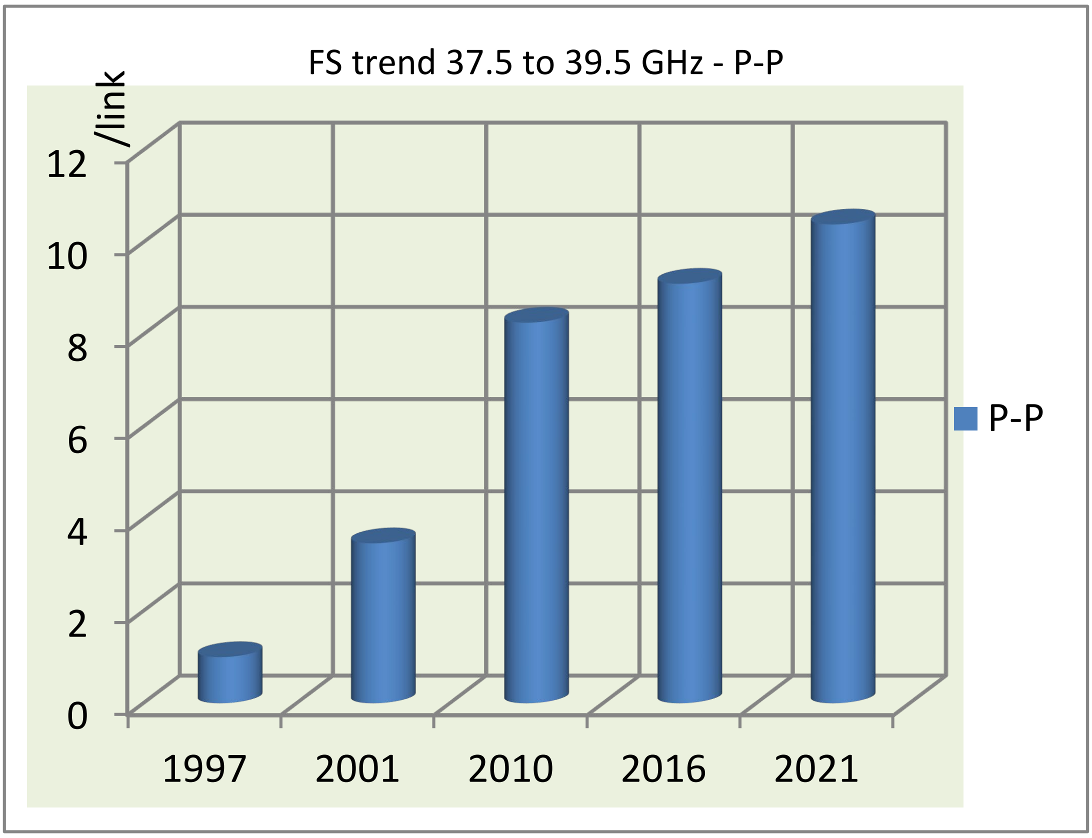


Figure 40: Historical trends for P-P links in band 37.5-39.5 GHz in CEPT (normalised to links operating in 1997)

Hop length: 95% percentile of “typical” length is about 3 km (0.3 km for those indicated as “minimum”), 7 km is the 50% percentile of the “maximum” indication.

A1.24 40.5-43.5 GHZ BAND

In the 2021 revision, 12 responding countries (Austria, Belgium, Bosnia and Herzegovina, Czech Republic, Finland, Germany, Ireland, Italy, the Netherlands, Norway, Serbia and Switzerland) declared the band to be open to P-P which is used by about ten responding administrations, with an overall number of about 6000 active links.

The channel plan follows the ERC Recommendation (01)04 [43], no national exceptions are declared.

Just P-P use has been reported.

Link-by-link licensing is mostly used (ten responding administrations – Belgium, Bosnia and Herzegovina, Czech Republic, Finland, Germany, Ireland, Italy, the Netherlands, Serbia and Switzerland) and block license (Norway and United Kingdom) is also present.

Majority of links are addressed to mobile backhauling and broadcasting infrastructure, with medium to high capacity; other generic uses are also noted.

Expectation for growth is expressed by one responding administration (Switzerland) while another (Ireland) noted possibility of a reduction. Possibility of allocation to other applications is given by Germany, while congestion is noted by one responding administration (Norway).

Possibility to utilise 224 MHz BW channels are reported by Finland and Switzerland.

Use of ATPC is specifically indicated by four responding administrations (Czech Republic, Germany, Norway and Switzerland) and ACM is almost noted by three responding administrations (Ireland, Norway and Switzerland).

Class 4 antennas are required by Finland, Class 3 are used as minimum antenna class by three responding administrations (Bosnia and Herzegovina, Ireland and Switzerland), while Belgium and Netherlands allow Class 2.

The number of declared active links is indicated in Table 19, while trend is reported in Figure 41. This band has been opened to P-P applications in 2010.

Table 19: Number of active links declared in RF range 40.5-43.5 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Station
2010	73			3
2016	5459	5299 (Note 1)	-	16
2021	5962	5960 Note 2:	-	-
Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires				

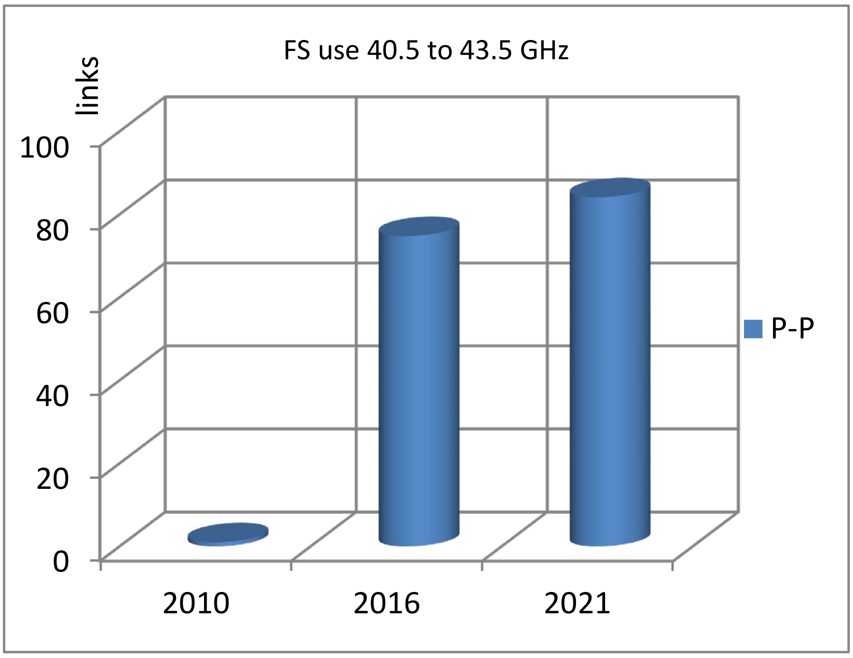


Figure 41: Historical trend for P-P and P-MP links in band 40.5-43.5 GHz in CEPT (normalised to links operating in 2010)

Hop length: 95% percentile of "typical" length is about 3 km (2 km for those indicated as "minimum"), 5 km is the 50% percentile of the "maximum" indication.

A1.25 48.5-50.2 GHZ BAND

No use of FS is indicated for this band, although some administrations declares possibility of P-P link topology mostly as link-by-link regime.

Channel plan for possible realisations follows Recommendations ERC Recommendation 12-11 [76].

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

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

A1.26 50.4-51.4 GHZ BAND

No use is reported in FS for this band, with very few indications (two responding administrations (Finland and Malta) indicate the band as open for use for P-P links, with link-by link licensing regime.

Low availability of equipment exists for this band.

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 few links in Switzerland, with length below 2 km. It is currently open in less than 10 CEPT responding countries.

ERC Recommendation 12-11 is indicated for a possible channel plan.

Majority of responding countries indicate a link-by-link licensing regime but possibility of block licence.

Low availability of equipment exists for this band.

A1.28 55.78-57 GHZ BAND

No active links have been indicated. Recommendation T/R 12-11 is indicated for a possible channel plan.

From the replies to the questionnaire, the planned licensing regime is mostly link-by-link based (seven countries gave reply), with few administrations providing indication of possibility of block assignment.

Concerning the usage of the band, no expectations to increase the use in coming years are reported.

Low availability of equipment exists for this band.

A1.29 57-64 GHZ BAND

Most responding administrations indicate that the band is open in their administrative domains.

The band is used by FS, with more than 22000 links in operation, declared by responding administrations; significant use is reported by 2 of them (Czech Republic and Slovak Republic).

Two sub-bands have been indicated: 57-59 GHz (about 1500 links) and 59-64 GHz (about 7000 links).

The channel plan for this band (57-59 GHz) follows ECC Recommendation (09)01 [54] which combines the whole 57-64 GHz range specifically for P-P application with Multi Gigabit Wireless Systems (MGWS) following ERC Recommendation 70-03 [55] and ETSI EN 302 567 [56] No national channel plan is declared.

Licence exemption regime is used by most answers (8-9 administrations), link-by link is declared by five responding administrations, light regime by 4.

Possible use for P-P is reported by 11 responding administrations (Bosnia and Herzegovina, Bulgaria, Czech Republic, Finland, Germany, Hungary, Latvia, Malta, Serbia, Slovak Republic and United Kingdom), Slovak Republic and United Kingdom also allow P-MP.

High capacity links have been reported, link-by-link. No specific use has been noted (fixed, broadband, other uses have been indicated).

Possibility of increase of use is indicated by few responding administrations. Antenna class 2 is indicated by two responding administrations as a minimum class.

Few indications of link lengths are available, all referring to links in range below 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 six responding administrations, although only in one of them (Czech Republic) a significant use (about 8000 link) is reported in this band.

Four administrations indicated unlicensed regime, while three countries declared light licence.

Foreseen application for P-P links is reported.

The frequency band is used according to the ECC Recommendation (05)02 [84], without indication of national frequency plans.

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

The use of these joined bands is recent, and the number of active links is continuously increasing (more than 4500 at time of this revision) in most responding administrations; in about 10 of them, more than 2000 links are in operation.

ECC Recommendation(05)07 [44] is used by all responding administration, no channel plan for the light licensed part is used in United Kingdom. Reference to Recommendation ITU-R F. 2006 (same channel plan as ECC) is also given. No national plan is indicated.

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

24 responding administrations indicate this joined bands as open only for P-P use.

Link-by-link licensing regime is indicated by 18 responding administrations (Belgium, Bosnia and Herzegovina, Cyprus, Finland, France, Germany, Ireland, Italy, Latvia, Malta, Moldova, the Netherlands, Norway, Romania, Slovenia, Sweden, Türkiye and United Kingdom), block license is used by 3 (Belgium, Malta and Switzerland).

Light licensing regime is referred to by six responding administrations (Bulgaria, Croatia, Czech Republic, Hungary, Norway United Kingdom) and license exemption is indicated by Serbia

Most applications are indicated for High capacity dedicated to mobile backhaul, other generic uses is also indicated.

Expectation to increase band use in next future was indicated by Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Finland, France, Germany, Hungary, Ireland, Latvia, Malta, Moldova, the Netherlands, Norway, Romania, Slovenia, Sweden, Switzerland and Türkiye, plan for HD-FS is indicated by one responding administration (Slovenia).

Some congestion is reported by few answering administrations:

- Use of ATPC specifically indicated by six responding administrations (France, Germany, Moldova, Norway, Sweden, Switzerland) and ACM is almost noted by five administrations (Croatia, Ireland, Norway, Sweden, and Switzerland);
- Possible use in BCA is indicated by Croatia, Latvia, Sweden, while MIMO is indicated by Norway and Sweden;
- Class 3 are used as minimum antenna class by seven responding administrations (Bosnia and Herzegovina, Bulgaria, Finland, France, Ireland, Sweden and Switzerland), while Belgium, and Netherlands allow Class 2.

This band was opened to P-P applications between 2005 and 2010 and the trend shows continuous increase.

The number of declared active links is indicated in Table 20, while trend is reported in Figure 42.

Table 20: Number of active links declared in RF range 71 to 86 GHz

Year	P-P total	PP (same admins)	P-P (unidirectional)	P-MP Central Stations
2010	96		-	-
2016	8440	8248 (Note 1)	-	-
2021	47522	47041 (Note 2)	-	-

Note 1: 2016 data for administrations responding both 2016 and 2021 questionnaires
Note 2: 2021 data for administrations responding both 2016 and 2021 questionnaires

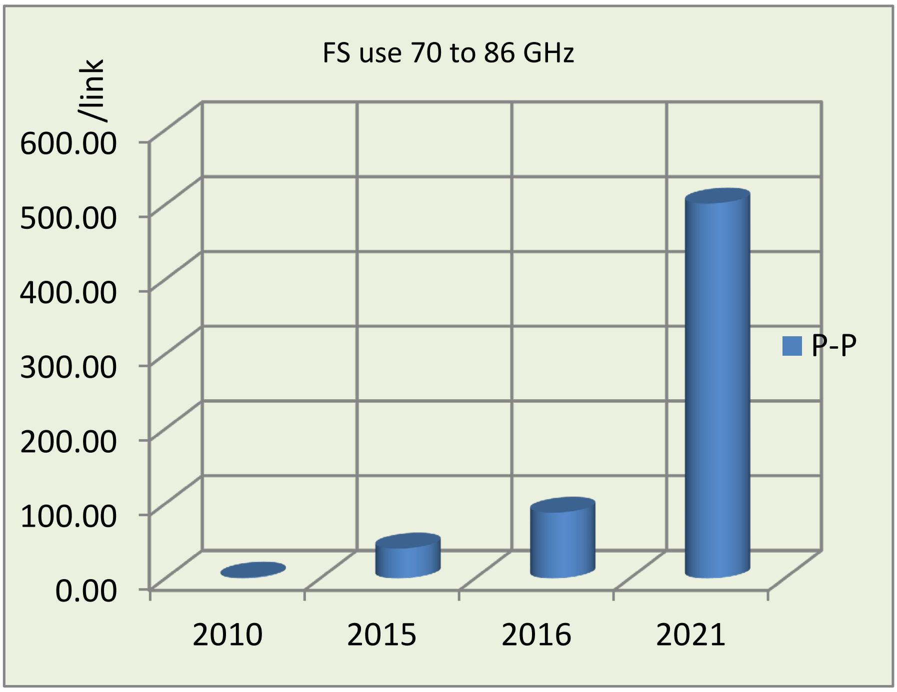


Figure 42: Comparative trends for the P-P links in the band 71-76/81-86 GHz in CEPT (normalised to 1 link in 2010)

Hop length: 95% percentile of “typical” is about 3 km (200 m for those indicated as “minimum”), 10 km is the 50% percentile of the “maximum” indication.

A1.32 92-95 GHZ BAND

No use is indicated in this frequency band.

Band is currently open in 1 responding administration, referring to light licensing regime for P-P use.

ECC Recommendation (14)01 [77] is given as reference by most answers.

A1.33 FEES

In general, licence fee depends on channel bandwidth and RF band. In several cases, the number of Tx is considered in calculation fees, while some administrations include also geometric considerations (area).

Concerning licence duration, most used time slot is 5 years, but actual duration depends on administration’ s strategies; time base of 10 years is sometimes referred, but other periods are also indicated, such as 15 years, 6, 8 years; and 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 21.

Table 21: Fees related website list

Country	Webpage	Functional link	English
Albania	http://akep.al/informacion/pagesa/llojet-e-pagesave; http://akep.al/informacion/pagesa/aktet-e-pagesave;	Y	N
Austria	http://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10012777	Y	N
Azerbaijan	http://spektar.rak.ba/en/Kalkulator.aspx	Y	Y
Bulgaria	http://crc.bg/files/_bg/TaxTarif_.pdf	Y	N
Switzerland	http://www.admin.ch/opc/fr/classified-compilation/20072116/index.html#a8	Y	N
Croatia	http://www.hakom.hr/default.aspx?id=273)	Y	Y
Cyprus	http://www.mcw.gov.cy/mcw/DEC/DEC.nsf/All/D55CAB220E004339C22579C1004DD8B6?Opendocument	Y	Y
Czech Republic	http://www.ctu.cz/ctu-online/poplatky-vybirane-ctu/poplatky-za-vyuzivani-radiovych-kmitoctu.html	Y	N
Denmark	https://eng.sdfi.dk/Media/638006573273922308/frekevensafgifter_2022_0_0.pdf	Y	N
Estonia	https://www.riigiteataja.ee/en/eli/511022015002/consolide	Y	Y
Finland	No info		
France	http://www.arcep.fr/index.php?id=11976 http://www.arcep.fr/fileadmin/reprise/dossiers/taxes/simulateur-cout-fh-nov2014.xlsm	Y	N
Germany	www.bundesnetzagentur.de	Y	N
Greece	https://www.eett.gr/opencms/export/sites/default/EETT_EN/Electronic_Communications/Radio_Communications/Rigths_Of_Use/FixedService/FeesFixedService.pdf	N	
Hungary	http://njt.hu/cgi_bin/njt_doc.cgi?docid=136918.319221	Y	N
Ireland	http://www.comreg.ie/radio_spectrum/search.541.874.10014.0.rslicensing.html	N	
Italy	http://www.parlamento.it/parlam/leggi/deleghe/03259dl4.htm	N	
Latvia	http://likumi.lv/ta/id/267460	Y	N
Lithuania	http://www.rrt.lt/rrt/lt/verslui/istekliai/radijo-dazniai/rrl.html	Y	N
Malta	https://legislation.mt/eli/sl/35.1/eng	Y	Y
Montenegro	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
Netherlands	http://www.agentschaptelecom.nl/onderwerpen/zakelijk-gebruik/straalverbindingen/tarieven-straalverbindingen	Y	N
Norway	http://eng.nkom.no/technical/frequency-management/fees-and-regulations/frequency-charges	Y	N
Portugal	http://www.anacom.pt/render.jsp?contentId=1180549#.VN3n6Sy4Jek	Y	N

Country	Webpage	Functional link	English
Romania	http://www.ancom.org.ro/uploads/forms_files/decizia_2012_551_versiune_consolidata_4_iulie_20141405000552.pdf	Y	N
Russia	http://rkn.gov.ru/communication/p552/	Y	N
Poland	Rulebook on radio-frequency usage fees	N	
Slovak Republic	https://www.teleoff.gov.sk/data/files/52311_51988_opatrenie-4_2022-pridelenie-frekvencii.pdf	Y	N
Slovenia	http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_827 http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_1010	Y	N
Spain	No info	N	
Sweden	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
Türkiye	Examples have been given in response to the questionnaire	N	
United Kingdom	http://www.legislation.gov.uk/uksi/2011/1128/contents/made	Y	Y

ANNEX 2: NATIONAL EXAMPLES OF REGULATING FIXED SERVICE

A2.1 FRANCE

A2.1.1 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: https://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.

A2.1.2 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.

A2.1.3 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.

A2.1.4 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

A2.2.1 Organisation

The National Media- and Infocommunications Authority (NMHH) is divided into several organisational units under which individual directorates deal with various fields related to regulatory issues on media and infocommunications. The directorates are further divided into particular departments. The main technical related directorates are under the same organisational unit dealing with frequency use: the civil, the non-civil frequency management directorate and directorate of measurement affairs. There are four departments under the civil Frequency- and Identifier Management Directorate responsible for certain fields, like spectrum management, frequency planning and coordination, and frequency licensing. The cooperation and coordination procedure between the civil and non-civil directorates are highly efficient as they are under the same organisational unit, which facilitates the processes.

A2.2.2 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 a 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 for certain amount of spectrum (frequency block) can be gained through awarding procedure. In this case flexibility is provided for the spectrum right holders regarding the frequency use and technical planning in their own frequency blocks. For the time being in Hungary block assignment method is applied only in a few frequency bands: in 26 GHz band until the fixed service licences expire in 2027 and in the 32 GHz frequency band to be awarded in 2023 for fixed service use which has been identified for such use due to the commitment on the introduction of MFCN in the 26 GHz band.

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, P-MP and mesh applications can be used on a licence-exempt basis.

In case of link-by-link assignment and light licensing the duration of the individual licence is mostly 5 years, in case of awarding procedure and block assignment the duration of the entitlement to radio spectrum use is defined individually (e.g. 15 years).

A2.2.3 Planning and design

In Hungary, the radio networks are designed either by the service provider itself, or the planning task is delegated to dedicated designer companies. For the technical planning of new links in a particular frequency band the authority have the right to provide data on the existing licenced links, networks. These data also cover the interference environment, which must be taken into consideration in the planning phase. It should be mentioned that only certified professionals with authority licence may perform technical planning duties and the designer carries extensive responsibility in respect of the interference calculations. After the planning phase, the authority, granting the licence, is entitled to verify the technical plans.

A2.2.4 Frequency fees

In Hungary there are different calculation methods for different types of frequency use. In case of link-by-link assignment the total amount of fee to be paid consists of two components:

- one-time radio spectrum reservation fee (which is equal to the radio spectrum usage fee for one month);
- monthly radio spectrum usage fee.

The amount of the radio spectrum usage fee is determined by legal rules. In case of link-by-link assignment the fee should be paid per transmitter and consists of two factors: radio spectrum usage unit rate [HUF/kHz] which depends on the frequency band and type of application (point-to-point or point-to-multipoint) and channel bandwidth. The fee to be paid is the product of the two factors.

In case block assignment only radio spectrum usage fee (band fee) shall be paid which consists of the following factors:

- Fixed radio spectrum usage unit rate (independent from the frequency band);
- Frequency-dependant band multiplier;
- Spectrum amount acquired.

The fee to be paid is the product of the three factors.

In case of light licensing a fixed price should be paid per station in the 60 and 70/80 GHz band.

A2.2.5 International co-ordination

For the effective utilisation of the radio spectrum and management of possible interference issues in border areas, there is a need for international coordination or notification of frequencies in several cases. NMHH fulfils its international frequency coordination activity according to the relevant international regulations, recommendations and bi- and multilateral agreements. The ITU regulation (Radio Regulations) gives guidance with respect to the international co-ordination for various types of services and applications which can be taken as a basis. In addition Hungary applies the HCM (Harmonised Calculation Method) agreement – signed by several European administrations – as a regional basic document with respect to the co-ordination which is adopted by most of our neighbouring countries. In some frequency bands bi- or multilateral agreements on preferential channels or codes have been concluded. With regard to the fixed service bands we have such multilateral agreements for the 26 GHz and the 28 GHz band (where typically block assignment can be used for point-to-point and point-to-multipoint systems) with preferential and non-preferential frequency blocks.

A2.2.6 Fixed service frequency bands in Hungary

National regulations are fundamentally based on the relevant ECC Decisions and Recommendations with the exception of some special national use (e.g. 12 GHz MMDS use).

It should be noted that in Hungary the optical network infrastructure is fairly well-established in most part of the country, which means that long-haul backbone links in the lower frequency range are not so crucial and dominant. On the other hand the increasing backhaul capacity requirements can be fulfilled in the higher frequency bands:

- 1.5 GHz and 2 GHz frequency bands are no longer used for fixed service applications;
- The high-capacity, long distance microwave backbone networks are operated at lower frequencies (in the 4 GHz (3.8-4.2 GHz), L6 GHz (5.925-6.425 GHz),) but they are losing ground to optical cable transmission, so the number of the links is low (especially in the 4 GHz band; only a few links) and stable (most of them remained in operation from past deployments);
- Due to nation-specific military use in U6 (6.425-7.125 GHz) and 8 GHz (7.9-8.5 GHz) band coordination is required between civil and non-civil department. For this reason and due to higher radio spectrum usage fees and the well-established optical infrastructure, these bands are not used;
- L7 band in Hungary is designated exclusively for non-civil fixed service links, U7 GHz band is moderately used for long haul links;
- 10 GHz (10-10.68 GHz) band is slightly used for broadcast related point-to-point links;
- 11 GHz (10.7-11.7 GHz) band is moderately used for high capacity (both 40 and 80 MHz channel bandwidths are available) backhaul links (no significant increase is foreseen). In the lower part of the band transmitter power restriction for fixed service use is applied due to broadcasting satellite service and stringent values on minimum antenna gain is required in the whole band for minimizing the risk of interference on uncoordinated VSAT receivers;
- 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 (restricted frequency usage rights);
- 13 GHz (12.75-13.25 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 non-civil purposes. Due to the band rearrangement the number of civil FS links decreased;
- 18 GHz (17.7-19.7 GHz) band is heavily used by high capacity (110 MHz maximum channel bandwidth is available) 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. The upper part of the band is designated for non-civil purposes;
- 26 GHz (24.5-26.5 GHz) band was auctioned through an awarding procedure and block assignment method has been applied. The acquired frequency blocks can be used for fixed service P-P and P-MP applications until the radio spectrum usage rights and licences expire (most of them in 2027). . The block assignment method provides flexibility in technical planning and management in the dedicated frequency blocks used by the right holders. Due to the fixed band-fee and flexible use the band is heavily used for backhaul links, but migration to other bands is expected because of the EU commitments on the introduction of MFCN in the 26 GHz band;
- 28 GHz band is not used for fixed service applications;
- 31 GHz (31-31.3 GHz) band is not used, but there has been some interest from a national service provider and a manufacturer in relation with the conditions for the use of the band;
- 32 GHz (31.8-33.4 GHz) band is to be awarded in 2023 for fixed service point-to-point use applying block assignment method. It can offer to the radio spectrum right holders of the 26 GHz frequency band an alternative which offers similar wave propagation characteristics and radio spectrum management solutions taking into account long-term investments. The maximum channel bandwidth available is 112 MHz taking into account that a spectrum cap of 168 MHz is defined per licensee;
- 38 GHz band is massively used by high capacity (mostly backhaul) links in urban areas, but a part of the links has been migrated to 70/80 GHz band due to higher achievable capacity with similar hop length. The upper part of the band is designated for non-civil purposes;

- The frequency range 40-59 GHz is very rarely used by fixed service applications (there are only a few links in 57-59 GHz band);
- 60 GHz (59-64 GHz) and 70/80 GHz (71-76/81-86 GHz) bands are used for very high capacity short-haul links applying light licensing method. The operators themselves can manage the registration of the links in the online database and can design the network taking into account the existing links without the contribution of the Authority;
- It should be noted that the 59-64 band is very slightly used, but 70/80 GHz band is very popular as a good solution for very high capacity last mile backhaul links with small antennas;
- 90 GHz and higher frequencies are not used for fixed service applications, yet.

A2.3 UNITED KINGDOM

A2.3.1 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 United Kingdom it is essential for the United Kingdom to effectively manage and secure optimal use of the fixed service spectrum and strategy which is developed through on-going consultations with United Kingdom 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;
- Shared Access licences.

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.

A2.3.2 Link-by-link Assignment Process

Fixed point to point link assignments are made by Ofcom in the 4 GHz, Lower 6 GHz, Upper 6 GHz, 7.5 GHz, 8GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz, 52 GHz, 55 GHz, and parts of the 70/80 GHz bands. More details can be found here.

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. United Kingdom 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.

A2.3.3 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 bands. Whilst these bands are allocated to the fixed service, users of that spectrum are not limited to using this spectrum for the fixed service. More details can be found here.

A2.3.4 Self-Coordinated /light licensed Spectrum

The parts of the 70/80 GHz bands have been made available in the United Kingdom 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 60 GHz (57-71 GHz), 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands are also available for higher transmit power up to and including 55 dBm e.i.r.p under Spectrum Access EHF licenses framework which sets conditions including requirement to keep records on location of devices.

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

A2.3.5 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.

A2.3.6 Licence Exemption

The 60 GHz (57-71 GHz) band has been made available on a licence exempt basis which also allows for fixed links use with transmit power level up to and including 40dBm e.i.r.p. More details can be found here.

A2.3.7 Shared Access License

The shared access licence is part of a new framework for enabling shared use of spectrum, aiming to make it easier for people and businesses to access spectrum for a wide range of local wireless connectivity applications.

The shared access licence is currently available in four spectrum bands which support mobile technology:

- 1800 MHz band: 1781.7-1785 MHz paired with 1876.7-1880 MHz;
- 2300 MHz band: 2390-2400 MHz;

- 3800-4200 MHz band; and
- 24.25-26.5 GHz. This band is only available for indoor low power licences.

Two types of licences are available:

- Low power licence. This authorises users to deploy as many base stations as they require within a circular area with a radius of 50 metres as well as the associated fixed, nomadic or mobile terminals connected to the base stations operating within the area.
- Medium power licence. This authorises a single base station and the associated fixed, nomadic or mobile terminals connected to the base station.

Further information can be found on Ofcom website here.

A2.3.8 Spectrum Pricing

The Wireless Telegraphy Act of 2006 (WTA'2006) provides 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. United Kingdom 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.

A2.3.9 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

A2.4.1 APPROACH OF LICENSING IN THE 57-64 GHz, 64-66 GHz AND 70/80 GHz BANDS

A2.4.1.1 Frequency bands 57-64 GHz and 64-66 GHz

According to ERC Recommendation 70-03 annex 3, Note 3 [55], the Czech Republic kept the possibility to deploy Fixed point-to-point links based on ETSI EN 302 217-2 [10] harmonised standard.

Light licensing regime was established with self-coordination mechanism. To allow parallel use of Wideband data transmission systems and Fixed point-to-point links, simplified supportive interference calculator was established. More details can be found on https://rlan.ctu.cz/en and section General authorisations (https://www.ctu.eu/general-authorisation).

A2.4.1.2 Frequency bands 71-76 GHz and 81-86 GHz

In the year 2008 the Czech Republic opened to civil use the upper part of the bands only (74-76 GHz and 84 - 86 GHz), because the lower parts were allocated to the military use. Towards the end of the year 2009 (after the revision of the Recommendation ECC Recommendation (05)07 [44]) the rest of the bands have been released from the military applications and opened to civil applications the bands 71-76 GHz and 81-86 GHz. Light licencing / 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 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. It is possible to deploy both FDD and TDD in 70/80 GHz bands.

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.

A2.5 CROATIA

In Croatia, HAKOM (Croatian Regulatory Authority for Network Industries) is responsible for overall management of the radio spectrum for civil use. In accordance with the Electronic Communications Act, related bylaws, and the Constitution, the Convention and the Radio Regulations of the International Telecommunication Union (ITU), HAKOM ensures and stimulates effective management and use of the radio frequency spectrum. The achievement of the effective spectrum management implies interference-free operation of radio communications services, taking into account protection of human health and safety of users and other persons. HAKOM prepares and adopts Radio Frequency Allocation Table and Radio Frequency Assignment Plan, grants licences for the use of radio frequencies, performs inspection and market surveillance of radio equipment, issues and publicises regulated radio interfaces, carries out control and monitors RF spectrum and protects users from interferences.

The Radio Frequency Allocation Table specifies the allocation of radio frequency bands for individual radio communications services in accordance with Radio Regulations of the International Telecommunications Union (ITU).

The Radio Frequency Allocation Table is a constituent part of the Ordinance on the allocation of the radio frequency spectrum, which is adopted by the minister upon proposal of the Council of HAKOM.

The Radio Spectrum Allocation Table may specify different allocations, conditions of assignment and use and manners for granting a license for the same radio frequency band.

The Radio Spectrum Allocation Table is available at HAKOM's website:

https://www.hakom.hr/hr/tablica-namjene-rf-spektra/238

The conditions for the assignment and use of radio frequencies shall be prescribed in detail by the Ordnance on assignment and use of radio frequency spectrum, which could also be found at HAKOM's website: https://www.hakom.hr/hr/pravilnici-2042/2042.

A2.5.1 Link-by-link assignment process

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 licences, especially in the higher frequency bands. Most of the frequency bands for fixed service are under link-by-link assignment regime.

Fixed point-to-point link assignments are available in the following bands;

- 2 GHz (2085-2110 MHz);
- 4 GHz (3800-4200 MHz);
- Lower 6 GHz (5925-6425 MHz);
- Upper 6 GHz (6425-7125 MHz);
- 7.2 GHz (7125-7425 MHz);
- 7.5 GHz (7425-7725 MHz);

- Lower 8 GHz (7725-8275 MHz);
- Upper 8 GHz (8275-8500 MHz);
- 11 GHz (10700-11700 MHz);
- 13 GHz (12750-13250 MHz);
- 14 GHz (14500-14620 / 15230-15350 MHz);
- 18 GHz (17700-19700 MHz);
- 23 GHz (22000-22600 / 23000-23600 MHz);
- 28 GHz (27500-29500 MHz);
- 38 GHz (37000-39500 MHz);
- 70/80 GHz (71000-76000 / 81000-86000 MHz).

The applicant has to fill in an application form, which is provided at the HAKOM's website. For registered applicants an electronic exchange is possible. The applicant 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, modulation and Tx output power. In this case, also the frequency assignment is sent to the customer in electronic format via e-mail. Applications should be processed by the HAKOM within 6 weeks.

Applicants have no legal basis for particular transmitting frequencies, but may state their preference. During the assignment procedure the HAKOM will check whether or not the preferred or other frequencies are available and can be coordinated. Interference calculation will be processed as following:

- 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, if needed;
- Coordination with other services (e.g. FSS), if needed.

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 fee is imposed and assignment is made for 5 year period (if not requested differently). After that period extension request is required.

Military has a priority use of 7.2 GHz (7.250-7.375 GHz) and lower 8 GHz (7.900-8.025 GHz) bands. These bands are also available for civil use but have to be coordinated with the military first.

A2.5.2 Self-Coordinated / Light licenced spectrum

The 70/80 GHz bands have been made available in Croatia a self-coordinated light licenced basis via a web based tool. These bands are intended for fixed terrestrial millimetre-wave point-to-point links, typically for short hop high capacity wireless access and infrastructure networks. Only FDD is allowed.

This mechanism of spectrum management consists of a simple registration process with the responsibility of coordination delegated to the licensee. HAKOM has to validate the filled form prior to frequency assignment. To enable coordination and establish priority, all link details are publicly available on HAKOM's website after registration.

A2.5.3 Licence Exemption

The 60 GHz (57-71 GHz) band has been made available on a licence exempt basis (via general licence) which allows for fixed links use with transmit power level up to and including 40dBm e.i.r.p. 23 dBm/MHz e.i.r.p. density, and 55 dBm e.i.r.p., 38 dBm/MHz e.i.r.p. density and transmit antenna gain ≥ 30 dBi that applies only to fixed outdoor installations (according to ERC Recommendation 70-03, annex 3 [55]).

General licences could be found here:

- OD-230;
- https://www.hakom.hr/UserDocsImages/op%C4%87e%20dozvole%20prosinac%202009.g/Opca_dozvola_230.pdf;
- OD-231;
- https://www.hakom.hr/UserDocsImages/op%C4%87e%20dozvole%20prosinac%202009.g/Opca_dozvola_231.pdf;
- OD-232;
- https://www.hakom.hr/UserDocsImages/op%C4%87e%20dozvole%20prosinac%202009.g/Opca_dozvola_232.pdf.

A2.5.4 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 coordination process is established to respect the interests of the existing users.

A2.5.5 Fees and contributions

Fees for directed point-to-point links are determined by the Ordinance on the payment of the fees for carrying out tasks of the Croatian Regulatory Authority for Network Industries (Article 12) and the Ordinance on the payment of the fees for the right to use addresses, numbers and radio frequency spectrum (Article 6).

Ordinances could be found respectively on the following links:

- NN 154/2022;
- https://narodne-novine.nn.hr/clanci/sluzbeni/2022_12_154_2430.html;
- NN 151/2022;
- https://narodne-novine.nn.hr/clanci/sluzbeni/2022_12_151_2359.html.

According to the Ordinance on the payment of the fees for carrying out tasks of the Croatian Regulatory Authority for Network Industries the amount of the annual fee is calculated as following;

1. For the use of radio frequency spectrum above 1 GHz in directional point-to-point links, which use a spectrum width greater than 2 MHz, the fee is EUR 106.18

2. For the use of radio frequency spectrum above 1 GHz in directional point-to-point links, which use a spectrum width of 2 MHz or less, no fee is charged.

3. For the use of radio frequency spectrum above 1 GHz in directed point-to-point links, which the permit is issued according to a simplified procedure (Light Licencing), the fee is 26.54 €.

According to the Ordinance on the payment of fees for the right to use addresses, numbers and radio frequency spectrum, the amount of the annual fee for the use of unpaired RF spectrum for directed point-to-point links is calculated according to the expression:

Annual fee [per 1 MHz] = 0.16 x a x b x maximum (1, minimum (5, c/d))

a = 66 €

b = congestion factor dependant on a frequency band (higher the frequency - lower the factor)

Table 22: Congestion coefficient

No.	Lower frequency limit (GHz)	Upper frequency limit (GHz)	Radio frequency band congestion coefficient
1	-	0.470	8
2	0.470	1.710	4
3	1.710	2.500	2
4	2.500	10.000	1
5	10.000	14.500	0.8
6	14.500	24.500	0.4
7	24.500	42.500	0.2
8	42.500	-	0.01

c = minimum hop length defined for each frequency band (lower the frequency higher the minimum hop length, in certain cases dependant on link capacity/modulation scheme).

Table 23: Minimum hop length

No.	Lower frequency limit (GHz)	Upper frequency limit (GHz)	Minimum hop length (km)
1	-	0.790	35
2	0.790	1.710	30
3 (Note 1)	1.710	10.000	25
4	10.000	14.500	12
5	14.500	19.700	5
6	19.700	-	0
Note 1: for links using modulation schemes with at least 64 states and a transmission capacity of at least 70 Mbit/s, the minimum hop length in the frequency band 1.71 GHz - 10 GHz is 20 km.			

d = actual hop length of a licensed link

The maximum(x, y) function returns the largest value of the arguments.

The minimum(x, y) function returns the smallest value of the arguments.

According to the mentioned formula, the amount of the annual fee depends on the used frequency band for the microwave link, the width of the channel and the distance between the locations forming the link.

If the applicant or license holder is assigned a radio frequency spectrum with a bandwidth other than 1 MHz, the amount of the fee will be proportionally reduced or increased.

If the applicant or license holder uses a total of 82.5 MHz or more of continuous radio frequency spectrum in the same radio frequency sub-band on one microwave link, with the use of horizontal and vertical polarisation in each individual radio frequency channel (XPIC), 50% of the regular fee should be paid.

For the use of radio frequency spectrum above 1 GHz in directed point-to-point links, for which the permit is issued according to a simplified procedure (self-coordinated / light licencing), 10% of the regular fee should be paid.

Permits for microwave links are usually issued for a period of 5 years, but the license holder can request the issuance of a licence for a shorter period of time. If the permit is issued for a term shorter than one year, the fee will be reduced proportionately. All fees have to be paid annually at the beginning of one year period.

ANNEX 3: LIST OF REFERENCES

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