UNOFFICIAL MACHINE TRANSLATION

Analysis of the current and future use of the 42 GHz band

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Contents

List of abbreviations and explanations

UHF	Ultra-high frequency
ECC	Electronic Communications Committee
XPIC	Cross-polarisation interference cancellation technology
ETSI	European Telecommunications Standards Institute
ČTÚ	Czech Telecommunications Office
WRC-19	World Radiocommunication Conference 2019
IMT	International Mobile Telecommunications
FWA	Fixed Wireless Access
CEPT	European Conference on Postal and Telecommunications Services
MFCN	Mobile/Fixed Communication Network
FCC	Federal Communications Commission
FSS	Fixed Satellite Service
FS	Fixed Service
RAS	Radio Astronomy Service
V2X	Vehicle-to-Everything
BTS	Base transceiver station
CPE	Customer-premises equipment
MIMO	Multiple-Input Multiple-Output
5G	Fifth-generation networks
DAS	Distributed Antenna System
NLOS	Non-Line-of-Sight (without direct line of sight)
NR FR2	New Radio Frequency Range 2
EFTA	European Free Trade Association
3GPP	3rd Generation Partnership Project
MWS	Multimedia Wireless Systems
MGWS	Multi-Gigabit Wireless Systems
IoT	Internet of Things (IoT)
TDD	Time-division duplex
SNR	Signal-to-noise ratio
NGSO	Non-Geostationary Orbit
dB	Decibel
UE	User Equipment

Executive Summary

5G NR (New Radio) technology is key to increasing the capacity of mobile networks, particularly in areas with high population density. Furthermore, it is suitable for high-speed communication with direct line of sight to specific locations. In the Czech Republic, the 42 GHz band (40.5–43.5 GHz) is currently used for point-to-point fixed-service links with gigabit transmission speeds. However, this band is less popular than the unlicensed 80 GHz band, which offers higher capacity and flexibility with minimal risk of interference. At a global level, however, the 42 GHz band is expected to be used for mobile telecommunications (MFCN) in the future. Geographical separation and advanced antenna technologies are essential to minimise collisions with other services. Authorisation of the band requires individual licences or registration, with different specifications for hotspots. The use of active sector antennas, which enable precise signal steering, is recommended.

Ongoing research at the Brno University of Technology is focusing on the characteristics of signal propagation in the 42 GHz band, which should contribute to improving the practical implementation of these solutions. Key elements of 5G NR standardisation in this band include flexible spectrum (meaning the ability to use multiple frequency bands and different channel widths), advanced modulation technologies, massive MIMO and beamforming, which enable efficient spectrum utilisation and higher data rates. The 42 GHz band is ideal for short distances and dense urban or suburban hotspots, where active antenna systems utilise high gain, i.e. high directivity in the direction of user terminal traffic. However, it is not suitable for nationwide mobile network coverage due to its limited range. Buildings and other obstacles pose a significant challenge to signal propagation in urban areas; this can be addressed through the appropriate placement of access points and intelligent distributed antenna systems (DAS).

The development and implementation of 5G technologies in the 42 GHz band are driven by industry trends and global demand for higher transmission capacities. Millimetre-wave technologies, such as 80 GHz (E-band) and 60 GHz (V-band), have already proven their viability and inspired the use of similar bands in 5G networks. Standardisation and preparation of the 42 GHz band for commercial use are still ongoing. ETSI and 3GPP are currently focusing on developing standards that are key to technological development in this band. Documents such as ETSI TS 138 104 and 3GPP specifications set out the technical requirements for the effective use of the 42 GHz band for 5G NR, including channel n259, which supports wideband transmissions in time division duplex (TDD).

The European Commission’s strategy ‘Connectivity for a European Gigabit Society’ sets out the objectives for building a gigabit society by 2030. The telecommunications sector is expected to demand high-capacity technologies for 5G networks, including FWA solutions based on 5G NR. The 42 GHz band has the potential to become a key element in meeting the needs of Industry 4.0 and the future development of mobile and fixed communications networks. Developments in the market environment have led to the creation of specialised devices with reduced capabilities (SoCs) that do not require all the functions of 5G networks. These so-called RedCap devices can be used, for example, as fixed or campus network equipment.

Management summary

5G NR (New Radio) technology is key to increasing the capacity of mobile networks, particularly in areas with high population densities. In addition, it is suitable for high-speed communications with direct line of sight to specific locations. In the Czech Republic, the 42 GHz band (40.5–43.5 GHz) is currently used for point-to-point fixed service links with gigabit data rates. However, this band is less popular than the licence-exempt 80 GHz band, which offers higher capacity and flexibility with minimal risk of interference. However, at a global level, the 42 GHz band is expected to be used for mobile telecommunications (MFCN) in the future. Geographical separation and advanced antenna technologies are necessary to minimise interference with other services. Authorisation of the band requires individual authorisation or registration, with different specifications for hotspots. The use of active sector antennas is recommended to enable precise routing of signals.

Ongoing research at Brno University of Technology is focusing on the characteristics of signal propagation in the 42 GHz band, which should help to improve the practical implementation of these solutions. The key elements of 5G NR standardisation in this band are flexible spectrum, advanced modulation technologies, massive MIMO and beamforming, which enable efficient spectrum utilisation and higher transmission rates. The 42 GHz band is ideal for short distances and dense urban or suburban hotspots where antenna systems achieve high gain and narrow directivity. However, it is not suitable for wide nationwide coverage due to its limited range. Buildings and other obstacles pose a significant challenge to signal propagation in urban areas, which can be addressed through the appropriate placement of access points and intelligent distributed antenna systems (DAS).

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Introduction

Millimetre-wave bands present an opportunity to address certain wireless communication needs. With traditional technologies utilising centimetre-wave bands, transmission speeds are increased by improving data transmission efficiency within the limited (i.e. existing) bandwidth of communication channels. Due to high demand for the use of the traditional part of the spectrum, it is not possible to expand communication channels.

Significantly increasing the transmission capacity of wireless technologies through the development of higher-order modulation schemes has proved very difficult to implement in practice. The commercial availability of equipment utilising sparsely occupied sections of the spectrum in the millimetre band represents a quantum leap in wireless communication. The first widely deployed equipment to utilise wide channels in the millimetre bands for data transmission (up to gigabit links) was fixed point-to-point technology in the 74–84 GHz band. By utilising bandwidths in multiples of 250 MHz per communication channel, this technology enabled the rapid expansion of high-capacity mobile and fixed connectivity services with gigabit-level performance. A significant advantage of the millimetre bands is their high antenna directivity and the limited propagation of the electromagnetic field, particularly in environments with obstacles. These characteristics are utilised to advantage when planning the dense deployment of individual devices, as they almost eliminate the risk of mutual interference. Gradual technical developments over the past decade have yielded technologies capable of transmitting gigabit capacities even in point-to-multipoint systems. These technologies and their users are therefore awaiting a decision from regulators on how the millimetre bands are to be utilised. Further regulatory developments are expected in the 42 GHz band, as well as developments in terms of anticipated usage models; however, a certain degree of caution can be expected, for example in light of experience with 5G/26 GHz.

The 42 GHz band is not currently utilised to a great extent. In recent years, we have witnessed exponential growth in data consumption. Insufficient capacity within the mid-band spectrum, combined with the growing need for available capacity to meet demand, is leading almost all stakeholders to explore the commercial potential of using millimetre-wave bands. Development in this area is made possible primarily by advances in the development of new telecommunications technologies. The aim of the study is to describe the fundamental technical, regulatory and practical aspects of utilising the 42 GHz band. This document will subsequently serve as a basis for the Ministry of Industry and Trade and other bodies, including the Czech Telecommunications Office (ČTÚ), for strategic decision-making on the further development of telecommunications in the coming years.

The study includes a description of current global trends, the development of millimetre-wave technology and the application of the band for high-speed links. It also contains comprehensive recommendations on the approach to the future use of the 42 GHz band, with an emphasis on the intensive and efficient use of the band. The study focuses on describing the standardisation achieved in the use of technologies in the 42 GHz band and ensuring interoperability between different systems and devices. It addresses the promotion of the development of mobile communications networks and industrial applications that will utilise the 42 GHz band. It also addresses the challenges associated with the infrastructure development required for the use of the 42 GHz band, particularly with regard to the need for new transmitting equipment and antennas. Another topic is the effective coordination and integration of the 42 GHz band with other frequency bands within the wireless communications spectrum. Related to this is a chapter devoted to the current and potential regulatory frameworks for the use of the 42 GHz band and their impact on the development of new services and technologies. The study also examines the technological aspects associated with the implementation of communication systems in the 42 GHz band, including the need for high-performance antennas and resistance to interference. Another topic is the limited range and signal propagation in the 42 GHz frequency band, particularly in urbanised areas and for indoor use. Finally, the study focuses on real-world applications of 5G technology utilising the 42 GHz band, with particular emphasis on Industry 4.0.

The development of telecommunications infrastructure, particularly 5G technology, has significant implications for society as a whole and provides many reasons why governments should actively pursue it. Significant improvements in connectivity and internet speeds enable faster and more reliable communication for both individuals and businesses, whilst higher speeds and lower latency open the door to innovation in many areas, including education, healthcare, transport and entertainment. Governments concerned with the well-being of their citizens should strive to develop 5G infrastructure, as this technology has the potential to transform the economy, improve citizens’ quality of life and strengthen their position in the global economy. Investment in 5G is an investment in the future, bringing long-term benefits for society as a whole.

1 Regulatory approaches to the UHF frequency band

1.1 Current use of the 42 GHz band in the Czech Republic

The 40.5–43.5 GHz band is currently designated in the Radio Spectrum Utilisation Plan[1] for use by frequency-duplex fixed-service links in point-to-point mode[2] , in accordance with Recommendation ECC/REC/(01)04[3] . The permitted channel bandwidth is 112 MHz for each transmission direction. With state-of-the-art technologies utilising high modulation levels, the transmission capacity corresponds to gigabit data rates with single polarisation, with the possibility of doubling the transmission capacity by using the XPIC[4]dual-polarisation solution.

The original intention for the harmonised use of the spectrum is described in document ETSI TR 103 230[5] as a system for building microwave access networks for small cells in mobile networks. The use of the frequency spectrum is governed by the principles of technology neutrality; point-to-point fixed links are used for general telecommunications purposes.

Interest in the use of fixed services in the 42 GHz band is not growing significantly, and the number of newly established point-to-point fixed links in the fixed service is low. One reason for this is the preference for using frequency bands such as the 70/80 GHz bands, based on General Authorisation VO-R/23/08.2017-6[6] . The total number of valid individual licences for operation in the 42 GHz band reached in the second quarter of 2024

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[1] The plan consists of a common section of the Radio Spectrum Utilisation Plan and sections of the Radio Spectrum Utilisation Plan for frequency bands defined by lower and upper frequency limits. In the Radio Spectrum Utilisation Plan (PVRS), the CTU sets out the technical parameters and conditions for the use of the radio spectrum by radiocommunication services. The CTU sets out the technical parameters and conditions for the use of the radio spectrum by radiocommunication services in the Radio Spectrum Utilisation Plan (PVRS). The plan builds on the frequency band allocation plan (national frequency table).

[2] Part of the Radio Spectrum Utilisation Plan No. PV-P/9/01.2014-1 for the 39.5–43.5 GHz frequency band; available online at: https://ctu.gov.cz/cs/download/plan-vyuziti-radioveho-spektra/rok_2014/pv-p_09-01_2014-01.pdf

[3] ECC/REC/(01)04 of 10 October 2001 on Recommended guidelines for the accommodation and assignment of multimedia wireless systems (MWS) and point-to-point (P-P) fixed wireless systems in the 40.5–43.5 GHz frequency band; available online at: https://docdb.cept.org/document/450.

[4] VanCo.cz’s supporting calculation table for link transmission capacity; available online at: https://www.vanco.cz/vypocet/.

[5] ETSI TR 103 230, Fixed Radio Systems; Small cells microwave backhauling; available online at: https://www.etsi.org/deliver/etsi_tr/103200_103299/103230/01.01.01_60/tr_103230v010101p.pdf

[6] General Authorisation No. VO-R/23/08.2017-6 for the use of radio frequencies and the operation of fixed service equipment in the 71–76 GHz and 81–86 GHz frequency bands, issued by the Czech Telecommunications Office; available online at: https://ctu.gov.cz/vseobecne-opravneni-c-vo-r23082017-6

232 individual licences[7] (i.e. 232 duplex links). By way of comparison, in the licence-exempt band with a very similar range and the potential to utilise the higher transmission capacities of the 70/80 GHz bands – due in particular to the possibility of implementing wider channels – 13,649 fixed point-to-point links[8]are registered. The issue of charges for the use of radio frequencies also plays a certain role, as the use of the 42 GHz band is subject to a fee.

It can therefore be concluded that the 42 GHz band is not currently being fully utilised in the Czech Republic.

1.2 Regulatory outlook in connection with the WRC-19 decisions, global trends and anticipated developments regarding the use of IMT/FWA

At the World Radiocommunication Conference (WRC-19), several decisions were adopted concerning the potential use of the 42 GHz band. One of the key outcomes of the WRC-19[9]proceedings was the identification of potential future bands for the deployment of IMT (International Mobile Telecommunications) technologies for fixed and mobile services, including the 37–43.5 GHz band.

According to WRC-19, further investigation into the use of the 42 GHz band should also cover its use for fixed satellite services in the space–to-earth direction with high utilisation density. In certain narrow sub-bands, use for other satellite services is being considered on a global scale, for example in non-geostationary satellite systems or radio astronomy service systems. Other uses under consideration do not concern landlocked states. In March 2020, the CEPT (European Conference of Postal and Telecommunications Administrations) decided to draw up a new decision on the harmonisation of the 40.5–43.5 GHz frequency band for use by next-generation terrestrial wireless systems[10] .

In 2024, we expect the European Commission to publish a draft binding decision, on which individual Member States will be invited to comment. The European Commission's future decision on spectrum use is likely to be based on a proposal from the Electronic Communications Committee (ECC), the harmonisation committee of the CEPT. The ECC draft (22)06[(11)] ·published in November 2022, specifies harmonised conditions for use in fixed

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7 The Information Portal on data concerning individual authorisations granted and spectrum allocations issued by the Czech Telecommunications Office was used; available online at: https://ctu.gov.cz/vyhledavaci-databaze/databaze-pridelenych-radiovych-kmitoctu-podle-vydanych-pridelu-a-individualnich-opravneni/vyhledavani

8 Technical specifications for point-to-point fixed radio systems in the 71–76 GHz and 81–86 GHz bands; Complete overview of notified links; available online at: https://ctu.gov.cz/vyhledavaci-databaze/technicke-udaje-pevnych-radiovych-systemu-typu-bod-bod-v-pasmech-71-76-ghz-a-81-86-ghz/kompletni-prehled

9 World Radiocommunication Conference 2019 (WRC-19) Final Acts, published by ITU Publications, International Telecommunication Union, Radiocommunication Sector; available online at: https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.14-2019-PDF-E.pdf

10 CEPT Report 82; available online at: https://docdb.cept.org/download/4177

11 ECC/DEC/(22)06 of 18 November 2022 on harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the 40.5–43.5

GHz band, available online at: https://docdb.cept.org/document/28571 and mobile telecommunications networks for the 40.5–43.5 GHz band, in line with the conditions already issued for the 26 GHz band. The basic frequency channel block is designed for 200 MHz, with the option of using bandwidths in multiples of 50 MHz. With this proposed bandwidth, potential networks utilising the 42 GHz band can be described as networks capable of providing gigabit connectivity to every user.

1.3 Potential collisions and restrictions on the use of the band with other services when sharing the band, and mitigation of unwanted interference

When defining the frequency allocation for the MFCN (Mobile/Fixed Communication Network), the ECC had to take into account the allocation requirements for the FSS (Fixed Satellite Service), FS (Fixed Service) and RAS (Radio Astronomy Service). Protection of these services within the frequency spectrum is possible, as they are fixed-location services.

Separation of radio frequencies in general terms is possible:

- spatially,
- frequency,
- polarisation, or
- coding.

In the case of the 42 GHz millimetre band, the method of preventing radio interference through spatial separation – that is, the geographical separation of transmission sources from receiving equipment – is of the greatest technical significance. A major advantage of millimetre bands is their limited propagation in space, as the residual energy of the transmitter in the atmosphere rapidly falls below the interference threshold. The physical properties of the band allow for the use of compact antennas[12] , owing to the physical relationship between frequency and the gain of antenna systems, whilst maintaining the narrow directivity of the antenna systems.

It is therefore possible, within the MFCN operating licence, to propose measures that will adequately ensure the use and potential future deployment of FSS ground receiving stations in the 40.5–42.5 GHz frequency band and FSS ground transmitting stations in the 42.5–43.5 GHz frequency band, whilst also protecting the MFCN in the 42.5–43.5 GHz band. FSS and RAS services are not used to any significant extent in the Czech Republic; technical measures will primarily address interference with the fixed FS service.

[12] Where appropriate, whilst maintaining the antenna dimensions, it is possible to achieve higher gain or directivity compared with lower bands.

CEPT has drawn up guidelines to support the roll-out of MFCN whilst ensuring, in an appropriate manner, the use of FSS receiving earth stations in the 40.5–42.5 GHz frequency band and the use of FSS transmitting earth stations in the 42.5–43.5 GHz frequency band in Recommendation ECC (22)01[13] . The CEPT Recommendation therefore addresses compatibility between MFCN in the 40.5–43.5 GHz band and FSS receiving earth stations in the 39.5–40.5 GHz band, with the aim of preventing and/or resolving interference issues.

Technical measures to prevent interference in the FSS are based on the geographical separation of the FSS service, whereby it will not be possible to operate MFCN services on a conflicting frequency within an appropriate separation distance from FSS services. To determine an appropriate separation distance, the propagation model set out in ITU-R Recommendation P.452 or ITU-R Recommendation P.2001 may be used, together with appropriate terrain data for the area surrounding the ground station.

A similar situation arises when preventing interference to point-to-point fixed service (FS) links.

Coexistence can be achieved by calculating the geographical separation distance and defining so-called coordination zones, which may be applied around stations of these other services, where further consideration may be required if MFCN base stations were located within these zones. In any case, it is necessary to establish a mechanism at national level to enable the coordination of MFCN equipment, taking into account the requirements for service sharing.

Protection of RAS can be achieved by calculating the geographical separation distance and establishing exclusion zones around RAS stations, which are defined at national level.

To ensure the protection of the RAS site, a mechanism would be required, such as a regulatory requirement to comply with exclusion zones defined and enforced at national level (taking into account terrain, obstacles, etc.).

A disadvantage of sharing FSS, FS and RAS services with MFCN is the restriction on establishing new protected FSS and FS services where authorisation to use MFCN frequencies has already been granted. Therefore, services such as MFCN are expected to be deployed in the form of hotspots with controlled or limited transmission power. When the CEPT report was drawn up, no technical mechanism was specified for MFCN equipment to prevent interference, apart from locating new base stations outside a pre-defined exclusion zone.

[13] ECC/REC/(22)01 of 18 November 2022 on guidelines to support the introduction of MFCN in the 40.5–43.5 GHz band whilst ensuring, in a proportionate manner, the use of FSS receiving earth stations in the 40.5–42.5 GHz frequency band and the use of FSS transmitting earth stations in the 42.5–43.5 GHz frequency band, as well as the possibility for the future deployment of these earth stations; available online at:

https://docdb.cept.org/document/28572

1.4 Authorisation for the use of the 42 GHz band and its possibilities

Authorisation of millimetre-wave bands where a need for service coordination has been identified, but which are also intended for deployment as indoor and outdoor hotspots, is appropriate on the basis of individual frequency usage authorisations. Individual frequency usage authorisations may be appropriately required for the siting of a network access point (hotspot, BTS).

It is possible to consider a dual regime for the allocation of authorisations for the use of frequencies, specifically for hotspots with a proposed high transmission power and for hotspots with low transmission power, or hotspots located inside buildings. In such a case, it is necessary to introduce a mechanism whereby the national regulator, as the administrative authority, will be able to impose additional measures regarding the use of frequencies, such as a ban on the use of conflicting frequency allocations in separation zones.

1.5 Summary recommendations for the use of the 42 GHz band with a view to intensive and efficient utilisation

To enhance the protection of shared services, we recommend requiring the use of active sector antennas capable of directing energy radiation towards the customer premises equipment (CPE).

The characteristics of higher frequency bands with shorter wavelengths allow for the use of advanced antenna systems, including multiple-input multiple-output (MIMO) techniques and beamforming. This should be reflected in the minimum requirements for the use of the band.

For planning the deployment of equipment in shared bands, knowledge of the location of shared-service systems is an essential requirement. The development of shared bands therefore requires a geolocation portal through which information on the use of shared services is made available remotely.

A fundamental prerequisite for the development of millimetre-wave bands in general is a minimal cost barrier for authorisation to use the spectrum. Only the attractiveness of using the band will generate demand for suitable technologies, thereby creating sufficient pressure for research and development at the start of the supply chain.

Conclusion to Chapter 1:

In the Czech Republic, the 42 GHz band (in a narrower range than that potentially used for MFCN networks, namely 40.5–43.5 GHz) is currently used primarily for point-to-point fixed-service links with transmission speeds of up to one gigabit. However, interest in this band is not growing, mainly due to the increasing popularity of the licence-exempt 70/80 GHz band, which offers higher transmission capacities and high deployment flexibility, whilst posing a minimal risk of unwanted interference due to the characteristics of the band. Global decisions and trends suggest that the 42 GHz band could be used for mobile telecommunications (MFCN) in the future. Geographical separation and the use of advanced antenna technology are key to preventing collisions with other services. Authorisation for the use of the band should, with a view to protecting the fixed radio communication service, be based on individual licences, with possible specifications for different types of hotspots. For efficient utilisation, the use of active sector antennas, which enable precise signal steering, is recommended. Future use of the band by the fixed service may positively influence the technological development of RedCap devices, i.e. low-cost chipsets with limited capabilities, utilising only the essential features of 5G networks whilst complying with all necessary 3GPP standards.

2 Technological characteristics of the 42 GHz millimetre band

2.1 Limited range and physical properties in free space, attenuation in the environment

The physical characteristics of the higher millimetre bands make them ideal for use in short-range systems. The characteristics of antenna systems (high gain, high directivity) and low scattering in the troposphere make the 42 GHz band ideal for densely built-up areas in the form of urban and suburban hotspots, although this does not preclude its deployment in rural communities, particularly in fixed network mode. Given the physical limitations, deployment in short-range cells is anticipated. Conversely, regional or even nationwide coverage should not be expected. The line-of-sight range and application distances can be derived from a propagation model (determining the level of interfering signals) based on ITU-R Recommendation P.452 or ITU-R Recommendation P.2001, together with appropriate data on the terrain surrounding the ground station. For mobile applications, available sources indicate a range from several hundred metres for high-modulation schemes to several thousand metres for fixed-site deployments using a CPE antenna with gain.

An accurate technical understanding of the use of millimetre-wave bands will only be provided by ongoing research, such as the project *'Multi-band prediction of millimetre-wave propagation effects for dynamic and fixed scenarios in rugged time-varying environments*', currently being carried out at the Brno University of Technology.[14] The project focuses on researching the specific characteristics of millimetre-wave propagation in various rugged urban environments and suburban areas. Time-varying channel properties will be investigated both from a short-term perspective, focusing on very rapid changes in the channel, and from the perspective of long-term changes spanning several hours or days. The project will produce statistical channel models based on actual measured data. New insights are expected, in particular, in the area of channel analyses taking into account the effects of weather (rain, snow) and the examination of long-term statistics. The aim of the project is to extend currently available analyses of radio wave behaviour to higher frequencies, thereby opening up new scenarios

[14] Multi-band prediction of millimetre-wave propagation effects for dynamic and fixed scenarios in rugged time-varying environments, focusing on frequencies in the 30–300 GHz range. The project is funded by the Grant Agency of the Czech Republic. Principal investigator: Prof. Ing. Aleš Prokeš, Ph.D. The results of this basic research project are being published on an ongoing basis; the research is expected to be fully completed by the end of 2025. Information about the project is available online at: https://www.vut.cz/vav/projekty/detail/33723?aid_redir=1

the use of wireless technologies employing non-traditional measurement methods, such as real-time spatial imaging of multipath components or new data pre-processing techniques, including machine learning.

2.2 Use of the 42 GHz band in line-of-sight and non-line-of-sight modes, penetration of solid obstacles, and the form of infrastructure required for widespread use of the band

In urban environments, where the deployment of millimetre-wave bands is expected to be most widespread, buildings and other obstacles along the path between the access point and the user pose a problem for signal propagation. Signal propagation is affected by diffraction and reflection losses. The reflected signal also loses quality due to depolarisation. To a certain extent, signal quality loss can be prevented during deployment planning by suitably positioning the network access point to correspond to the highest concentration of users. A certain degree of compensation for signal quality loss is provided by an intelligent distributed antenna system (DAS), which can be operated using hybrid signal beamforming.

Measures to maintain signal quality are most effective in pre-defined areas, such as stadiums or indoor spaces. In such locations, additional technical measures can be utilised, such as intelligent signal repeaters and passive reflectors. The systems are described in more detail in the GSMA report '5G mmWave Deployment – Best Practices'[15] from October 2022.

The use of millimetre-wave technology in NLOS (non-line-of-sight) mode cannot be ruled out for certain applications, provided that a loss in transmission quality is accepted. Deployment planning must take into account the very limited ability of millimetre-wave energy to penetrate obstacles along the path, as detailed by the GSMA in the report mentioned above.

- additional attenuation caused by vegetation foliage at 39 GHz of 28 dB
- when passing through building walls at 39 GHz at a level of 42 dB

The most effective application of the 42 GHz system is in line-of-sight mode. The infrastructure required for widespread use of the band involves directing antenna systems directly towards areas where people congregate in mobile networks. Conversely, in fixed networks with precisely defined user locations, the characteristics of the band can be utilised to provide significant advantages, which are further enhanced by the ability to select a suitable antenna system for the user.

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[15] 5G mmWave Deployment Best Practices Whitepaper; available online at: https://www.gsma.com/solutions-and-impact/technologies/networks/gsma_resources/5g-mmwave-deployment-best-practices-whitepaper/

2.3 Use in urban environments and deployment models; applications of the 42 GHz band in mobile services

Use in urban environments corresponds to the characteristics of the band and the propagation characteristics of millimetre-wave radio waves. In the case of fixed radio networks, this involves applications in an access point–user topology in line-of-sight mode, or in a mixed MESH network mode.

In the case of mobile radio networks, this involves the use of hotspots for large gatherings of people where we anticipate sporadic, massive demand for data communication, particularly at sports stadiums, railway stations, town squares or sports centres.

2.4 Applications of the 42 GHz band as an infrastructure terrestrial system

The 42 GHz band has the potential to create mobile network hotspots, provided there is sufficient uptake of mobile network end-user devices capable of utilising it. In theory, it is possible to envisage its application for mobile network backhauling when connecting small mobile network cells using traditional frequencies.

It is also likely to be used in fixed wireless access (FWA) networks in point-to-multipoint mode or in a mesh topology to connect users in urban or suburban environments. However, by 2024, the 26 GHz band appears to offer greater potential for such applications.

Conclusion to Chapter 2:

The 42 GHz band is ideal for short distances and dense urban and suburban hotspots, where antenna systems achieve high gain and narrow directivity. However, due to its limited range, it is not suitable for regional or nationwide coverage. In urban areas, buildings and other obstacles pose a challenge to signal propagation, causing losses due to reflection and depolarisation. These losses can be mitigated by the appropriate placement of access points and the use of intelligent distributed antenna systems (DAS). In predefined spaces, such as stadiums, intelligent signal repeaters and passive reflectors can help. The 42 GHz band is also suitable for fixed radio networks operating in line-of-sight mode or hybrid MESH networks. For mobile networks, there is considerable potential for backhaul requirements. Purely mobile applications (5G) cannot be ruled out, particularly when meeting connectivity requirements in areas with high concentrations of people, such as sports stadiums and railway stations. The problem, however, is that in handheld devices (smartphones) supporting 3GPP 5G NR FR2 with channel n259 are not currently available on the European market.

Ongoing research, for example at the Brno University of Technology, is focusing on the characteristics of signal propagation in the 42 GHz band in urban and suburban areas, which will help to further improve the practical implementation of solutions utilising this band.

3 Standardisation in the 42 GHz band

3.1 Standardisation of equipment for the 42 GHz band within the ETSI system

ETSI (European Telecommunications Standards Institute) is the organisation responsible for developing technical standards, including for fixed and mobile technologies. Without standardisation of products for operation in the 42 GHz band, the development of technologies intended for use in this band cannot be expected. Standardisation primarily concerns technical specifications, electromagnetic compatibility and product safety. The standards set out requirements for the efficient use of the radio spectrum and interoperability.

ETSI's impetus for developing technical standards is the so-called mandate from the European Commission or EFTA. The mandate or standardisation requirement (SReq) relevant to MFCN networks in the 42 GHz band was issued solely to CEPT, which responds to the mandate in CEPT Report 82.[16]

The mandate tasks CEPT with proposing solutions for the mutual mitigation of interference between the fixed service (FS), the radio astronomy service (RAS) and the fixed satellite service (FSS), and mobile/fixed communication network (MFCN) services.

Existing ETSI documents relating to the requirements for the use of the 42 GHz band for MFCN adopt the technical specifications of 3GPP (3rd Generation Partnership Project), for example ETSI TS 138 104[17] . 3GPP deals with specifications for radio interfaces, network architectures and other related technical guidelines.

In contrast, the technical conditions for the use of the band for the FS fixed service and for MWS (Multimedia Wireless Systems) – which are not used in the Czech Republic – are well defined.

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[16] Report from CEPT to the European Commission in response to the Mandate

"to develop least restrictive harmonised technical conditions suitable for next-generation (5G) terrestrial wireless systems for priority frequency bands above 24 GHz"

Harmonised least restrictive technical conditions for the 40.5–43.5 GHz frequency band, available online at https://docdb.cept.org/document/28574

[17] 5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104 version 17.8.0 Release 17), available online at: https://www.etsi.org/deliver/etsi_ts/138100_138199/138104/17.08.00_60/ts_138104v170800p.pdf

The 40.5–43.5 GHz band is designated in Europe for priority use by the fixed radiocommunication service. In the late 1990s, the original European plan was drawn up under Decision CEPT/ERC/DEC/(99)15[18] (1999 edition) to standardise the 42 GHz band for interactive multimedia services to customers. Experiments were carried out in this band involving multi-channel television transmissions and local radio broadcasting, including microwave distribution links. However, with the rapid development of modern packet-switched access networks in bands below 6 GHz (e.g. fixed access networks in the 5 GHz, 3.5 GHz and 2.4 GHz bands), including the development of IMT networks, this concept did not gain traction and the band remained virtually unused in Europe. The strategy for its further use was therefore reassessed in Europe, and CEPT Recommendation ECC/REC/(01)043 was issued for the band in 2010, permitting the use of the frequencies for fixed, high-capacity point-to-point radio links, the widespread use of which has since developed in the Czech Republic as well. Consequently, Decision CEPT/ERC/DEC/(99)15 was also revised accordingly. The necessary standardisation for MWS systems is available, for example ETSI EN 301 997[19] or ETSI EN 302 326[20] .

3.2 Standardisation within the 3GPP system

Millimetre-wave bands are the gateway to truly high-capacity data transmission. However advanced radio signal modulation methods may be, the key to a truly significant increase in transmission capacity lies in expanding the bandwidth of the channel used from tens of megahertz to hundreds of megahertz. In the case of traditional frequency bands designated for wireless communication, there is high demand for spectrum utilisation for both historical and technical reasons; lower frequencies below 6 GHz offer better penetration of obstacles and extensive coverage for mobile services, whilst for fixed telecommunications services, demand for spectrum utilisation is particularly high in the bands from 5 GHz up to 38 GHz.

The radio spectrum is also utilised by other non-telecommunications services. Given the current demands for the roll-out of wireless communication services offering gigabit speeds, regulators are finding it difficult to identify contiguous frequency bands that would meet the requirements for wider communication channels without adversely affecting other services using the radio spectrum. It was only with the development of technologies designed for the millimetre bands that the possibility arose to meet these requirements in less utilised parts of the spectrum.

[18] CEPT Recommendation ECC/REC/(01)04 – Recommended guidelines for the accommodation and assignment of Multimedia Wireless Systems (MWS) and Point-to-Point (P-P) Fixed Wireless Systems in the 40.5–43.5 GHz frequency band [Recommended guidelines for the accommodation and assignment of Multimedia Wireless Systems (MWS) and Point-to-Point (P-P) Fixed Wireless Systems in the 40.5–43.5 GHz frequency band].

[19] Transmission and Multiplexing (TM); Multipoint equipment; Radio Equipment for use in Multimedia Wireless Systems (MWS) in the frequency band 40.5 GHz to 43.5 GHz; Part 1: General requirements

[20] Fixed Radio Systems; Multipoint Equipment and Antennas

An example of pioneering millimetre-wave technology is the 80 GHz band (E-band), which was made available in May 2008 under General Authorisation VO-R-04.2008-4[21] for the fixed point-to-point service. The opening up of opportunities to utilise the unoccupied band with a 250 MHz bandwidth base channel provided such a significant impetus for telecommunications technology manufacturers that a transmission speed of 20 Gbps with frequency duplex[22] is now commonly available with current technologies.

At the Mobile World Congress in Barcelona in 2024, a new range with a transmission capacity of 50 Gbps[23] was unveiled by at least three major manufacturers. A strong global market and user demand have spurred the development of further promising technologies with high transmission capacity, where the use of a wide communication channel eliminates the need for complex modulation techniques. Industrial mastery of microwave components and their mass production has contributed to the widespread adoption of fixed-service systems across other millimetre-wave bands as well, utilising modern techniques for directing the energy field beam towards the user's station, and to the widespread adoption of WiGig[24]technology for the 60 GHz band.

This technology, announced in 2009 as IEEE 802.11ad, was originally intended for connecting short-range devices, primarily indoors. In accordance with CEPT/ECC/REC (09)01[25], the development of equipment for fixed point-to-point services, based on the ETSI EN 302 217[26] standard, was initially permitted. In 2019, ECC Report 288[27]was published, leading the CEPT to establish technical conditions for the operation of MultiGigabit Wireless Systems (MGWS) equipment, including for point-to-multipoint modes in the 57–71 GHz band. European Commission Implementing Decision 2019/1345 enabled national regulators to issue the relevant authorisations for the use of the band. In January 2020, the Czech Republic updated General Authorisation VO-R/12/03-2021[28] . By the second quarter of 2024, 128,698[29] devices with gigabit network transmission capacity were in use in the fixed service (Fixed Wireless Access) for telecommunications purposes in the Czech Republic. Strong interest from industry led the WiFi Alliance, into which the WiGig Alliance was incorporated, to develop

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21 Czech Telecommunications Office Archive, available online at https://ctu.gov.cz/vseobecna-opravneni-archiv

22 CERAGON IP50E

23 For example, the CERAGON IP100E

24 The Wireless Gigabit Alliance (WiGig) is a trade association that developed and promoted the adoption of multi-gigabit wireless communication technology operating in the unlicensed 60 GHz frequency band. The association was incorporated into the Wi-Fi Alliance in March 2013. The formation of the WiGig Alliance to support the IEEE 802.11ad standard was announced in May 2009. The final version 1.0 of the WiGig specification was published in December 2009. In May 2010, WiGig announced the publication of its specification, the launch of its own adoption programme, and a partnership agreement with the Wi-Fi Alliance to collaborate on the expansion of Wi-Fi technologies. In June 2011, WiGig announced the publication of the version 1.1 certification specification.

25 CEPT/ECC/REC (09)01; use of the 57–64 GHz frequency band for point-to-point fixed wireless systems; available online at: https://docdb.cept.org/download/a5bcf903-bb19/REC0901.PDF

26 Fixed Radio Systems: characteristics and requirements for point-to-point equipment and antennas; digital systems operating in frequency bands from 1 GHz to 86 GHz.

27 ECC Report 288: Conditions for the coexistence between the Fixed Service and other envisaged outdoor uses/applications in the 57–66 GHz range; available online at https://docdb.cept.org/download/1365

28 Archive of the Czech Telecommunications Office; available online at: https://ctu.gov.cz/vseobecna-opravneni-archiv

[29] The Czech Telecommunications Office’s RLAN portal; available online at: https://rlan.ctu.cz/cs/

the next generation of the 802.11ay technical standard[30] . A disadvantage of the V-Band is the lower permitted power, and consequently reduced range in point-to-multipoint mode. The use of high-gain antenna systems is a prerequisite for providing fixed-location services.

The development of telecommunications technologies utilising millimetre-wave bands described above has sufficiently demonstrated the viability of the technical solution and has, to a large extent, formed the basis for mobile service providers' requirements for the design of gigabit 5th-generation network systems within the 3GPP framework. According to the technical report ETSI TR 103 230[31]as well, transmission systems in the millimetre bands are used as access networks for small cells in mobile networks.

3GPP (3rd Generation Partnership Project) is an international collaboration between telecommunications standardisation organisations, which focuses on the development of global specifications for mobile telecommunications systems. It was founded in December 1998 and its aim is to provide uniform and coherent sets of specifications for mobile systems that support the evolution from 2G through 3G to 4G and now 5G networks. 3GPP deals with specifications for radio interfaces, network architectures and other related technologies.

Specifications for next-generation wireless technologies are developed not only across generations but also through individual

'releases' – sets of documents that gradually introduce new features and improvements for 5G networks. The first proposals for 5G standardisation emerged during work on Release 14, which was finalised in 2017. A key feature of the new generation of mobile networks was the use of Massive MIMO technologies, advanced modulation schemes and technologies to reduce latency. Release 14 laid the foundations for subsequent work on Release 15, which was the first phase of the specifications for 5G networks. This release was officially completed in December 2017. Release 15 included the basic architecture and definitions for Non-Standalone (NSA) 5G operations, meaning that 5G networks utilised existing 4G LTE infrastructure for certain aspects of the network, such as connectivity to base stations. Release 15 also introduced the term 5G NR (New Radio), which included millimetre-wave bands as part of future development.

[30] IEEE 802.11ay, 'Enhanced Throughput for Operation in Licence-exempt Bands above 45 GHz', was the successor to IEEE 802.11ad WiGig. Compared to the previous generation, it adds a MIMO mode with up to eight spatial streams. The final version of the technical standard was published in March 2021.

[31] ETSI TR 103 230 Fixed Radio Systems; Small-cell microwave backhauling; available online at: https://www.etsi.org/deliver/etsi_tr/103200_103299/103230/01.01.01_60/tr_103230v010101p.pdf

The main features of the 5G NR standard in Release 15 include:

- **Flexible spectrum**: 5G NR supports a wide range of frequencies from below 1 GHz to millimetre waves above 24 GHz, enabling various use cases ranging from large-scale IoT deployments to ultra-high-speed mobile broadband applications.
- **Advanced modulation technologies**: It utilises more sophisticated forms of signal modulation, which increases the amount of data that can be transmitted via radio waves.
- **Massive MIMO and beamforming**: These technologies enable a more targeted and efficient use of the spectrum by directing the transmitted radio frequency energy – and thus the signal – directly to users, rather than allowing the energy to radiate in all directions.
- **Network Slicing**: This enables operators to create multiple virtual networks on the same physical infrastructure, ensuring optimised and efficient use of resources for different services and applications.

Release 16 adds the following features to the 5G NR functionality:

- **Ultra-Reliable Low Latency Communications (URLLC)**: Enhancements for applications requiring very low latency and high reliability, such as in the automotive industry and industrial automation.
- **Enhancements for Industrial IoT**: Improved connectivity and functionality for industrial applications, including better support for massive MIMO and network slicing.
- **Integrated Access and Backhaul (IAB)**: The ability to utilise 5G technology not only for the access network but also for backhaul, which is important for extending 5G coverage to areas where traditional backhaul infrastructure is not available.
- **Non-Public Networks (NPNs) / Private 5G Networks**: Specifications for private networks that can be used by businesses to meet specific needs, such as security and bespoke configuration.
- **Enhancements to Vehicle-to-Everything (V2X) communications**: Expanded capabilities for communication between vehicles and infrastructure, which is key to the development of autonomous vehicles.

Release 17

- **Advanced IoT capabilities**: Further enhancements to support IoT devices, including improved energy efficiency and the ability to communicate in extreme conditions.
- **Support for Non-Terrestrial Networks (NTN)**: Includes capabilities for communication via satellites and other non-terrestrial platforms, which extends the availability and reach of 5G networks through the reception of satellite signals by a suitable 5G NR-enabled handset.

- **Enhancements for RedCap (Reduced Capability) devices**: Specifications for devices with lower computational and power capabilities, which can nevertheless utilise certain 5G features.
- **Enhancements for V2X and augmented reality**: Further development of technologies and standards to support applications such as augmented reality and enhanced vehicle-to-everything (V2X) communication.

With each new release, 3GPP continues to develop and provide a more detailed description of 5G technology, focusing primarily on defining new areas and applications.

A key objective of 5G network development is to ensure greater security. A fundamental aim is to improve integration with various types of devices and networks for different use cases. This represents a sort of technically defined
'smorgasbord' of options for utilising the radio spectrum, which has long since moved beyond traditional mobile networks to encompass the expanded use of 5G applications for fixed connections or satellite services. The innovations are certainly not aimed solely at mobile operators; 3GPP is targeting the utilisation of these products across all industrial sectors and telecommunications applications.

Each release of technical specifications is accompanied by an update to 3GPP's technical information, which is adopted by ETSI as a TS (Technical Specification). From our perspective, the most important is (ETSI) TS 138 104[32], which defines suitable frequency channels for 5G. For MFCN applications in the 42 GHz band, channel n259 TDD appeared in the later versions of Release 15 as part of the FR2 frequency plan in the frequency range from 24.25 GHz to 52.6 GHz.

The n259 FR2 5G-NE channel is designed for Time Division Duplex (TDD)[(33)]communication, with a total bandwidth of 4 GHz in the 39.5–43.5 GHz band. The use of a single carrier frequency for both downloading and uploading data, rather than frequency duplex where each transmission direction has its own frequency, is a key feature enabling the efficient use of spectrum offered by modern technologies compared with older generations.

The usable bandwidths in the channel arrangement are multiples of 50 MHz, i.e. 50, 100, 200 and 400 MHz .

The capacity of a transmission channel depends on many factors, such as the type of modulation, the coding scheme and the propagation environment, which significantly limits signal quality. Under less than ideal conditions, radio equipment switches to less complex modulation states (often lower modulation states within a single modulation method – typically amplitude and phase modulation in the case of point-to-point links), which are already possible with

[32] 3GPP (ETSI) TS 138 104, Base Station (BS) radio transmission and reception; available online at: https://www.etsi.org/standards or https://portal.3gpp.org/.

[33] Time division duplex is a method of two-way communication using a single frequency band. A time-slot method is used for communication in both directions, so that signal transmission and reception in each direction take place at different time intervals.

[34] The 400 MHz channel can only be used with an SCS of 120 kHz. SCS stands for subcarrier spacing. Release 17, version 17.8.0

a degraded signal can be demodulated by the subscriber equipment’s receiver. Particularly for bands in the FR2 5G-NR range with millimetre wavelengths, the radio signal propagation environment is a decisive factor for meaningful utilisation; lower frequency bands provide a significantly more stable transmission function under adverse propagation conditions.

To get an idea of the capacity potential of a band, it is sufficient to calculate the data rate of a basic channel with a bandwidth of 50 MHz. For wider channels, it is sufficient to derive multiples of the base channel. For a simple estimate of the capacity of a 50 MHz bandwidth channel in 5G networks, we can use the basic formula from Shannon–Hartley’s theorem, which gives the maximum theoretical data transmission rate C over a communication channel:

$C = B \log_2(1 + SNR)$

where:

- C is the channel capacity in bits per second (bps),
- B is the channel bandwidth in hertz (Hz),
- SNR is the signal-to-noise ratio, expressed as a dimensionless number.

To give a specific example, if we assume that the SNR is relatively high, for example 30 dB (which is typical for good conditions in the FR2 bands), we can convert this ratio to a linear scale:

- $SNR = 10^{(30/10)} = 1000$

Let’s plug the value into the formula: $C = 50 \times 10^6 \times \log^2(1 +$

$1000) \approx 50 \times 10^6 \times 9.97$

$C \approx 498.5 \times 10^6$ bps, or approximately 500 Mbps.

The total transmission capacity of a channel with a bandwidth of 100 MHz will be *approximately* 1 Gbps, for a 200 MHz channel *approximately* 2 Gbps, and for a 400 MHz channel approximately 4 Gbps. The approximate capacities given correspond to the total bandwidth capacity; to calculate the transmission capacity per user, it is necessary to define the specific application, the level of transmission protection within the channel via coding, including the number of users and their locations within the environment.

3.3 Interoperability between systems using the 42 GHz band

Interoperability – that is, the ability of systems to work together – refers, in the context of radio systems, either to the ability to communicate with one another or to the ability to effectively mitigate harmful mutual interference, for example through methods to reduce the effects of interference between operators using the same type of service.

To ensure interoperability between systems from different manufacturers and of different device types, it is essential that all systems adhere to the same technical standards. Standardisation is the remit of 3GPP, and manufacturers voluntarily comply with its technical specifications. Mutual compatibility between systems developed on the basis of non-3GPP protocols (FSS, FS, RAS) is therefore not possible.

Interference prevention between operators can be achieved for certain 5G NR channels through mutual network synchronisation, subject to prior agreement between operators. The methodology for mutual synchronisation is described in Chapter 9 of 3GPP TS 38.401 (ETSI 138 401). However, the applications described primarily relate to traditional 5G bands.

Conclusion on Chapter 3:

The 42 GHz band in the Czech Republic (40.5–43.5 GHz) has the potential for use in 5G networks; its development depends on the availability of standardisation and technical specifications. ETSI and 3GPP are focusing on developing these standards, which are key to technological development in this band as well.

Historically, this frequency band has been designated primarily for fixed radio communication services, as well as FSS and RAS; however, new standards enable its use for MFCN purposes. Documents such as ETSI TS 138 104 and 3GPP specifications set out the technical requirements for the effective use of the 42 GHz band for 5G NR (New Radio), including channel n259, which is designed for broadband transmissions in time division duplex (TDD). This channel allows for flexible use of bandwidth ranging from 50 MHz to 400 MHz, ensuring high transmission capacities.

Key elements of 5G NR standardisation in this band include flexible spectrum, advanced modulation technologies, massive MIMO and beamforming. These technologies enable efficient spectrum utilisation and higher data rates compared with current deployments using a maximum FDD bandwidth of 112 MHz. Current 3GPP specifications ensure interoperability between different MFCN systems and devices, which is essential for the development and deployment of 5G networks. The development and implementation of 5G technologies in the 42 GHz band are also supported by industrial trends (Industry 4.0) and global demand for higher transmission capacities. Millimetre-wave technologies, such as the 80 GHz band (E-band) and 60 GHz (V-band), have already demonstrated the viability of high-speed transmission and are inspiring the use of similar bands in 5G networks.

In summary, it can be said that, as yet, there are no feasible and realistic regulatory and user models for the 42 GHz band in the European context. However, there is sufficient supporting documentation and pre-specifications from ETSI and 3GPP to ensure the establishment of an appropriate regulatory framework and to adequately define the potential benefits of the band, the use of which is anticipated and being studied at a global level. Preparations for the commercial use of this band are still ongoing, and further development can be expected.

4 The innovative potential of the 42 GHz band

4.1 Use in telecommunications

The general division of telecommunications systems into fixed and mobile services has very blurred boundaries (which is one reason why the term MFCN was introduced). Some frequency allocations originally intended for mobile services are commonly used for fixed wireless access (FWA) purposes[35] . An example is the 5G TDD allocations in the C-band range, which operators also use as FWA to connect users at fixed locations[36] , most commonly in the residential segment[37] . The future combined use of the 39.5–43.5 GHz band is directly based on the Electronic Communications Committee (ECC) Decision (22)06[38] ‘Harmonised Technical Conditions for Mobile/Fixed Wireless Networks’. The use of high transmission capacities in the 50, 100, 200 and 400 MHz in the 42 GHz band will enable future applications ranging from connecting fixed-network users within the range of a hotspot (access point) to the backhauling of small cells at base stations operating at lower frequencies used by mobile networks.

Theoretically, it is possible to use direct connections for end-user terminals in this band; however, the availability of other, more suitable bands for these purposes – including millimetre-wave bands – argues against such a scenario. The unsuitability of the 42 GHz band for mobile data services stems from the short range of handheld devices when communicating with a base station, which would make it suitable primarily for locations where large numbers of people regularly gather in a small area. In the Czech Republic, there are only a handful of such large gathering places where, in theory, the potential of 5G channels with better propagation characteristics might be exhausted. The limited opportunities for use will not generate end-user demand for devices capable of utilising the 42 GHz band.

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[35] Fixed Wireless Access (FWA):

FWA is an alternative to traditional wired connections, enabling the provision of broadband internet in areas where cable or fibre-optic infrastructure is not available. This solution is particularly useful in rural and remote areas.

[36] Article on the Lupa.cz website; ‘Operator O2 has started offering fixed 5G connections for the home, but speeds are limited’; available online at: https://www.lupa.cz/aktuality/operator-o2-zacal-nabizet-fixni-5g-pripojeni-na-doma-rychlost-je-ale-omezena/

[37] Description of the installation of fixed broadband on Vodafone’s mobile network; available online at: https://www.vodafone.cz/pece/internet-data/internet-v-pocitaci/technologie-pevny-internet-prehled/

[38] ECC/DEC/(22)06 of 18 November 2022 on harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the 40.5–43.5 GHz band; available online at: https://docdb.cept.org/document/28571

The potential of traditional frequency bands below 6 GHz is far from exhausted, as demonstrated by an article on the Lupa.cz website[39] *'Gigabit at the ice hockey match. See how the mobile network at the O2 Arena was upgraded ahead of the World Championships'.* When upgrading the network in the arena, which has a capacity of 17,500 spectators, CETIN used a system comprising fourteen antenna sockets operating at the frequencies LTE 2.6 GHz TDD, LTE 2.6 GHz FDD and LTE 3.7 GHz TDD. In addition, there are a further 42 antennas for the 800, 900, 1,800 and 2,100 MHz frequencies. This brings the total to 70 antennas. Each antenna slot utilises a 175 MHz bandwidth when the blocks are combined. A further six sectors for low-band (below 1 GHz) and mid-band (1–6 GHz) have blocks of 16 and 20 MHz available. The measured test speeds fluctuated around 900 Mb/s for downloads and 190 Mb/s for uploads. It should be emphasised that, once 5G technology is fully rolled out for the lower frequency bands below 6 GHz, theoretical data rates per user will increase significantly further.

The potential of the millimetre-wave bands for large concentrations of mobile service users is greater in the 5G NR n257 and n258 channels (26/28 GHz)[40], where, as with the 42 GHz band, combined use for both mobile and FWA purposes is possible. Future requirements for the development of the 42 GHz band for telecommunications extend well beyond the year 2030, particularly in countries with areas of high population density. The benefit lies in the availability of more channel blocks across a total usable frequency range of up to 4 GHz.

The general use of the 42 GHz band for telecommunications purposes is also hindered by the proposed restrictions relating to the risk of mutual interference with shared FS, FSS and RAS services. The Electronic Communications Committee, in Decision ECC 22(06), describes these restrictive conditions:

- sharing studies have shown that FSS space stations in the 42.5–43.5 GHz frequency band would, based on the agreed assumptions, be protected with a margin of more than 16 dB for GSO and 24.3 dB for NGSO, and that it will be necessary to ensure that these services remain protected;
- for outdoor base stations operating in the 42.5–43.5 GHz band, the elevation angle of the main beam should normally be below the horizon, and the mechanical alignment must be at or below the horizon;
- only a very limited number of MFCN base stations will communicate with a positive elevation angle relative to indoor MFCN mobile stations;

[39] Lupa.cz website, article 'Gigabit at the ice hockey'. See how the mobile network at the O2 Arena was upgraded ahead of the World Championships; available online at: https://www.lupa.cz/clanky/gigabit-na-hokeji-podivejte-se-jak-byla-pred-mistrovstvim-sveta-modernizovana-mobilni-sit-v-o2-arene/galerie-24440-11/

[40] A list of countries using the 26/28 GHz millimetre bands is available on Wikipedia.org; available online at: https://en.wikipedia.org/wiki/List_of_5G_NR_networks#cite_note-Singtel_SA_SG_1-480

- Outdoor base stations are typically to be installed on rooftops in urban/suburban areas, which significantly increases signal attenuation and thus reduces the required separation distances from RAS or FSS (ground stations);
- Coexistence issues between fixed links and MFCNs in the 40.5–43.5 GHz frequency band will be addressed at national level or through bilateral agreements on cross-border coordination;
- the protection of existing and future RAS stations will require the establishment of appropriate protection zones around RAS stations on a case-by-case basis[41];
- outdoor hotspot coverage was assumed in the sharing studies to involve the deployment of base stations communicating with terminals on the ground and a very limited number of indoor terminals with positive elevation, which results in the main beam of outdoor base stations typically being elevated below the horizon, thus causing high discrimination against satellites;
- ECC Report 309 analyses the use of airborne UEs for communication in the current harmonised MFCN frequency bands, but did not examine the 40.5–43.5 GHz frequency band.

These restrictive requirements also apply to use in industrial applications.

4.2 Use in industrial applications

The 42 GHz band in MFCN mode, as part of the millimetre-wave spectrum (mmWave), can provide not only very high data rates over short ranges in industrial applications. The target is specific industrial applications that require fast and reliable communication. Below are some key areas where the 42 GHz band has the potential to deliver breakthrough innovations.

4.2.1 Improvements to Machine-to-Machine (M2M) services

For applications such as smart cities, autonomous vehicles and industrial IoT – which require fast and reliable communication between devices to function properly – the 42 GHz band may be advantageous due to its ability to rapidly transmit large volumes of data, its extremely low packet delay (latency) and the stability of the communication.

[41] According to craf.eu, the RAS station in the Czech Republic is operated only in Ondřejov and uses lower frequencies. See also: https://www.craf.eu/radio-observatories-in-europe/ondrejov/)

Possible applications include:

Industrial Internet of Things (IIoT):

The 42 GHz band can enable faster and more secure data transmission between industrial IoT devices. This is critical for applications requiring fast response times and high data capacity, such as automated production lines, robotic systems, and real-time monitoring and control of equipment.

Virtual and Augmented Reality (VR/AR):

For industrial VR and AR applications, such as staff training, maintenance and repairs, or advanced engineering design work, the 42 GHz band provides high-quality, seamless transmission of the images and data required for this technology.

Security and surveillance:

Real-time, high-resolution image and video transmissions for surveillance and security systems can be significantly enhanced thanks to the high speeds and low latency offered by the 42 GHz band.

Smart factories and automation:

In smart factories, where real-time communication and coordination between machines and systems are essential, the 42 GHz band can support closer integration and process automation.

However, to realise these possibilities, it is essential that technological solutions and infrastructure are tailored to the specific requirements and challenges posed by millimetre-wave technology, including its limited range and sensitivity to physical obstacles. Solutions may include advanced network planning, the use of transmission techniques such as beamforming, and the development of a dense network of access points and relay stations to maintain signal quality and reliability.

Possible applications are summarised in the various visions presented by major manufacturers[42] and industry websites (RFPage.com) in their use cases. Also of interest is a discussion published on the website of the French regulator ARCEP [43], *'Industrial use cases for 5G: ARCEP extends the availability of its test platform in the 3.8–4.0 GHz band by one year and highlights testing opportunities in the 26 GHz band'.*

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[42] Leveraging the potential of 5G millimetre wave; available online at: https://www.ericsson.com/en/reports-and-papers/further-insights/leveraging-the-potential-of-5g-millimeter-wave

[43] Autorité de régulation des communications électroniques, des postes et de la distribution de la presse (ARCEP); *'5G industrial use cases: Arcep extends the availability of its trial platform in the 3.8–4.0 GHz band by a year, and highlights trial opportunities in the 26 GHz band'*; available online at: https://en.arcep.fr/news/press-releases/view/n/5g-191222.html

4.3 Innovative potential for the 42 GHz band

We must assess the 42 GHz band and its innovative capabilities in the context of more readily available alternatives and its technical and regulatory constraints. Although it has the capacity to connect (given the available channel bandwidths and the total available bandwidth of 4 GHz) an extremely high number of devices with capacities exceeding multiples of gigabit connections, the physical characteristics of the band may work against the necessary demand from the telecommunications and non-telecommunications sectors for widespread mass adoption.

A lack of demand undermines manufacturers' willingness to invest in research and development of the component base for the 42 GHz band. Conversely, a lack of available equipment will stifle industry demand and divert its interest towards readily available solutions. The key to utilising new bands lies in the mass production of equipment that meets the requirements of 3GPP and the future regulatory framework. Looking beyond the horizon of 2030, however, demand for MFCN equipment cannot be ruled out. Particularly in the densely populated megacities of East Asia, we anticipate demand for an additional high-speed 5G band; alongside the 26 GHz band, the 42 GHz band is a clear candidate.

Conclusion to Chapter 4:

The 42 GHz band is one of the candidate bands with potential to meet the needs of Industry 4.0 in the future. However, the current regulatory framework and demand are focused to a much greater extent on other bands utilising millimetre waves. Competition for the 42 GHz band comes not only from other 3GPP 5G NR FR2 bands, but also from unlicensed bands standardised by the Wi-Fi Alliance. Given the European Commission's strategy[44] *'Connectivity for a European Gigabit Society'*, which sets out ambitious targets for building a gigabit society by 2030, demand from the telecommunications sector for high-capacity technologies providing connection capacity for 5G network cells, and demand for FWA solutions based on 5G NR, cannot be ruled out.

[44] European Commission; Connectivity for a European Gigabit Society; available online at: https://digital-strategy.ec.europa.eu/en/library/connectivity-european-gigabit-society-brochure