



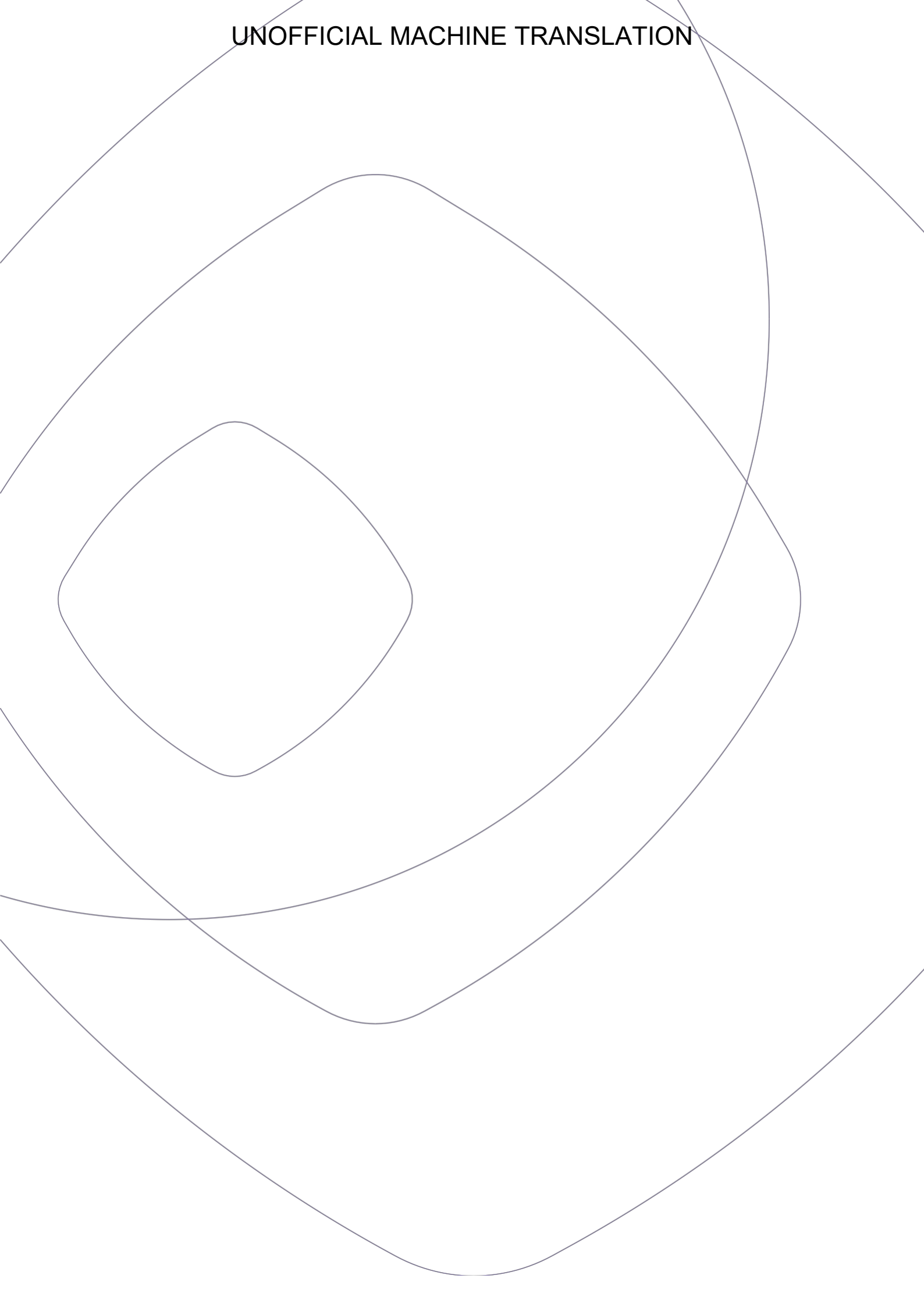
Analysis and design of the process for utilising and allocating of frequencies in the 26 GHz band

Prepared for the Ministry of Industry and Trade

[October 2024]



UNOFFICIAL MACHINE TRANSLATION



Contents

List of abbreviations and glossary	4
Executive summary	6
Management summary	7
1 Introduction	8
1.1 Opinion on aspects relating to the spectrum for next-generation wireless systems	8
1.2 Second RSPG opinion on 5G networks	9
1.3 RSPG opinion on the challenges of 5G implementation	10
1.4 RSPG opinion on further spectrum requirements and guidelines for the rapid deployment of future wireless broadband networks	11
2 Analysis of the current state of 26 GHz band usage	14
2.1 The current regulatory framework for the use of the 26 GHz band	14
2.2 Current use of the band in terms of services and entities	20
2.3 Use of the 26 GHz band in selected countries	
2.4 Practical examples of shared spectrum usage	41
2.5 Examples of the use of millimetre-wave bands for the provision of electronic communications services 44	
3 Frequency usage models for the vertical sector	49
4 Approaches to shared use of frequencies	51
4.1 Technologies for radio spectrum sharing	52
5 Analysis of approaches to frequency allocation in the 26 GHz band	66
5.1 Which part of the frequency band will be allocated or made available?	67
5.2 How can frequencies be allocated, or under what conditions can they be made available?	69
5.3 What might be the geographical coverage of the allocated frequencies?	73

List of abbreviations and explanatory notes

3GPP	3rd Generation Partnership Project
5G	Fifth-generation networks
AAS	Active Antenna Systems
AFC	Automated Frequency Coordination
AFC	Automated Frequency Controller
AGCOM	Italian Communications Regulatory Authority
AI	Artificial intelligence
CBRS	Citizens Broadband Radio Service
CEPT	European Conference of Postal and Telecommunications Administrations
C/I	Carrier-to-Interference
CQI	Channel Quality Indicator (a scaled version of SINR used in modulation selection as an indicator of signal quality)
ČRa	Czech Radiocommunications
ČTÚ	Czech Telecommunications Office
dBm	Decibel-milliwatt
dB μ V	Unit of absolute level relative to a voltage of 1 μ V (microvolt)
DL	Download
ECC	Electronic Communications Committee
EDRS	European Data Transmission System
EESS	Earth exploration-satellite service
eMBB	Enhanced Mobile Broadband
ESC	Environmental Sensing Capability
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FSS	Fixed-satellite service
FWA	Fixed Wireless Access
FWA	Fixed Wireless Access
GAA	General Authorised Access users
HRK	Croatian kuna
IMT	International Mobile Telecommunications
IoT	Internet of Things
ISS	Inter-satellite service
ITU	International Telecommunications Union
LoS	Line-of-Sight
LPWAN	Low-power wide-area network
Mbps	Megabits per second

UNOFFICIAL MACHINE TRANSLATION

MFCN	Mobile Fixed Communication Networks
MIMO	Multiple-input multiple-output
mMTC	Massive machine-type communications
ms	Millisecond
MVNO	Mobile virtual network operator
N/A	Not available
NLoS	Non-Line-of-Sight
NR	New Radio
OFCOM	Regulatory and competition authority for the communications sector in the United Kingdom
PAL	Priority Access Licensees
PCI	Physical-Layer Cell Identity
PPDR	Public Protection and Disaster Relief System
RR	Radio Regulations
RSPG	Radio Spectrum Policy Group
RSRP	Reference Signal Receive Power
SAS	Spectrum Access System
SCS	Subcarrier spacing
SDL	Supplementary downlink (band for boosting the downlink of other bands)
SINR	Signal-to-Noise Ratio
SRR	Short-range radars
SRS	Space Research Service
SSB	Synchronisation Signal Block for NR
TDD	Time Division Duplex
TRP	Total Radiated Power
UAV	Unmanned Aerial Vehicles
U/D	Uplink/Downlink
UL	Upload
ULS	Universal Licensing System
URLLC	Ultra-Reliable and Low Latency Communications
UTC	Coordinated Universal Time
WAS	Wireless Access System
WiGig	Wireless Gigabit Alliance
WLL	Wireless Local Loop
µs	Microsecond

Executive summary

The 24.25–27.5 GHz frequency band falls within the group of millimetre-wave bands suitable for providing ultra-high-capacity connectivity. This band, together with the 3.4–3.8 GHz and 40.5–43.5 GHz and 66–71 GHz, identified as one of the bands for meeting the objectives of the 5G Action Plan by 2020, with the aim of ensuring increased coordinated availability of radio spectrum for the development of very high-speed fixed and wireless networks.

Frequency bands in the millimetre-wave range are characterised by very limited coverage range due to the predominant nature of line-of-sight propagation, compared to lower frequency bands where more favourable conditions for signal propagation apply. However, the limited coverage range often means that base stations can be deployed inside buildings, and their physical size (smaller antenna arrays compared to lower bands) facilitates their installation. These bands also have limited potential for indoor coverage from outdoor base stations due to signal losses when passing through windows and building walls. This characteristic, on the other hand, represents a strength in terms of their potential for indoor use.

In the Czech Republic, the technical parameters and conditions for the use of the radio spectrum in the 24.25 GHz to 27.5 GHz frequency band are set out in Radio Spectrum Utilisation Plan No. PV-P/2/10.2020-10. According to PV-P/2/10.2020-10, the 26.5–27.5 GHz band is designated for mobile service applications for the provision of wireless broadband electronic communications services (IMT). Five adjacent blocks, each 200 MHz wide, are defined in this section, with the upper edge frequency of the last block being 27.5 GHz. Operation is via time-division duplex (TDD). Further conditions necessary for the practical use of this band will be set out by the CTO in the relevant section of the spectrum utilisation plan at a later date. The use of frequencies by base stations and terminals is envisaged on the basis of individual authorisations for the use of radio frequencies (currently permitted only for experimental purposes).

The CTO's objective is to make frequencies in the 1000 MHz range available for the provision of wireless broadband electronic communications services. The basic technical conditions for the use of the 26 GHz band are determined both by the Commission's implementing decisions and by recommendations and other documents issued by the Electronic Communications Committee (ECC). At national level, however, it is possible to set specific conditions in accordance with national needs.

For the purposes of identifying good practice, this study analysed the use of the 26 GHz band in 12 EU countries, the UK and the US (28 GHz band). The aim of the analysis was to identify approaches in individual countries regarding the method and conditions of allocation, including pricing; the definition of entities authorised to use the frequencies; conditions for frequency use, including development criteria; and conditions for frequency sharing in order to increase the efficiency of their use. The overview of spectrum use includes an overview of the practical use of frequencies.

In order to determine the most appropriate approach to frequency allocation in the 26 GHz band, the advantages and disadvantages of various framework scenarios for regulatory conditions governing the use of the frequency spectrum were assessed, which affect the efficiency of frequency use, specifically: a) Which part of the frequency band should be allocated or made available?, b) How can frequencies be allocated, or under what conditions can they be made available?, c) What might be the geographical coverage of the allocated frequencies?

Based on an assessment of the advantages and disadvantages of the individual scenarios, the CTO will adopt a decision on the appropriate approach to the allocation of frequencies in the 26 GHz band. In doing so, the CTO will also take into account the prospects for the future use of the remaining part of the 26 GHz band, i.e. 24.25–26.5 GHz.

Management summary

The 24.25–27.5 GHz frequency band belongs to the group of millimetre wave bands. These bands are suitable for the provision of ultra-high-speed connections. The 24.25–27.5 GHz frequency band (along with the 3.4–3.8 GHz, 40.5–43.5 GHz and 66–71 GHz bands) has been designated as a priority band suitable for fulfilling the objectives of the 5G Action Plan by 2020, with the aim of ensuring increased coordinated availability of radio spectrum in order to develop fixed and wireless networks with very high speeds.

Frequency bands in the millimetre wave range are typically characterised by very limited coverage due to the predominantly line-of-sight nature of propagation, compared to lower frequency bands where more favourable signal propagation conditions apply. However, the limited coverage range often means that base stations can be deployed inside buildings, and their physical size (smaller antenna array compared to lower bands) contributes to less complexity in their installation. These bands have limited potential for indoor signal coverage from outdoor base stations, due to signal transmission losses through windows and building walls. On the other hand, this characteristic improves their potential for indoor use.

In the Czech Republic, the technical parameters and conditions for the use of the radio spectrum in the 24.25–27.5 GHz are stipulated by the radio spectrum usage plan no. PV-P/2/10.2020-10. According to PV-P/2/10.2020-10, the 26.5–27.5 GHz band is designated for mobile service purposes for the use of systems providing wireless broadband electronic communications services (IMT). Five adjacent 200 MHz blocks are defined within the band. The upper edge frequency of the last block is 27.5 GHz.

The harmonised approach to implementing the 26 GHz band for mobile services is achieved through the use of Time Division Duplex.

Further conditions necessary for the practical use of this band will be determined by the ČTÚ in the relevant part of the radio spectrum usage plan.

The use of frequencies by base stations and terminals is assumed to be subject to individual rights of use (use of frequencies is currently permitted only for experimental purposes).

The aim of the ČTÚ is to make 1000 MHz of the band available for the provision of wireless broadband electronic communications services. The basic technical conditions for the use of the 26 GHz band are determined by the Commission's implementing decisions and by recommendations and other documents issued by the Electronic Communications Committee (ECC). At the national level, however, it is possible to set specific conditions in accordance with national needs.

In order to identify best practice, this study analysed the use of the 26 GHz band in 12 EU countries, the United Kingdom and the USA (28 GHz band). The aim of the analysis was to identify approaches in individual countries, specifically the method and conditions of allocation, including pricing, the definition of entities authorised to use frequencies, the conditions for frequency use (including development criteria), and the conditions for frequency sharing in order to increase the efficiency of their use. The study provides an overview of the practical use of frequencies.

The advantages and disadvantages of various scenarios were assessed in order to determine the most suitable approach to the allocation of frequencies in the 26 GHz band. The scenarios define regulatory conditions for the use of the frequency, which affect the efficiency of frequency use. The regulatory conditions cover the following issues: a) Which part of the frequency band should be allocated or made available?, b) How can frequencies be allocated, or under what conditions can they be made available?, c) What should be the territorial scope of coverage of the allocated frequencies?

Based on the evaluation of the advantages and disadvantages of the individual scenarios, the ČTÚ will decide on the appropriate approach to the allocation of frequencies in the 26 GHz band.

The ČTÚ will also take into account the prospects for the future use of the remaining part of the 26 GHz band, i.e. 24.25–26.5 GHz.

1 Introduction

For the purposes of providing terrestrial broadband electronic communications services in mobile networks, including use by private and industrial networks, three basic radio frequency ranges covering a number of radio frequency bands have been identified at European level:

- Frequency bands below 1 GHz for the purpose of ensuring coverage (the 700 MHz, 800 MHz and 900 MHz bands),
- Frequency bands below 6 GHz for the purposes of ensuring coverage and capacity (the 1400 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2600 MHz and 3600 MHz bands) and
- Frequency bands above 6 GHz, typically in the millimetre wave bands, for the purpose of ensuring ultra-high capacity (for example, the 26 GHz band).

Frequency bands above 1 GHz can usually provide individual users with more contiguous and wider sections of the spectrum than frequency bands below 1 GHz and are therefore ideal for providing high transmission capacity.

Frequency bands in the millimetre-wave (mm-wave) bands provide very limited coverage range, due to the predominant nature of line-of-sight propagation compared to lower frequency bands, where more favourable conditions for signal propagation apply. However, the limited coverage range often means that base stations can be deployed inside buildings, and their physical size (smaller antenna arrays compared to lower bands) facilitates their installation. These bands also have limited potential for providing indoor coverage from outdoor base stations due to signal losses when passing through windows and building walls. This characteristic, on the other hand, represents a strength of their potential for use inside buildings.

The Radio Spectrum Policy Group (hereinafter 'RSPG') has identified the 24.25–27.5 GHz frequency band (hereinafter also 'the 26 GHz band') (together with the 3.4–3.8 GHz, 40.5–43.5 GHz and 66–71 GHz bands) as one of the bands for meeting the objectives of the 5G Action Plan by 2020, with the aim of ensuring increased coordinated availability of radio spectrum for the development of very high-speed fixed and wireless networks.

The RSPG has issued four opinions on 5G-related issues:

1. RSPG Strategic Plan for 5G in Europe – Opinion on spectrum-related aspects for next-generation wireless systems (RSPG16-032 FINAL)
2. RSPG Strategic Roadmap on 5G for Europe – Second RSPG Opinion on 5G Networks (RSPG18-005 FINAL)
3. RSPG Strategic Roadmap on 5G for Europe – RSPG Opinion on the challenges of 5G deployment (3rd RSPG Opinion on 5G) (RSPG19-007 FINAL)
4. RSPG Opinion on Further Spectrum Needs and Guidance for the Rapid Deployment of Future Wireless Broadband Networks (RSPG21-024 FINAL)

1.1 Opinion on spectrum-related aspects for next-generation wireless systems

RSPG Strategic Plan for 5G in Europe – Opinion on spectrum-related aspects for next-generation wireless systems (RSPG16-032 FINAL)

According to this RSPG opinion:

- It notes the mobile sector's support for the 24.25–27.5 GHz frequency band as a pioneering band for the roll-out of 5G in Europe in the above-24 GHz band.
- It recommends the 24.25–27.5 GHz frequency band as a pioneering band for 5G in the above-24 GHz band.
- Recommends that Europe introduce harmonisation measures based on a decision on the frequency band no later than 2020.
- It recommends that Member States make part of the 24.25–27.5 GHz frequency band available for 5G in line with market demand, whilst taking into account that the roll-out of 5G in this frequency band is likely to remain geographically limited until 2020.
- It expressed the view that, when harmonising the 24.25–27.5 GHz frequency band, it is necessary to take into account the expectation of a gradual roll-out of 5G, which will begin in urban areas using only part of this frequency band.
- It notes that mobile network operators are currently the main users of the 24.25–27.5 GHz frequency band for fixed services. This may reduce the need for extensive reallocation of the band from fixed links. Consequently, it can be expected that

UNOFFICIAL MACHINE TRANSLATION

the demand for new frequencies for fixed-link purposes in the backbone network from mobile network operators, following the adjustment of the conditions for using the 26 GHz band, will be managed within the existing frequency bands allocated to the fixed service.

1.2 Second RSPG Opinion on 5G Networks

RSPG Strategic Plan for 5G in Europe – Second RSPG Opinion on 5G Networks (RSPG18-005 FINAL)

According to this RSPG opinion:

- It expressed the view that Member States will need flexibility in allocating authorisations for access to spectrum in terms of the appropriate geographical area (national, regional, urban, local, for example at the level of a production plant), individual authorisation or general authorisation.
- It expressed the view that all commercial licences in the bands identified for 5G within Member States should be subject to trading or leasing in order to create conditions for new market opportunities.
- With regard to the 24.25–27.5 GHz frequency band, it expressed the view that:
 - i. The preferred authorisation method should be a regime of individual authorisations, whilst not ruling out the possibility of using a general authorisation regime, provided that sharing conditions are applied to ensure the protection of other users of frequencies in this band (e.g. EESS/SRS).
 - ii. The Commission should include requirements to preserve the possibility of further development of existing satellite services (FSS and EESS/SRS) in any technical harmonisation concerning the 26 GHz band. Future earth stations should be authorised on the basis of transparent, objective and proportionate criteria to ensure their future operation and to ensure that they do not have a significant impact on the deployment and coverage of 5G networks. Responsibility for granting or refusing authorisations for new satellite earth stations will lie exclusively with the Member States.
 - iii. By 2020, Member States should make a sufficiently large portion of the band (1 GHz) available for 5G, depending on market demand, taking into account that the roll-out of 5G in this band is expected to be in the interest of ensuring local coverage.
 - iv. Regulatory flexibility for the gradual release of the 26 GHz band will enable the effective roll-out of 5G without an unavoidable negative impact on current users of the 26 GHz band. Member States should plan the migration of fixed links from the band to ensure its availability for 5G, taking into account the geographical extent of market demand for 5G.
- The RSPG opinion further states:
 - i. The 26 GHz band will be used in areas of very high demand, such as transport hubs, entertainment centres, industrial or retail sites (creating islands of very high capacity). Given its characteristics, the band will not be used to provide coverage for large areas.
 - ii. Access to higher-frequency bands creates scope for new forms of sharing. The roll-out of 5G in millimetre-wave bands (such as the 26 GHz band) will take the form of small cells. These cells will have limited coverage and, particularly in the early stages, will be concentrated mainly in urban and suburban areas. They can be installed outdoors or indoors, for example using street furniture.
 - iii. A significant portion of the 26 GHz band is currently used for wireless fixed links in European countries. Depending on the location of fixed links, the demand for 5G small cells and the extent to which interference can be mitigated using new technologies, it will be possible to deploy 5G small cells in the same frequency range as some of the existing fixed links.
 - iv. Technical studies need to be carried out within the CEPT focusing on coexistence with fixed service applications (point-to-point, point-to-multipoint) in the 26 GHz band (and in other relevant millimetre-wave bands). These studies should take into account relevant technological developments and their potential positive impact on sharing possibilities, e.g. improvements in antenna technology such as massive MIMO and beamforming, as well as different antenna mounting positions for 5G and fixed services (street level, roof level).
 - v. In areas where adequate coexistence cannot be achieved, it will be necessary to release spectrum from fixed links to enable the roll-out of 5G. Regulatory authorities will need to consider the best approach to spectrum release. Fixed links could be phased out of the band gradually, provided such an approach is deemed appropriate and consistent with national policy objectives. The phased removal of fixed links contrasts with previous cases (in lower frequency bands), where the band had to be completely cleared before licences were granted to mobile network operators. Fixed links could, for example, be moved outside specific sub-bands of the 26 GHz band and/or outside geographical areas within a country in the interests of 5G deployment. Such an approach could be more cost-effective and practical than developing complex technologies and systems enabling small 5G cells and fixed-link receivers to operate on the same frequency and in close proximity. Alternatively, regulatory authorities may consider full spectrum release to be the best approach given their national circumstances and policy objectives.
 - vi. Flexibility in the timetable for releasing the 26 GHz band in response to the needs of various market players is important in order to minimise the overall costs associated with 5G deployment and to minimise the burden placed on existing fixed-line operators.
 - vii. In the long term, it is clear that the 26 GHz band will no longer play a significant role for fixed service purposes. The possibility of continuing to operate a limited number of fixed links in the 26 GHz band on a shared basis with 5G will depend on the effectiveness of potential techniques to mitigate the negative effects of mutual interference and the extent of 5G deployment, particularly in less populated and rural areas.
 - viii. Harmonisation of the 26 GHz band for 5G will need to take into account other services in the same band or in adjacent bands.

UNOFFICIAL MACHINE TRANSLATION

- ix. Before allocating frequencies from the 26 GHz band for 5G, administrations are recommended to consult relevant stakeholders to ascertain whether they have plans to deploy additional terrestrial stations, and to cooperate with them to identify potential sites where such future terrestrial stations could be deployed. This is unlikely to have a significant impact on 5G deployment and coverage. If such sites are identified, the possibility of deploying planned terrestrial stations should be maintained, and transparent, objective and proportionate criteria should be established to ensure their future operation. Where necessary, relevant provisions may be included in the relevant 5G authorisation.
- x. The use of higher frequency bands (above 24 GHz), which enable new services and applications, is likely to require an authorisation approach that allows for the inclusion of various groups of new market entrants alongside existing network operators. Furthermore, 5G requires much greater channel bandwidth to deliver the full speed of Enhanced Mobile Broadband (eMBB). Consequently, spectrum may not be available in sufficient quantities to provide each operator with an exclusive allocation, free from existing users.
- xi. Member States will require flexibility in utilising combinations of possible approaches to spectrum authorisation. Alternative authorisation approaches may include a general authorisation regime, licensed shared use between different users, geographical sharing (including sub-national licences, regional licences and licences for specific locations, including at local level directly for business entities) or more dynamic approaches to spectrum sharing in time and space with the potential use of geolocation databases.
- xii. One possible approach would be to envisage the use of a general authorisation regime in the highest frequency bands (e.g. 66–71 GHz) and the use of an individual authorisation regime in the 26 GHz band, where stricter restrictions need to be applied, with a focus on the individual authorisation regime and the application of stricter sharing rules.
- xiii. Allowing the trading or leasing of spectrum can reduce investment uncertainty and increase the efficiency of spectrum use. Member States should ensure that spectrum trading or leasing does not have an adverse impact on competition.
- xiv. Demand for business applications could be largely met by mobile network operators. Making spectrum available to entities operating in specific sectors could create an opportunity for those entities to offer specific applications using their own infrastructure or via the infrastructure of mobile network operators.
- xv. Some new applications, such as the Internet of Things or the provision of indoor coverage, may also develop using spectrum under a general authorisation. Allowing the use of spectrum for these applications under a general authorisation can be an important stimulus for innovation and contributes to increasing the dynamism of the market environment.

1.3 RSPG Opinion on the Challenges of 5G Implementation

RSPG Strategic Roadmap on 5G for Europe – RSPG Opinion on the Challenges of 5G Deployment (3rd RSPG Opinion on 5G) (RSPG19-007 FINAL)

According to this RSPG opinion:

- It states that connectivity for the vertical sector can be provided through:
 - i. solutions offered by mobile network operators,
 - ii. solutions offered by third parties and/or
 - iii. proprietary solutions developed by the vertical sector in bands harmonised at EU level for electronic communications services or in a frequency band reserved for the vertical sector.
- It recommends that Member States consider other solutions for spectrum use, including dedicated or shared spectrum for business/industry needs (vertical sector), which may not necessarily be feasible for mobile network operators. Such solutions could benefit from economies of scale and the availability of ecosystems in frequency bands with harmonised technical conditions at EU level.
- The RSPG opinion further states:
 - i. From a spectrum management perspective, there are various ways to address the needs of the vertical sector.
 - ii. The connectivity needs of the vertical sector can be met in three possible ways:
 - a) Mobile operators' solutions for the vertical sector – for some entities in the vertical sector, the use of a public mobile network will suffice to meet connectivity requirements. This reduces the need for dedicated spectrum allocations for specific vertical applications. However, some sectors may have specific needs that mobile network operators cannot meet. Consequently, it should be possible to utilise other solutions regarding spectrum usage in order to respond to the needs of the vertical sector.
 - b) Frequencies reserved for the vertical sector – this covers two types of vertical sector entities. The first type is largely dependent on network infrastructure. Such entities are capable of generating aggregated requirements/needs for spectrum managers (particularly regarding coverage of large areas). The second type comprises more fragmented and specialised users who primarily require local coverage and usually use a private network (such as local industrial 'on-site'). These types of users may have requirements for dedicated spectrum for reasons of cost, security or a desire for full control over the network. In both cases, technical conditions harmonised at EU level, suitable for mobile networks and providing economies of scale, are appropriate for these types of use.

- c) An EU-level vertical sector-specific band – this vertical category could benefit from specialised harmonised technical conditions at EU level in the context of technology neutrality, suitable, for example, for pan-European service provision.

1.4 RSPG Opinion on further spectrum needs and guidelines for the rapid deployment of future wireless broadband networks

RSPG Opinion on further spectrum needs and guidance on the rapid deployment of future wireless broadband networks (RSPG21-024 FINAL)

According to this RSPG opinion:

- There is a specific demand for local access to licensed spectrum for vertical networks:
 - i. in the mid-bands, which has been addressed differently across Member States due to varying national circumstances (e.g. priorities for efficient spectrum use), and
 - ii. in the millimetre wave bands.
- It notes that there is no specific need for spectrum for FWA in the millimetre wave bands, although operators should also have the option to focus on this application within their allocated frequencies.
- Recognises that different authorisation approaches foster innovation and different technologies.
- Recommends that Member States promote consistent approaches to making spectrum available for the vertical sector in the millimetre wave band, with the possibility of use for local access purposes in the 26 GHz and 42 GHz bands.

In accordance with Recital 135 of Directive (EU) 2018/1972 of the European Parliament and of the Council establishing the European Electronic Communications Code, it is necessary to ensure that, by 31 December 2020, the 3.4–3.8 GHz and 24.25–27.5 GHz bands, or parts thereof, are made available to terrestrial systems capable of providing wireless broadband services under harmonised conditions laid down by technical implementing measures adopted in accordance with Article 4 of Decision No 676/2002/EC, the 3.4-3.8 GHz and 24.25-27.5 GHz bands, or parts thereof, are made available by 31 December 2020, as these bands have specific characteristics in terms of coverage and data capacity that allow them to be suitably combined to meet the requirements of 5G networks.

The Code envisages that future use of the 26 GHz band for terrestrial 5G wireless services will focus, amongst other things, on urban and suburban areas with higher population densities, whilst a certain degree of deployment of these services can be expected along major roads and railway lines in rural areas. This presents an opportunity for the 26 GHz band to be used outside these geographical areas for services other than 5G wireless services, such as business-specific communications or in-building applications, and for Member States to designate and make this band available on a non-exclusive basis.

In accordance with Article 54(1)(b) of Directive (EU) 2018/1972 of the European Parliament and of the Council, with regard to terrestrial systems capable of providing wireless broadband services, Member States shall, by 31 December 2020, adopt, where necessary to facilitate the roll-out of 5G networks, all appropriate measures to enable the use of at least 1 GHz in the 24.25–27.5 GHz band, provided that there is clear evidence of market demand and the absence of significant obstacles that would prevent the migration of existing users of the band or the release of the band.

In accordance with Commission Implementing Decision (EU) 2019/784 of 14 May 2019 on the harmonisation of the 24.25–27.5 GHz for terrestrial systems to provide wireless broadband electronic communications services in the Union, the 26 GHz band offers significant capacity for the provision of innovative wireless broadband electronic communications services using 5G technology based on small cells and with a block size of 200 MHz.

Commission Recommendation (EU) 2020/1307 of 18 September 2020 on a common set of Union tools to reduce the costs of deploying very high capacity networks and to ensure timely access to investment-friendly 5G radio spectrum in order to strengthen connectivity in support of the economic recovery following the COVID-19 crisis in the Union (hereinafter 'Recommendation 2020/1307') sets out recommendations for Member States comprising simple and realistic measures designed to help create the conditions for the allocation of radio spectrum for 5G networks under investment-friendly conditions and to facilitate the roll-out of fixed and wireless ultra-high-capacity networks (including optical networks and next-generation wireless networks), for example by removing unnecessary administrative barriers and streamlining authorisation procedures.

According to Recommendation 2020/1307, the roll-out of 5G wireless networks would benefit from flexible authorisation regimes that support investment in wireless networks and ensure the efficient use of spectrum. Bands above 24 GHz ('millimetre wave bands'), including the 24.25–27.5 GHz frequency band, offer a wide range of radio spectrum with geographically limited propagation characteristics. Whilst Member States should generally use competitive procedures, such as auctions, to grant rights of use for scarce frequency bands, in certain cases these procedures may limit the potential for investment in dense 5G wireless networks, as well as the flexibility and resulting efficiency of spectrum use. Individual authorisations

UNOFFICIAL MACHINE TRANSLATION

for the use of harmonised millimetre-wave bands, which employs an accelerated administrative procedure that is open, objective, proportionate and non-discriminatory, and is governed by transparent criteria and procedures.

In accordance with paragraph 19 of Recommendation 2020/1307, Member States should request the Peer Review Forum referred to in Article 35 of the Code to review in advance proposed measures for the granting of spectrum usage rights in the 700 MHz, 3.4–3.8 GHz and 24.25–27.5 GHz, with a view to exchanging best practices.

In accordance with paragraph 20 of Recommendation 2020/1307, Member States should, in order to incentivise radio spectrum users to invest substantially in the roll-out of 5G networks, inform the European Commission, in particular through the Radio Spectrum Policy Group, of the specific measures they consider to be best practices, including those that have been or are to be introduced at national level when authorising the use of radio spectrum in the 700 MHz, 3.4–3.8 GHz and 24.25–27.5 GHz.

In particular, Member States should report on all relevant measures aimed at:

- a) promote appropriate reserve prices that reflect the minimum level of fees for radio spectrum usage rights,
- b) prevent spectrum shortages by ensuring the allocation of all radio spectrum harmonised at Union level,
- c) provide, in a non-discriminatory manner, the option to pay fees for radio spectrum usage rights in instalments over the duration of those rights,
- d) apply an individual authorisation regime for the 24.25–27.5 GHz frequency band that promotes its timely use, including a regime based on accelerated administrative procedures where applied to geographically limited rights of use,
- e) combine financial incentives with obligations or formal commitments to accelerate or extend high-quality wireless coverage,
- f) in accordance with competition law, to provide for the sharing of passive and active infrastructure, as well as for the joint deployment of infrastructure based on the use of radio spectrum.

In the RSPG Opinion on Spectrum Sharing – Pioneering Initiatives and Bands (RSPG21-006 FINAL) of 10 February 2021, the RSPG notes that spectrum sharing in the EU has so far been implemented in a rather static and conservative manner and needs to be developed, particularly given its potential to increase the efficiency of radio spectrum use and provide incentives for innovation.

In its opinion, the RSPG states:

- When allocating new rights of use, Member States should consider spectrum sharing between existing and new users through innovative and more dynamic solutions.
- The technical conditions for sharing can be defined on a case-by-case basis, drawing on the technical options and approaches under consideration.
- Where one or more existing users of services other than electronic communications services are using a band, Member States should assess whether multi-level sharing is feasible.
- Member States could consider spectrum sharing arrangements that enable the vertical sector and other spectrum users to gain access to spectrum on a mutually beneficial basis.
- Member States will need to assess the potential impact of the measures introduced on competition.
- Wherever appropriate and useful, sharing conditions may be applied to achieve more efficient use of spectrum, in particular to meet coverage targets or to accelerate network roll-out, increase coverage, and improve capacity and service quality. Allottees must be informed in advance of the technical conditions and parameters of such spectrum sharing arrangements.
- Member States should give priority to spectrum-sharing agreements, including those based on spectrum aggregation between licensed operators, and, where necessary, attach conditions to such agreements in order to achieve public interest objectives such as more efficient spectrum use, improved network coverage or capacity, and increased network coverage density.
- Spectrum sharing is not a universal tool for resolving spectrum scarcity when addressing the conflicting requirements of different groups of spectrum users.
- When defining the technical conditions for spectrum sharing (at ETSI or CEPT level), it is necessary to take into account the long-term development requirements of all users.
- Member States and the Commission should support the development of transmitters and receivers with technical specifications that will ensure the effectiveness of regulatory decisions on spectrum use. These requirements should also include sufficient safeguards to ensure that equipment cannot be modified by the user in a way that would adversely affect spectrum sharing or coexistence arrangements.
- Member States should encourage the development of equipment capable of tolerating a certain level of unforeseen interference.
- Member States should, in order to strengthen the confidence of spectrum users, reinforce market surveillance to ensure that equipment complies with key requirements, particularly in cases where sharing conditions depend on equipment characteristics (dynamic frequency selection or database-based authorisation).

UNOFFICIAL MACHINE TRANSLATION

The RSPG recommends the following approach to promote spectrum sharing:

- Exploring dynamic forms of spectrum sharing
 - To facilitate the introduction of new spectrum sharing options in the context of spectrum scarcity, the way in which sharing conditions are defined should be based on realistic scenarios rather than worst-case scenarios and should take measurement results into account as much as possible, in order to better understand the impact of actual interference.
 - Member States should promote the efficient use of spectrum by facilitating the deployment of spectrum-efficient systems by spectrum users and by encouraging the upgrade of current technologies to new, more spectrum-efficient technologies.
 - Member States should support the development of initial 'proof of concept' systems in bands where advanced spectrum-sharing systems have been developed, such as cognitive radio systems and other systems utilising information and communication technology or database systems, at least at an experimental level and under the supervision of the regulatory authority, and assess how these systems can be used for sharing purposes in other frequency bands.
 - Where appropriate and feasible, and where there is demand, Member States should issue temporary test or innovation (test and trial/innovation and trial) authorisations to promote innovation. Such authorisations should enable users, including those who are not traditional operators, to access spectrum.
 - The European Commission and Member States should support and authorise the trial and experimental operation of spectrum-sharing systems using artificial intelligence-based technologies, in order to create the conditions for the use of these technologies in commercial spectrum sharing and to build user confidence in them.
 - In order to implement spectrum-sharing solutions based on systems utilising information and communication technology or database systems, Member States should support the activities of CEPT and ETSI aimed at promoting the deployment of such systems. This would require the development of standard communication interfaces between equipment and databases, as well as a framework for the establishment and management of databases.
 - These activities should be sufficiently general in nature to allow for adaptation to the conditions of spectrum sharing in different bands and to different geographical specificities.
 - Where appropriate and possible, and in line with the objectives of the EU single market, Member States should, when implementing spectrum-sharing solutions based on a geolocation database, make use of the aforementioned standard communication interfaces and database management framework, and support the development of a database-based approach to spectrum sharing, including those using equipment capable of operating in multiple countries, taking into account interoperability requirements whilst safeguarding the interests of services dedicated to public and national security.
 - To facilitate sharing scenarios, Member States may make information on radio spectrum usage available online. Prior to publication, Member States should adapt the information into a suitable anonymised format, e.g. information relating to protected or excluded zones, protection criteria, and periods of use, in accordance with national rules (cybersecurity, confidentiality, legal requirements, etc.).
 - Given the examples of authorisation allocation in a reserved spectrum band under a simplified authorisation regime based on an automated platform, Member States may consider using similar approaches in their respective authorisation processes, with a view to promoting spectrum sharing.
- Coordinated approaches
 - To facilitate spectrum sharing, the RSPG calls on Member States to share their experiences with innovative solutions and initiatives for spectrum sharing, in particular to:
 - i. share experiences relating to new cases of sharing and more dynamic approaches to spectrum management, including solutions to cases of harmful interference and coexistence issues,
 - ii. share best practices in cases with a cross-border dimension within the EU context, taking into account the results of EU-funded projects and pilot schemes, as well as vertical sector trials,
 - iii. cooperate on cross-border and public-private research and development projects, e.g. using EU-funded programmes, whilst sharing the results of such projects,
 - The RSPG recommends that the European Commission continue to fund and prioritise EU research projects focused on the commercial development of technologies and network architectures that can make spectrum sharing more efficient and facilitate its development.
 - The RSPG recommends that Member States take into account the development of innovative solutions and initiatives focused on spectrum sharing outside the EU.
 - In order to promote more dynamic spectrum sharing and the automation of spectrum access in the medium term, the European Commission and Member States should, on the basis of relevant CEPT and ETSI outputs, identify spectrum use case scenarios which require spectrum sharing and enable the development of proven spectrum-sharing concepts based on systems utilising information and communication technology support with innovative technologies such as artificial intelligence/machine learning and collaboration techniques. Member States should utilise the above-mentioned spectrum sharing solutions to help build trust among users and industry, alongside enhanced market surveillance and monitoring of spectrum use, in order to accelerate the commercial deployment of the chosen solution.

2 Analysis of the current state of 26 GHz band usage

2.1 The current legal framework for the use of the 26 GHz band

The legal framework for the use of the 26 GHz band at European Union level consists of:

- Directive (EU) 2018/1972 of the European Parliament and of the Council establishing the European Electronic Communications Code (hereinafter referred to as 'the Code'),
- Commission Implementing Decision (EU) 2019/784 of 14 May 2019 on the harmonisation of the 24.25–27.5 GHz frequency band for terrestrial systems providing wireless broadband electronic communications services in the Union (hereinafter 'Decision 2019/784'),
- Commission Implementing Decision (EU) 2020/590 of 24 April 2020 amending Decision (EU) 2019/784 as regards the update of the relevant technical conditions applicable in the 24.25–27.5 GHz frequency band (hereinafter referred to as 'Decision 2020/590').

Pursuant to Article 54(1)(b) of the Code, with regard to terrestrial systems capable of providing wireless broadband services, Member States shall, by 31 December 2020, adopt, where necessary to facilitate the roll-out of 5G networks, all appropriate measures to enable the use of at least 1 GHz in the 24.25–27.5 GHz band, provided that there is clear evidence of market demand and the absence of significant obstacles that would prevent the migration of existing users of the band or the release of the band.

Parts of the 26 GHz frequency band are used in EU Member States for:

- terrestrial fixed wireless links,
- short-range vehicle radars,
- transport and traffic telematics equipment (in particular for vehicle radars),
- radio positioning equipment operating in an 'underlay' mode based on ultra-wideband technology,
- space and satellite services
 - downlink communications to ground stations in the Earth Exploration Satellite Service (EESS), the Space Research Service (SRS) and in support of the European Data Relay System (EDRS),
 - uplink communications to satellite on-board receivers in the Fixed Satellite Service (FSS),
 - communications between non-geostationary and geostationary satellites in the inter-satellite service (ISS), including EDRS.

Table 1: Current use of the 26 GHz band in EU Member States

Service and application	Allocated band segment (GHz)
Terrestrial fixed wireless links (fixed links), including backbone links	24.25–27.5
Short-range vehicle radars	24.25–26.65
Equipment for transport and traffic telematics (particularly for vehicle radars)	24.25–24.50
Radio positioning equipment operating in an 'underlay' mode based on ultra-wideband technology	24.25 – 27
Space and satellite services	
<ul style="list-style-type: none"> • Downlink communications to ground stations in the Earth exploration satellite service (EESS), space research service (SRS) and in support of the European Data Relay System (EDRS) 	25.5 – 27
<ul style="list-style-type: none"> • Uplink communications to satellite on-board receivers in the Fixed Satellite Service (FSS) 	24.65 – 25.25
<ul style="list-style-type: none"> • Communications between non-geostationary and geostationary satellites in the inter-satellite service (ISS), including EDRS 	24.45 – 24.75 and 25.25 – 27.5

Decision 2019/784 harmonises the essential technical conditions for the availability and efficient use of the 24.25–27.5 GHz frequency band in the Union for terrestrial systems providing wireless broadband electronic communications services.

UNOFFICIAL MACHINE TRANSLATION

In accordance with Article 2 of Decision 2019/784,¹ Member States shall, by 30 March 2020, make available on a non-exclusive basis the 24.25–27.5 GHz frequency band for terrestrial systems to provide wireless broadband electronic communications services in accordance with the essential technical conditions set out in the Annex to Decision 2019/784.

Depending on the authorisation regime applied in the 26 GHz band, Member States shall analyse whether it is necessary to impose additional technical conditions to ensure the proper coexistence of terrestrial systems providing wireless broadband electronic communications services with other services in that band.

Member States shall, in accordance with the relevant technical conditions set out in the Annex to Decision 2019/784, ensure that terrestrial systems for wireless broadband electronic communications services provide adequate protection for:

- a) systems in adjacent bands, in particular in the Earth exploration-satellite (passive) service and in the radio astronomy service in the 23.6–24.0 GHz frequency band,
- b) earth stations in the Earth exploration-satellite service and in the space research service for downlink communications operating in the 25.5–27.0 GHz frequency band,
- c) satellite systems for uplink communications in the fixed satellite service operating in the 24.65–25.25 GHz frequency band,
- d) satellite systems for inter-satellite communications operating in the 24.45–24.75 GHz and 25.25–27.5 GHz frequency bands.

Member States may authorise the continued operation of fixed links in the 24.25–27.5 GHz frequency band, provided that terrestrial systems providing wireless broadband electronic communications services can coexist with such fixed links through controlled spectrum sharing. Member States shall regularly monitor the need for the continued operation of fixed links in the 24.25–27.5 GHz frequency band.

Provided that the number of new terrestrial stations and their locations are determined in such a way as not to unduly restrict wireless broadband electronic communications services, and subject to market demand, Member States shall ensure that it remains possible to deploy terrestrial stations:

- in the Earth exploration-satellite service (downlink) or in the space research service (downlink) in the 25.5–27.0 GHz frequency band,
- in the fixed-satellite service (downlink) in the 24.65–25.25 GHz frequency band.

The general parameters for the use of the 26 GHz band by terrestrial systems to provide wireless broadband electronic communications services are set out in the Annex to the Decision as follows:

- The duplex mode of operation is time division duplex (TDD).
- The size of the allocated block is a multiple of 200 MHz. To ensure the efficient use of the entire band, narrower blocks of 50 MHz, 100 MHz or 150 MHz may also be used adjacent to another spectrum user's allocated block.
- The highest frequency of the allocated block coincides with the upper edge of the 27.5 GHz band, or is offset from it by multiples of 200 MHz. If the block is narrower than 200 MHz or needs to be shifted to take account of existing uses, this shift is a multiple of 10 MHz.
- The technical conditions set out in the Annex form the basis for addressing the coexistence of terrestrial systems providing wireless broadband electronic communications services and the coexistence of these systems with systems in the Earth exploration-satellite (passive) service, in the form of limits on unwanted emissions into the 23.6–24 GHz frequency band, as well as with space station receivers in the form of restrictions on the main beam tilt of the active antenna system of an outdoor base station. Further measures at national level may be necessary to ensure coexistence with other services and applications.
- Transmissions from base stations and terminals in the 24.25–27.5 GHz frequency band are in accordance with the block edge spectrum mask set out in the Annex to Decision 2019/784.

With regard to the coexistence of terrestrial wireless broadband electronic communications services, including next-generation or 5G services and existing services in the 26 GHz band, the following applies in accordance with Decision 2019/784:

- In the case of terrestrial fixed wireless links, an approach allowing for flexibility at national level needs to be applied.
- The use of the band for short-range vehicle radars should be phased out from 1 January 2022².

¹ In the context of Decision 2019/784, the term 'identification and making available' of the 26 GHz frequency band refers to the following steps: (i) adapting the national legal framework on spectrum allocation to include the intended use of this band in accordance with the harmonised technical conditions set out in this Decision; (ii) initiating all necessary measures to ensure, to the extent necessary, coexistence with existing uses in this band; (iii) initiating appropriate measures, supported where appropriate by the launch of a consultation process with stakeholders, to enable the use of this band in accordance with the applicable legal framework at Union level, including the harmonised technical conditions set out in Decision 2019/784.

² Developments in the market for short-range vehicle radars show a consistent trend towards the introduction of new radars in the 77–81 GHz frequency band, which is harmonised at Union level. No coexistence issues with short-range vehicle radars have therefore been identified.

UNOFFICIAL MACHINE TRANSLATION

- In the case of transport and traffic telematics equipment (in particular for vehicle radars), the band segment is allocated on an unprotected and non-interference basis. Vehicle radars are not currently used in this band, nor is such use planned, but the level of such use in the 76–81 GHz frequency band is increasing.
- In the case of radio positioning equipment operating in an ‘underlay’ mode based on ultra-wideband technology, it should be possible to adapt such use to developments in the utilisation of the 26 GHz frequency band for terrestrial wireless broadband electronic communications services.
- Space and satellite services should be adequately protected from interference from terrestrial wireless broadband electronic communications services; at the same time, scope needs to be created for their further development.
- Next-generation terrestrial services (5G) should be introduced in the 26 GHz frequency band on the basis of harmonised technical conditions. These conditions should safeguard the uninterrupted operation and development of satellite earth stations (in the EESS, SRS and FSS services) with frequency allocations in this band, so that earth stations can be authorised in the future on the basis of transparent, objective and proportionate criteria. These conditions should also ensure that existing and future satellite services are unlikely to have a significant negative impact on the deployment and coverage of 5G terrestrial networks.
- Coexistence between terrestrial wireless broadband electronic communications services (including 5G) and terrestrial stations in the EESS, SRS and FSS services operating in the 26 GHz frequency band can be ensured, where appropriate, by applying technical restrictions on the deployment of terrestrial services within a limited geographical area around a satellite earth station. In this regard, a proportionate approach to facilitating such coexistence may be to prioritise the deployment of new terrestrial stations away from areas with high population density or high levels of human activity³.
- Member States should assess the possibility of the continued operation of fixed links in the 26 GHz band based on the shared use of radio spectrum with terrestrial electronic communications broadband services, including 5G, or the cessation of their operation in that band. This assessment should take into account possible interference mitigation techniques and national and cross-border coordination, as well as the extent of 5G deployment, taking into account market demand for 5G systems, particularly in less populated and rural areas. The possibility of spectrum sharing, subject to national choice, depends, inter alia, on the availability of detailed information on the deployment of fixed links and the feasibility of allocating large contiguous blocks of spectrum for 5G systems⁴.
- Terrestrial wireless broadband electronic communications services, including 5G, in the 26 GHz band should ensure adequate protection of the EESS (passive) service in the 23.6–24 GHz frequency band. At national level, specific measures may be necessary to ensure the protection of radio astronomy stations operating in the 23.6–24 GHz frequency band. These measures are likely to limit the usability of the entire 26 GHz band in the vicinity of these stations. Protection of the EESS (passive) service in the 50.2–50.4 GHz and 52.6–54.25 GHz frequency bands is ensured by the existing general limits on unwanted emissions applicable to base stations.
- Existing uses, such as satellite receivers in the FSS and ISS services, could be affected by the use of unmanned aerial vehicles (hereinafter ‘UAVs’), such as drones, in conjunction with terrestrial wireless broadband electronic communications networks using the 26 GHz frequency band. Consequently, connections from base stations to terminals on board UAVs should be prohibited in the 26 GHz frequency band, and only connections from terminals on board UAVs to base stations should be permitted, in accordance with applicable air traffic management regulations. In this regard, connections from UAV-borne terminals to base stations could have a significant impact, for example, on the separation distance from ground stations in EESS/SRS services sharing the 26 GHz band on an equal footing. This requires further examination, which may result in additional harmonised technical conditions. The use of UAVs with wireless broadband electronic communications networks should not hinder the deployment of future ground stations in EESS/SRS services. However, the EC’s mandate for a study of mobile network bands (issued in 2023) for use by unmanned aerial vehicles does not include the 26 GHz band.
- The regulation should include cross-border agreements⁵ between radio spectrum users or national regulatory authorities to ensure the implementation of Decision 2019/784 with a view to avoiding harmful interference and improving the efficient use of radio spectrum and convergence in spectrum use.

Decision 2020/590 amended Table 4 (Supplementary basic power limit for base stations) and Table 6 (Supplementary basic power limit for terminals) of the Annex to Decision 2019/784 in order to align the protection limits harmonised at EU level with the protection limits set out in the ITU-R Radio Regulations, as amended. The protection limits have been harmonised with the aim of increasing the availability and choice of equipment and eliminating the negative impact on equipment costs.

³ CEPT is developing sets of technical tools (for example, Recommendation ECC (19)01 ‘Set of technical tools to support the deployment of 5G whilst ensuring the appropriate use of existing and planned receiving terrestrial stations in the EESS/SRS service in the 26 GHz band and the possibility of future deployment of such terrestrial stations’. Among other things, these toolkits provide national regulatory authorities with methodologies for determining coordination areas around terrestrial stations.) to support the roll-out of 5G on the basis of an individual authorisation regime, whilst allowing, in the relevant parts of the 26 GHz frequency band, for the uninterrupted use of existing and planned receiving earth stations in the EESS/SRS services and transmitting earth stations in the FSS service. These toolkits may facilitate coexistence in the fulfilment of obligations under this Decision.

⁴ To this end, CEPT provides technical guidance on the coexistence of terrestrial broadband electronic communications services, including 5G, and fixed links, taking into account the progressive roll-out of 5G.

⁵ ECC Recommendation (23)02 on cross-border coordination for mobile/fixed communication networks (MFCN) in the 24.25–27.5 GHz frequency band

UNOFFICIAL MACHINE TRANSLATION

In the Czech Republic, the technical parameters and conditions for the use of the radio spectrum in the 24.25 GHz to 27.5 GHz frequency band by radiocommunication services are set out in Part of the Radio Spectrum Utilisation Plan No. PV-P/2/10.2020-10 (hereinafter 'PQRS').

UNOFFICIAL MACHINE TRANSLATION

Table 2: Use of the 26 GHz band according to the Radio Spectrum Utilisation Plan No. PV-P/2/10.2020-10

Band (GHz)	Allocation to services	Usage	Note	Future development
24.25–26.65	equipment operated outside radio communication services	temporary use by short-range vehicle radars (SRR)	General Authorisation No. VO-R/10/12.2019-9 for the use of radio frequencies and the operation of short-range equipment	The Office will decide on the termination of the use of the 24.25–26.65 GHz band by SRR equipment in accordance with the decision of the ECC and the Commission on the harmonisation of the 79 GHz band
24.05–27	equipment operated outside radio communication services	short-range equipment – industrial radars for sounding water levels	General Authorisation No. VO-R/10/12.2019-9 for the use of radio frequencies and the operation of short-range devices	The regulation of operating conditions for short-range equipment is subject to periodic updates carried out by the CEPT ECC Electronic Communications Committee and the Commission
24.25–24.5	fixed service	Temporary fixed links (SAP/SAB)		<ul style="list-style-type: none"> in the fixed service in the 24.5–26.5 GHz band, this is intended for point-to-point links (FWA network operations in the fixed service were discontinued in 2020) use of wider channel bandwidths any future use of the 26.5–27.5 GHz band by the fixed service depends on the development and manner of use in the mobile service and on the possibilities for coexistence between the two services
24.5–24.549 25.445–25.557 26.453–26.5		Protection bands	cannot be used	
24.605–24.619 24.675–24.689 24.745–24.773 25.613–25.627 25.683–25.697 25.753–25.781		Protected sections	cannot be used until 31 December 2020	
24.549– 24.605/25.557– 25.613 24.619– 24.675/25.627– 25.683 24.689– 24.745/25.697– 25.753	fixed service	duplex sections intended for use with point-to-multipoint fixed links within FWA fixed wireless access networks (but no later than 31 December 2020)		
24.549– 25.445/25.557– 26.453	fixed service	point-to-point fixed links	Individual authorisations for the use of the 24.549–24.773/25.557–25.784 GHz frequency bands are issued by the Office with effect from 1 January 2021	
24.25–27.5	mobile service	systems for the provision of wireless broadband electronic communications (IMT)	stations use frequencies in accordance with the conditions set out in the Annex to Decision 2020/590	
26.5–27.5	mobile service	systems for the provision of wireless broadband electronic communications services (IMT)	<ul style="list-style-type: none"> five adjacent blocks of 200 MHz bandwidth are defined, with the upper edge frequency of the last block being 27.5 GHz operation is via time-division duplex (TDD) use of frequencies by base stations and terminals is only permitted on the basis of an individual licence to use radio frequencies for experimental purposes 	The Office will specify the conditions for the use of the 24.25–27.5 GHz bands, including conditions for coexistence with the fixed service, based on market demand and experience with experimental IMT/5G operations, and will specify planning procedures and conditions for the authorisation of the use of radio and other parameters
24.25–26.5 GHz	mobile service	systems for the provision of wireless broadband electronic communications services (IMT)	No specific conditions for the use of radio frequencies have currently been laid down, and no individual licences are being issued for IMT systems in this band	
25.25–27.5	inter-satellite service	<ul style="list-style-type: none"> applications in space research and Earth observation Data transmissions originating from industrial and medical activities in space 		It is anticipated that the allocation to the inter-satellite service in the 24.45–24.75 GHz band will be terminated
25.5–27	satellite Earth observation		Earth stations of this service in the 25.5–27 GHz band may not claim protection from stations in the fixed and mobile services, nor may they restrict their use and development	
	space research service			the space research service is not used in the Czech Republic

UNOFFICIAL MACHINE TRANSLATION

Documents issued by the Electronic Communications Committee (ECC) represent an important tool for harmonising frequency management.

The ECC's outputs relating to the 26 GHz band provide the basic technical characteristics and parameters of the 26 GHz band to facilitate the coexistence of services, including the protection of established operators in adjacent bands, which must be taken into account when developing various scenarios for authorising the use of the 26 GHz band.

In 2016, the European Commission mandated CEPT to establish harmonised technical conditions necessary to facilitate the use of 5G technologies in the 26 GHz band. In response to this mandate, the ECC produced CEPT Report 68, which addresses sharing and compatibility conditions to ensure the protection of existing spectrum users in the 26 GHz band and adjacent bands. The technical conditions set out in CEPT Report 68 were established on the basis of the assumption of an individual authorisation regime, although it specifically states that individual authorisations may include both authorisations granted on a national basis and those granted on a geographical basis smaller than the national level.

On the basis of this report, the ECC drew up Decision (18)06, which sets out common minimum least-restrictive technical conditions for the deployment of mobile/fixed communication networks (MFCNs) in the 26 GHz band.

Other documents published by the ECC to assist administrations in authorising the use of the 26 GHz band, so as to ensure that it can be used for advanced wireless communication services whilst minimising harmful interference to other services, are:

- ECC Recommendation (19)01 "ECC Recommendation of 8 March 2019 on a technical toolkit to support the deployment of 5G whilst ensuring, to the extent reasonable, the use of existing and planned EESS/SRS terrestrial receiving stations in the 26 GHz band and the possibility of future deployment of such terrestrial stations"
- ECC Recommendation (20)01 "Guidelines to support the deployment of 5G whilst ensuring, to an appropriate extent, the use of existing and planned FSS terrestrial stations in the 24.65–25.25 GHz frequency band and the possibility of future deployment of such terrestrial stations"
- ECC Report 303 "Guidelines for administrations on coexistence between 5G and fixed links in the 26 GHz band ('Toolkit')"
- ECC Report 307 "Toolkit for the most appropriate regulatory framework for synchronisation, including MFCN coexistence in the 24.25–27.5 GHz band in unsynchronised and semi-synchronised modes"

Given the unique characteristics of millimetre-wave frequencies and the potential diversity of services and deployment models that could be supported by opening up the 26 GHz band, there is a consensus that the conventional approach of issuing national individual licences with exclusive frequency allocations is unlikely to ensure their optimal use or meet the diverse needs of users.

The manner in which spectrum is released is influenced in each country by various factors, including population size, population density, existing spectrum allocations, upcoming spectrum releases, demand for services and market competition. These factors, which vary considerably between countries, influence demand and anticipated usage scenarios. However, comparative data show that regulatory authorities are increasingly adopting innovative approaches, with some regulatory authorities favouring simplified authorisation and sharing rules, as detailed in Chapter 2.3.

ECC Report 317 assists regulatory authorities considering authorisation regimes for the 24.25–27.5 GHz band other than individual authorisations, and provides guidance in particular regarding the assurance of coexistence with radio services, without, however, considering any changes to the technical conditions set out in ECC Decision (18)06.

ECC Report 317 discusses the following approaches:

- local licences,
- indoor licences,
- area-specific licences,
- light licensing,
- national general authorisation,
- local general authorisation.

Recommendation ECC (23)02 addresses cross-border coordination for MFCN networks in the 24.25–27.5 GHz frequency band, covering the process and procedures to be followed to ensure minimal cross-border interference. The Recommendation includes harmonised technical conditions for MFCNs in the 26 GHz band to protect established services such as radio astronomy and MFCNs in neighbouring countries.

Field strength levels for cross-border operation between MFCN systems are defined in the Recommendation as follows:

'Base stations of asynchronous TDD MFCN systems on both sides of the border in the 26 GHz frequency band for all PCIs (in the case of NR) may be used without coordination with the neighbouring country, provided that the mean field strength of each cell produced by the base station does not exceed 62 dB μ V/m/(200 MHz) for operational channels (which corresponds to an SSB field strength level of 1 52 dB μ V/m/(120 kHz) for NR, taking into account a subcarrier spacing (SCS) of 120 kHz) at a height of 3 m above ground level at the border between countries.'

UNOFFICIAL MACHINE TRANSLATION

Coordination procedures cover both synchronised and non-synchronised systems and include a process for sharing unique cell identity groups at the physical layer so that networks operating near borders can coexist.

A harmonised approach to the use of the 26 GHz band for mobile networks mandates the use of time-division duplex (TDD) operation. This means that a certain level of synchronisation is required to prevent collisions between the transmission time slot of one network and the reception time slot of another network. In the case of the 26 GHz band, the widespread use of mobile devices outside an operator's mobile network is likely to be limited. However, if the regulatory authority wishes to allocate frequencies in close proximity to MNO networks, cooperation on TDD synchronisation will be essential. The regulatory authority needs to know the TDD synchronisation configuration agreed by the MNOs so that it can incorporate the necessary measures for licence holders operating in close proximity to such public networks.

Unlike frequency division duplex (FDD), TDD is only effective if all base station transmissions occur simultaneously. If this does not happen, the coordination distance between sites will increase significantly more than would otherwise be possible, and the spectral efficiency of the band will be significantly reduced. For this reason, even if the systems are isolated, the synchronisation capability must at least be regulated and implemented, even if it may not be used initially. This allows for the integration of an isolated system as soon as necessary, as all licence conditions and hardware will have been set up in advance and the licence holder will have no objections, given that they voluntarily implemented synchronisation before being obliged to do so. Once the systems are synchronised, they all operate from a single reference, and it is possible to change the synchronisation timing in the future if necessary to adapt to international conditions or MNO conditions. Knowledge of the identity and timing used in any neighbouring MNO network is an advantage in the initial planning phase of such a requirement for authorisation purposes.

Networks with different functions may choose different time frames for the uplink/downlink (U/D), which is accepted and generally not subject to synchronisation – the subject of synchronisation is the system's overall transmission and reception rate. Conflicts between elements of different selected U/D frames are inevitable, but this is less detrimental than a complete disconnection between systems, and flexibility is required in selecting a U/D frame suitable for the service in use. It is recommended that a subset of available TDD time frames be agreed upon and implemented in the authorisation, providing sufficient flexibility to allow upload- and download-intensive systems to select a suitable U/D frame, thereby preventing the use of a large number of mutually incompatible frames. Even the frames defined in 3GPP have elements where it is acceptable to select either the uplink or downlink in certain frames, so even if all networks use the same frame, there will be variations.

2.2 Current spectrum usage in terms of services and entities

In accordance with Article 2 of Decision 2019/784, Member States shall, by 30 March 2020, designate and make available on a non-exclusive basis the 24.25–27.5 GHz frequency band for terrestrial systems to provide wireless broadband electronic communications services.

In accordance with Article 54(1)(b) of the Code, with regard to terrestrial systems capable of providing wireless broadband services, Member States shall, by 31 December 2020, adopt, where necessary to facilitate the roll-out of 5G networks, all appropriate measures to enable the use of at least 1 GHz in the 24.25–27.5 GHz band, provided that there is clear evidence of market demand and the absence of significant obstacles that would prevent the migration of existing users of the band or the release of the band.

According to ITU-R Recommendation M.2083-0⁽⁶⁾ the IMT-2020 usage scenarios include:

- Enhanced Mobile Broadband (eMBB) – mobile broadband designed for use cases involving access to multimedia content, services and human-centric data. Demand for mobile broadband will continue to grow, leading to enhanced mobile broadband. The enhanced mobile broadband scenario will bring new application areas and requirements alongside existing mobile broadband applications, in the interests of better performance and a continuously improving user experience. This use case covers a range of scenarios, including coverage of large areas and areas with high user density (hotspots), which have different requirements. For areas with high user density, very high traffic capacity is required, whilst the demand for mobility is low and user connection speeds are higher than in the case of large-area coverage. For wide-area coverage, seamless coverage and medium-to-high mobility are required, with significantly higher user connection speeds compared to current connection speeds. The requirement for connection speed is more moderate compared to connection speeds in the case of hotspots.
- Ultra-Reliable and Low Latency Communications (URLLC) – this use case has strict requirements for characteristics such as throughput, latency and availability. Some examples include wireless control of industrial production or manufacturing processes, remote medical surgery, distribution automation via smart grids, transport safety, etc.
- Massive machine-type communications (mMTC) – this use case is characterised by a very large number of connected devices, which typically transmit a relatively small volume of sensitive data without delay. Low device cost and the longest possible battery life are required.

⁶ IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond; according to ITU-R Recommendation M.2150-2, the IMT-2020 specifications, known as 5G, were developed by 3GPP and consist of Long-Term Evolution (LTE) and New Radio (NR) Release 15 and later.

UNOFFICIAL MACHINE TRANSLATION

It is expected that further opportunities for the use of IMT-2020 will emerge which cannot currently be predicted. Flexibility is therefore essential for future IMT to adapt to new application opportunities, which will bring a wide range of requirements. Future IMT systems will incorporate a large number of different functions. Depending on the circumstances and varying needs in different countries, future IMT systems should be designed in a highly modular manner, so that it is not necessary to implement all functions in all networks.

In the Czech Republic, the 26.5–27.5 GHz segment of the 26 GHz band is allocated to the mobile service for the use of systems providing wireless broadband electronic communications services (IMT). Currently, five adjacent blocks with a bandwidth of 200 MHz are defined, with the upper frequency of the last block being 27.5 GHz and operation using time-division duplex (TDD). The use of these frequencies by base stations and terminals is currently only possible on the basis of an individual authorisation to use radio frequencies for experimental purposes.

The band thus defined is in accordance with the requirement under Article 54(1)(b) of the Code to take all appropriate measures to enable the use of at least 1 GHz in the 24.25–27.5 GHz band, provided that there is a clear demonstration of market demand and the absence of significant obstacles that would prevent the migration of existing users of the band or the release of the band.

In the 26.5–27.5 GHz band, two individual authorisations for experimental purposes are currently in force for the Prague area

- O2 – 800 MHz, 3 stations + ML – experimental 5G network,
- ČRa – 100 MHz 1 x point-to-multipoint – testing the characteristics of a radio network for the provision of wireless broadband electronic communications services in the 26 GHz frequency band.

On 29 February 2024, the individual authorisation for experimental purposes held by VanCo for the 200 MHz 1x point-to-multipoint channel expired; the purpose of this authorisation was to test technology for fixed access designed to coexist with 3GPP standards, whilst not requiring a complex and costly network core.

2.3 Use of the 26 GHz band in selected countries

2.3.1 Italy

Frequencies in the 26.5–27.5 GHz band were part of a spectrum auction held in September and October 2018. The auction also included frequencies in the 700 MHz and 3.6–3.8 GHz bands.

Only the 26.5–27.5 GHz band was set aside for 5G purposes. According to the national frequency table, the 24.25–26.6 GHz band is allocated to satellite services, Earth exploration, space exploration and fixed services, including frequency blocks allocated to the WLL (wireless local loop) service⁷. Individual authorisations for this use are valid until 31 December 2022.

Frequency band	26.5 – 27.5 GHz
Total allocated bandwidth (MHz)	1,000
Number of auction blocks	5
Block size (MHz)	200
Coverage	Nationwide
Maximum number of blocks per auction participant	4
Frequency allocation period	until 31 December 2037
Development criteria	Within 48 months of the frequency allocation, build a broadband radio network using the allocated frequencies ⁸ in all provinces
Starting price of the block (€)	32,586,535.00
Purchase price (€)	
Telecom Italia S.p.A.	33,020,000.00
Iliad Italia S.p.A.	32,900,000.00
Fastweb S.p.A.	32,600,000.00
Wind Tre S.p.A.	32,586,535.00
Vodafone Italia S.p.A.	32,586,535.00

⁷ 56 MHz block in the FDD system with a guard band between individual blocks

⁸ Use of the allocated frequencies means the commissioning of the relevant base stations or central stations or fixed links (P-P or P-MP) or small cells with specific use of the allocated frequencies and coverage of the reference area of the cell or sector, connected to a transmission network that guarantees end-to-end operation and the launch of a commercial service using the allocated frequencies. A commercial service means an offer directly to the public or via a wholesale access offer, including in the form of roaming, MORAN, MOCN or the provision of layers, with restrictions on frequency aggregation.

UNOFFICIAL MACHINE TRANSLATION

Further conditions for the use of frequencies:

- Users of frequencies in the 26 GHz band shall establish the necessary guard band and implement the technical measures required to prevent harmful interference to users of adjacent bands, in accordance with the relevant technical regulations, within their own allocated frequencies. If harmful interference persists, the Ministry may, in order to ensure the efficient use of the spectrum, impose, in a justified and proportionate manner, stricter technical standards, including the mitigation of technical specifications or the limitation of transmitted spectral power, or the synchronisation of networks operating in adjacent blocks, or the use of frequency blocks in 'restricted' mode or preferential channels. If these measures do not guarantee the complete absence of harmful interference, each user is obliged, where necessary, to immediately deactivate the interfering system.
- Successful bidders must take all necessary measures to prevent interference with other authorised users of the frequencies and plan the activation of each new installation of their network, verifying in advance compatibility with existing uses within the band and in the adjacent band for which protection is required, through the correct implementation of the protection conditions and sharing model as defined, without jeopardising any further development of established services in the adjacent band. In accordance with the technical standards to be defined for the coexistence of in-band systems, the Ministry may anticipate the future development of established services through transparent, objective and proportionate authorisation criteria that will have the least possible impact on the development and coverage of 5G services.
- Experimental use of allocated frequencies in the 26 GHz band is permitted until the introduction of equipment compliant with the new 5G technical regulation, which must be notified to the Ministry in advance. To this end, the successful bidder shall submit an experimental plan that does not involve commercial use and which is approved by the Ministry. Equipment used for experimentation shall comply with the same protection obligations as those provided for the relevant band.
- In the event of persistent harmful interference during the use of frequencies under this provision, the Ministry may, in a proportionate and justified manner, impose measures capable of eliminating the causes of such interference in accordance with the principle of fairness.
- The installation of new equipment for broadband and ultra-broadband electronic communications services through the use of frequencies subject to auction must ensure the protection and uninterrupted operation of existing uses.
- Successful bidders shall submit to the Ministry and the Office, on an annual basis until the expiry of the individual authorisation, a report on the status of the construction of broadband networks using the allocated frequencies and on the provision of related services, documenting in particular the coverage of locations, network architecture and technologies used.
- Rights to use frequencies in the 26 GHz band ensure shared use of frequencies for all successful bidders, with binding priority of use of frequencies in the allocated band. Successful bidders may dynamically use all frequencies in the band in areas where other successful bidders are not using them. For the purposes of this use, successful bidders may enter into non-discriminatory commercial agreements, share costs proportionately, or entrust management to a trusted third party, in order to prevent harmful interference and ensure the coordination of successful bidders' planning.
- Successful bidders are obliged to grant access to defined entities (access seekers) for the purpose of providing 5G services. Access means the wholesale provision of capacity, including the use of frequencies by the entity seeking access. The rights to use the frequencies do not pass to the access seeker. For the purposes of fulfilling the access obligation, successful bidders must meet the following minimum criteria, which are not mutually exclusive:
 - if the access seeker requests access to a reference area for which frequencies or part thereof are already being used by a specific successful bidder, an agreement is concluded with that successful bidder, who provides access to the allocated frequencies;
 - if the access applicant requests access to an area where there is no coverage, the successful bidders shall manage the contract collectively or delegate the management of frequency use to a trusted third party; in this case, the access applicant and the successful bidders may delegate the task of ensuring network coverage to a third party.
- The access seeker may not be, either directly or indirectly, an operator of public electronic communications services. The access seeker is obliged to obtain special authorisation from the Ministry for the management of the network and the use of frequencies and may not provide electronic communications services to the public unless a specific agreement is reached with the successful bidder. The applicant for access must inform the Ministry of the conclusion of the agreement and of their plan for the use of capacity or frequencies. Details of this plan are published on the Ministry's website. The agreements do not affect any obligations established in connection with the use of frequencies and compliance with the sharing model. An agreement may also be concluded for part of the frequencies in the 26 GHz band.
- In the case of privately or publicly owned property with restricted public access, where coverage by frequencies in the 26 GHz band requires the permission of the property manager, provided that there is no interference with frequencies used in public areas within the aforementioned property (e.g. ports, airports, stadiums, concert arenas, cinemas, theatres, national parks, the underground, etc.), coverage may be provided by any successful bidder who, provided there is no interference with the networks of other potential successful bidders operating on the property, may use all frequencies in the 26 GHz band. The successful bidder or bidders achieving this coverage are obliged to offer other successful bidders rights to use the 26 GHz band (provided that the property is accessible to the public) on fair and non-discriminatory commercial terms within the property, in the form of roaming or other agreed technical arrangements, so as to enable the customers of all successful bidders for frequencies in the 26 GHz band to use services within the property.
- Within 180 days of the allocation of frequencies and prior to granting access to an entity requesting access, successful bidders shall submit to the Ministry and the Office a general procedure for handling access requests and shall update this procedure annually. The procedure shall be

UNOFFICIAL MACHINE TRANSLATION

published on the successful bidders' websites. The Ministry and the Office may, at any time within the scope of their powers, order the amendment of the terms of the above procedure in a justified and proportionate manner.

- In order to ensure proper coordination, successful bidders are obliged to make the technical characteristics and geographical location of the installed systems available to other operators upon a reasoned request and on a reciprocal basis.
- Successful applicants shall identify appropriate techniques for mitigating the adverse effects of harmful interference and for coordination, including synchronisation techniques, in order to avoid any interference problems within the band and/or adjacent bands in relation to equipment entitled to protection. These techniques must be implemented in a proportionate and justified manner, taking into account relevant international standards, methodologies and best practices.
- Where the application of the required techniques does not guarantee the complete absence of harmful interference in all possible cases of interference, both within and outside the band, successful applicants must take any further measures that may be necessary, taking into account relevant international standards, methodologies and best practices, including network synchronisation. Where specifications, additional coordination or mitigation techniques are applied with an operator or operators using the same bands in neighbouring geographical areas or adjacent bands in the same areas, the operators concerned shall share the burden between the affected areas in a proportionate manner. If these measures do not guarantee the complete absence of harmful interference, the Ministry may impose stricter technical measures, including retrospectively, such as specific techniques to limit radiated spectral power, the use of preferred channels, or further restrictions, including additional geographically excluded zones or zones in which only certain privileged architectural configurations are permitted. In the event of persistent harmful interference between operators operating in adjacent blocks, the Ministry may impose network synchronisation or the establishment of an internal protection zone or the use of frequency bands in 'restricted' mode. Users of neighbouring bands shall cooperate in good faith to resolve any possible case of harmful interference and are obliged to ensure the efficient use of the spectrum in accordance with the principles laid down by law.

In June 2021, the regulatory authority published a consultation document entitled 'Consultation on the possible use of radio spectrum for the vertical sector'. The consultation document was published in accordance with Regulatory Authority Decision No. 131/21/CONS, by which the Authority decided to launch consultations regarding possible new uses of radio spectrum for the vertical sector, with the aim of obtaining useful information and views on the Authority's future activities in the field of spectrum licensing.

The main aim of the consultation was to assess the effectiveness of current measures for making radio spectrum available, taking into account the need to create conditions for spectrum use at local level, in particular their compatibility with measures to ensure spectrum sharing, spectrum access and spectrum use without the need for individual authorisation.

2.3.2 Estonia

An auction of frequencies in the 24.7–27.1 GHz band took place in May 2023.

Frequency band	24.7–27.1 GHz
Total allocated bandwidth (MHz)	2,400
Number of auction blocks	6
Block size (MHz)	400
Coverage	Nationwide
Maximum number of blocks per auction participant	2
Frequency allocation period	Not specified
Development criteria	-
Starting price of the block (€)	800,000.00
Purchase price (€)	
Elisa (2 blocks)	1,625,525.00
Telia (2 blocks)	1,602,223.00
Tele 2 (2 blocks)	1,600,000.00

Further conditions for the use of frequencies:

- The construction and operation of the network, the equipment used and the provision of services are subject to the rules and obligations arising from the relevant standards, decisions and recommendations of the EC, CEPT, ETSI and ECC.
- The operation of neighbouring networks must be ensured in synchronised mode; until a synchronised mode is determined, network operators are obliged to agree on a synchronised mode. Holders of individual authorisations are obliged to inform the regulatory authority of the synchronisation mode used. In the event of geographical separation, it is possible to use an unsynchronised or partially synchronised mode of operation for neighbouring networks.
- In the event that an internationally recognised synchronisation model is introduced, the regulatory authority is authorised to amend the conditions of the individual authorisation relating to the synchronisation model.
- The network must be built in accordance with at least the 3GPP Release 15 standard.
- The deployed network may be used to provide 5G FWA services.

UNOFFICIAL MACHINE TRANSLATION

2.3.3 Finland

An auction of spectrum in the 25.1–27.5 GHz band took place in June 2020. The 24.25–25.1 GHz band (850 MHz) was excluded from the auction and will be designated for the deployment of local networks.

Frequency band	25.1–27.5 GHz
Total width of allocated band (MHz)	2400
Number of auction blocks	3
Block size (MHz)	800
Coverage	Nationwide
Maximum number of blocks per auction participant	1
Frequency allocation period	until 31 December 2033
Development criteria	-
Starting price of the block (€)	7,000,000.00
Purchase price (€)	
Elisa Oyj	7,000,000.00
Telia Finland Oyj	7,000,000.00
DNA Oyj	7,000,000.00

Further conditions for the use of frequencies:

- The frequencies may be used for the deployment of 5G networks.
- Networks in the 26 GHz band must be synchronised so that guard bands do not need to be applied; in specific use cases (such as indoors), synchronisation is not required.
- Base station antennas must normally be directed so that each antenna transmits only with the main beam directed below the horizon, and furthermore, the antenna must be mechanically directed below the horizon, except when the base station is only receiving.
- The coordination distance from the border of a neighbouring country is 90 kilometres. If there is no coordination agreement between mobile network base stations and usage in neighbouring countries (links, mobile networks and FSS terrestrial transmitting stations), the regulatory authority shall apply this value such that, if a base station is closer than 90 kilometres from the border, the need for coordination shall be assessed separately for mobile network base stations. Exceptions are possible in the case of indoor use, or if terrain obstacles towards the border provide sufficient protection, etc. Details of base station transmitters in the 25 100 – 27 500 MHz band operating at a maximum distance of 90 kilometres from the border of a neighbouring country must be provided to the regulatory authority for coordination assessment prior to deployment, unless there is a separate coordination agreement on frequency use with that country.
- The following total radiated power (TRP) values are specified

- **Base station**

Frequency band 25 100 – 27 500 MHz

Maximum TRP

Total radiated power value outside the block allocated to the licence holder	0 to 50 MHz outside the licence holder's block	12 dBm/50 MHz
--	--	---------------

Frequency band 24 250 – 27 500 MHz

Maximum TRP

Total radiated power outside the licence holder's allocated block	more than 50 MHz outside the licence holder's block	4 dBm/50 MHz
---	---	--------------

Frequency band 23 600 – 24 000 MHz

Maximum TRP

Base stations put into service before 1 January 2024	-33 dBW/200 MHz
Base stations put into operation from 1 January 2024	-39 dBW/200 MHz

UNOFFICIAL MACHINE TRANSLATION

○ Terminal equipment

Frequency band 23 600 – 24 000 MHz	Maximum TRP
Terminal equipment put into service before 1 January 2024	-29 dBW/200 MHz
Base stations put into service from 1 January 2024	-35 dBW/200 MHz

- The licence holder must provide the regulatory authority with the most up-to-date technical information on base stations and repeaters in the system, as well as their locations. The technical information provided must include the structure of the synchronised operation framework and the source of the synchronisation signal (clock). The regulatory authority must be informed of any changes to synchronisation sufficiently in advance of their implementation.
- The licence holder has the right to share the use of mobile network base stations with another licence holder on the frequencies for which the other licence holder holds a licence. The licence holder must inform the regulatory authority of the use of the shared network and frequencies prior to the deployment of the network. The licence holder must also inform the regulatory authority if the use of the shared network ceases, either partially or completely.
- The regulatory authority may amend the technical conditions of a licence without the holder's consent if this is necessary due to a change in the approved radio frequency allocation plan, radio frequency regulations or obligations under international treaties, or if there are other justifiable grounds.

2.3.4 Spain

An auction of frequencies in the 24.7–27.5 GHz band took place in December 2022. The 24.7–25.1 GHz band (400 MHz) was reserved for regional allocations and the 25.1–27.5 GHz band was reserved for national allocations.

Frequency band	24.7–27.5 GHz
Total allocated bandwidth (MHz)	2,400 at national level 400 at regional level
Number of auction blocks	12 at national level (25.10 – 27.50 GHz) 38 at regional level (24.70 – 25.10 GHz)
Block size (MHz)	200
Coverage	Nationwide and regional
Maximum number of blocks per auction participant	5 (1 GHz across the entire band)
Frequency allocation period	20 years, with the option to extend for a further 20 years
Development criteria	-
Starting price of the block (€)	4,000,000.00 national coverage 7,050.06 – 715,195.77 regional coverage
Purchase price (€)	
Telefonica	20,000,000.00 (5 blocks of 200 MHz each)
Orange	8,000,000.00 (2 blocks of 200 MHz each)
Vodafone	8,000,000.00 (2 blocks of 200 MHz each)
Globe Telecom	201,171 (1 block in the Castilla y León region)

Further conditions for the use of frequencies:

- Any technology may be used to provide services in accordance with the principle of technological neutrality.
- The licence holder is obliged to inform the Ministry of the specific technology to be used and the measures to be taken to limit harmful interference prior to launching services; in the event of a change to the original technology, the licence holder is obliged to inform the Ministry of this change.
- The Ministry shall lay down the conditions for the use of frequencies in border areas.
- Authorisation holders are responsible for the coordination of adjacent channels.
- The operation of networks is subject to the provisions of the relevant European Commission harmonisation decisions.

UNOFFICIAL MACHINE TRANSLATION

2.3.5 Austria

The frequency auction took place in March 2024 alongside frequencies in the 3600 MHz band. The band was divided into two sections, 25.5–25.9 GHz (400 MHz) and 26.5–27.5 GHz (1000 MHz), and was designated for nationwide allocations.

Frequency band	25.5–25.9 GHz 26.5 – 27.5 GHz
Total width of the allocated band (MHz)	1400 at national level
Number of auction blocks	7
Block size (MHz)	200
Coverage	Nationwide
Maximum number of blocks per auction participant	5 (1,000 MHz)
Frequency allocation period	In the 25.5–25.9 GHz band from 1 January 2025 to 31 December 2046 In the 26.5–27.5 GHz band from the date of allocation until 31 December 2046
Development criteria	see below
Starting price of the block (€)	1,900,000
Purchase price (€)	
A1 Telecom	4,628,000 (2 blocks of 200 MHz each)
T Mobile	4,628,000 (2 blocks of 200 MHz each)
Hutchison	6,947,000 (3 blocks of 200 MHz each)

Further conditions for the use of frequencies:

- In the event that licence holders in the 26 GHz band interfere with one another as a result of unsynchronised or insufficiently synchronised network operation, and a bilateral or multilateral agreement on synchronisation cannot be reached, the following specifications apply:
 - transmissions from the licence holder's base station must use a specific frame duration and frame structure. The frame duration is 0.625 ms. This is accompanied by the use of the 'DDDSU' frame structure, where
 - 'D' = downlink timeslot,
 - 'U' = uplink timeslot, and
 - 'S' = New Radio (NR) special timeslot, as defined by 3GPP standards – this is configured as D:G:U=10:2:2.
 - Authorisation holders are responsible for ensuring that frames are based on a uniform reference time (+/- 1.5 µs) so that all frames of each authorisation holder are aligned in the same way and transmissions are subsequently synchronised.
- The regulatory authority must be informed without delay of any synchronisation agreements between licence holders.
- The operation of networks is subject to the provisions of the relevant harmonisation decisions of the European Commission, ETSI, ECC and CEPT.
- Base stations with unsynchronised TDD systems may be used without prior coordination with a neighbouring country. This is only possible if the mean field strength generated by the base station does not exceed the following values:
 - 62 dBµV/m/(200 MHz) (this corresponds to an SSB field strength of 52 dBµV/m/(120 kHz) for NR) at a height of 3 metres above ground level at the border,
 - in the case of a frequency block width other than 200 MHz, a correction value calculated using the formula $10 \times \log_{10}$ (frequency block width in MHz/200 MHz) dB must be added to the field strength values,
 - in the case of an SCS (subcarrier spacing) other than 120 kHz, the corresponding correction values in accordance with ECC/REC (23)02 must be applied.
- No agreements have yet been concluded with neighbouring countries for the 26 GHz band, and, given the propagation characteristics, assessments are underway as to whether they are necessary at all within the band.
- To ensure the optimal performance of digital mobile broadband access systems used in cross-border areas, licence holders should, in accordance with ECC/REC (23)02 for the 26 GHz band, licence holders should also implement the coding schemes specific to the technology, as well as other radio parameters, particularly where the centre frequencies of signals in border areas coincide.
- Authorisations from the regulatory authority remain in place for microwave links in the 24.5–24.9 GHz and 25.5–25.9 GHz frequency bands. Until these authorisations expire, receivers for radio stations must be protected by a maximum power spectral density of -151 dBW/MHz (in accordance with ITU-R Recommendation F-758). Licence holders have the option of reaching a mutual agreement with the licence holders concerned. Changes to existing operating licences must be notified to the regulatory authority.
- When setting up outdoor base stations, care must be taken to ensure that each antenna transmits only with the main beam oriented below the horizon and also has a mechanical antenna tilt mechanism that is below the horizon.
- The Act provides for secondary use of the 25.5–25.9 GHz and 26.5–27.5 GHz frequency bands.
 - In the case of secondary use, geographical and temporal restrictions may be imposed. As a result of these restrictions, any subsequent negative impacts or limitations can be kept to a minimum. The current status of operational base stations will be taken into account when allocating geographical and temporal licences.

UNOFFICIAL MACHINE TRANSLATION

- Authorisations will be granted only to specific radio stations.
- For time-limited authorisations, a period not exceeding one month will be set.
- The temporary deployment of wireless cameras serves as the primary reference use case for secondary use.
- Data on base stations operated for broadband services shall be reported quarterly to the regulatory authority.
- The licence holder is guaranteed the arrangement of the allocated frequency blocks, as specified in the allocation phase, for a period of at least ten years, specifically until any reorganisation resulting from the granting or transfer of other rights of use in this frequency band.
- The minimum number of locations in which the licence holder is required to operate the network is set out in the table below.

Allocated band	Minimum number of locations by 1 January 2027 at the latest	Minimum number of locations by 1 January 2030 at the latest	Minimum number of sites by 1 January 2034 at the latest
200 MHz	10	30	100
≥ 400 MHz	20	60	200

- A location that is eligible to meet the coverage obligation must have a base station capable of transmitting at least 2 watts of electrical power per sector. The actual transmission power level may be lower.
- A location qualifies as a location within the meaning of the coverage obligation only if the radio frequencies transmitted there are used to connect end-users.
- Only base stations operated outdoors are considered locations for the purposes of this obligation.
- The licence holder must have actual, legal and technical control over any such base station.
- Sites operated as active sharing points are not considered sites for the sharing party within the meaning of this obligation. Accordingly, a site within the meaning of this obligation is considered a site for no more than one rights holder.
- Separate sectors count as a single location – even in cases where these sectors are not located on a single shared antenna mast.
- For the purposes of the coverage obligation, two sites are counted as two separate sites only if they are at least 25 metres apart as the crow flies.
- Any licence holder who fails to meet the coverage obligation will be fined €10,000 for each non-operational site. This applies to all levels of the coverage obligation. The amount remains payable each year following the relevant effective date until the licence holder operates the minimum number of sites.
- In the event of a waiver of rights to use the allocated frequencies between 31 December 2025 and 31 December 2026, the fine shall amount to 50% of the fine payable for failure to meet the coverage obligation by the first due date.
- The licence holder must publish a map on its website showing the coverage area for all frequency bands specified as ECS spectrum for mobile and broadband services. The map should use realistic simulation to show the transmission speeds available to end-users outdoors, broken down by download and upload speeds. The maximum available data transmission speed should also be indicated. In the map display, each area covered by the service must be shown in sectors measuring at least 100 m x 100 m and must display the commonly available bandwidth as well as the estimated maximum download and upload speeds.
- No cooperation regarding core network functions is permitted between two licence holders in the 26 GHz band where more than one of the participating companies holds rights to more than 10% of the nationwide spectrum usage rights in the 700 MHz, 800 MHz, 900 MHz, 1500 MHz, 1800 MHz, 2100 MHz, 2600 MHz or 3600 MHz.
- The Regulatory Authority is authorised, in accordance with the law, to impose obligations on undertakings that operate or are authorised to operate electronic communications networks in relation to the sharing of passive infrastructure or the conclusion of local roaming agreements. In both cases, such an obligation may be imposed if it is necessary for the local provision of services that depend on the use of radio spectrum, and provided that it is not possible to grant any undertaking comparable access to end-users on fair and reasonable terms. Where access to and sharing of passive infrastructure alone is not sufficient to address the situation, the regulatory authority may impose an obligation to share active infrastructure.

UNOFFICIAL MACHINE TRANSLATION

2.3.6 Denmark

Frequencies in the 26 GHz band were part of the auction of frequencies in the 1500 MHz, 2100 MHz, 2300 MHz and 3500 MHz bands. The auction covered frequencies in the 24.65–27.5 GHz band.

The 24.25–24.65 GHz band (400 MHz) is designated for use by private networks.

Frequency band	24.65–27.5
Total width of the allocated band (MHz)	2850
Number of auction blocks	3 blocks of 400 MHz (without coverage obligation) in combination with 3 blocks in the 3500 MHz band (with coverage obligation) or 7 blocks of 200 MHz and 1 block of 250 MHz (without coverage obligation) or 14 blocks ⁹
Block size (MHz)	400/200/250
Coverage	Nationwide
Maximum spectrum range per auction participant	1650 MHz
Frequency allocation period	from the date of allocation until 31 January 2042
Development criteria	
Starting price per block (DKK)	75,000,000 for one 400 MHz block in the 26 GHz band in combination with one 80 MHz block in the 3500 MHz band 5,000,000 for one 200 MHz or 250 MHz block
Purchase price (DKK) ¹⁰	
Hi3G	1000 MHz
TDC Net	1250 MHz
TT-N	600 MHz

Further conditions for the use of frequencies:

- Frequencies in the 24.969–25.333 GHz and 25.977–26.341 GHz bands are allocated for fixed links until the end of 2025 and the end of 2026 respectively.
- Emissions from base stations must comply with the relevant harmonised standard of the ETSI EN 301 908 series applicable to the selected technology.
- Frequencies must be used in accordance with the conditions of the European Commission's harmonisation decisions.
- TDD shall be used with the following synchronisation scheme:
 - DL/UL pattern: DDDSU (4:1) (D = downlink, S = special subframe, U = uplink)
 - special subframe configuration: 10:2:2 (10 x downlink: 2 x gap: 2 x uplink)
 - Cyclic prefix: normal
 - subcarrier spacing: 120 kHz
 - time base: UTC, as described in ITU-R Recommendation TF.460
 - Radio frames are synchronised to the UTC second, which corresponds to the phase synchronisation defined by ITU-T. A typical timing signal is 1 pps (pulse per second). The rising edge marks the start of the UTC second. The DL/UL pattern, as described above, begins at the start of the radio frame.
 - maximum deviation from UTC, as described in ITU-T Recommendation G.8271, i.e. a maximum deviation from UTC of +/-1.5 µs for the transmitter antenna radiation point
 - The conditions will be reviewed by the regulatory authority every five years during the validity period of the allocation and will be amended accordingly, subject to notice.
- The use of frequencies is subject to coordination between the licence holder and other licence holders in the 24.25–27.5 GHz band, given that no frequencies have been allocated for guard bands. Until 1 December 2021, the licence holder must not cause interference to fixed radio links in the same frequency band. If the use of a frequency causes interference to fixed radio links in the same frequency band, the licence holder must cease such use immediately.
- Subject to agreement with licence holders in frequency bands adjacent to those specified in the licence, the licence holder may deviate from the technical requirements set out in the licence relating to unwanted emissions in the relevant frequency band, provided that the conditions relating to other licence holders are met, and that the contract does not affect users of frequencies other than the contracting parties.

⁹ Provided that no auction participant expresses an interest in the combined block in the 3500 MHz and 26 GHz bands

¹⁰ The purchase price of the blocks in the 26 GHz band has not been published; only the total price of all allocated blocks across all allocated bands has been published.

UNOFFICIAL MACHINE TRANSLATION

- The licence may be transferred in its entirety to another holder without prior consent.
- The transfer or surrender of part of the licence is subject to approval.
- The licence holder shall notify the regulatory authority of any planned lease or transfer of the licence or part thereof before such lease or transfer takes place. Information on current plans for lease or transfer will be published in the frequency register.
- The regulatory authority may decide that a licence holder operating an electronic communications network using frequencies in a specific area must comply with any reasonable request for access to existing passive infrastructure or a request to conclude a roaming agreement for the purpose of providing electronic communications services.
- The licence holder must install antennas and transmitting and receiving equipment capable of utilising the frequencies specified in the licence on at least 100 mast sites within four years of the licence taking effect. The equipment at the relevant mast sites shall be connected to the necessary telecommunications infrastructure in such a way as to enable the licence holder, via the relevant mast sites, to offer end-users at least one electronic communications service (at the licence holder's discretion) using the frequencies specified in the licence.
- The licence holder shall provide the regulatory authority with data specifying the locations of the masts on which the antennas and transmitting and receiving equipment have been installed, so that at least one electronic communications service can be offered to end-users using the frequencies specified in the licence.

2.3.7 Germany

The use of frequencies in the 26 GHz band (24.25–27.5 GHz) is governed by the administrative rules for local use of frequencies in the 26 GHz band for broadband purposes, dated 15 May 2023.

The 26.5–27.5 GHz band is intended for civil and military use. Coordination with the radio applications of the Federal Armed Forces is therefore required.

The following rules apply to the use of the 26 GHz band for broadband purposes:

- The entire 24.25–27.5 GHz band is designated for local broadband use and may be utilised within the MFCN.
- Frequencies are allocated to MFCN on the basis of technology and service neutrality, which will enable the implementation of retail telecommunications services and applications such as network links, Industry 4.0 and IoT.
- Any natural or legal person is entitled to apply for the allocation of frequencies.
- Frequency allocation is not possible on the basis of a general authorisation in order to ensure compatibility. Current usage by various radio communication services and the associated need for protection require coordination when allocating new authorisations.
- In the interests of ensuring efficient use and protection against harmful interference, frequencies are allocated in the form of individual authorisations. The allocation of local frequencies using individual authorisations allows for the necessary coordination between radiocommunication services and enables the conditions of use for local broadband applications to be flexibly adapted to the requirements of applicants for frequency allocation, taking into account bandwidth and the area of use.
- For the purposes of the frequency allocation application process, no spectrum limit or limit on the size of the area for which frequency allocation is sought will be set. The Regulatory Authority anticipates that the maximum bandwidth requested will be 800 MHz due to the parameters of currently available equipment. The greater the bandwidth requested by the applicant, the more detailed the justification for the request must be. If an applicant requests an allocation of more than 800 MHz, a detailed justification for the request must be provided in the frequency usage plan.
- If the applicant requests specific sub-bands within the 26 GHz band, this must also be clearly justified in the frequency utilisation plan.
- If the licence holder does not utilise the allocated band, the regulatory authority is entitled to withdraw the entire allocated band or part thereof after 12 months (the 'use-it-or-lose-it' principle).
- The frequency utilisation plan must include, in particular, a clear and detailed description of how the frequencies for which the applicant is applying will be effectively utilised in the area covered by the application within 12 months. Information on frequency utilisation in the case of allocations for multiple locations must be submitted after 6, 9 and 12 months.
- If no spectrum has been allocated for local networks in a specific area and an application for multi-site spectrum usage is accepted which would reduce the availability of spectrum in any of the areas to less than 800 MHz, the regulatory authority shall provide potential spectrum users in that location with the opportunity to express an interest in obtaining spectrum for their own use. However, this does not establish a right to reserve frequencies for subsequent allocation for local applications within a specific location.
- To ensure that sufficient free frequencies remain available at a later stage, all licence holders within a given location or multi-location licence holders are subject to a duty to negotiate. The duty to negotiate encompasses not only the negotiation of contractual terms but also the negotiation of terms with the licence holders concerned.
- All MFCN application operators concerned are also subject to a duty to negotiate agreements with other operators.
- Frequencies are allocated taking into account the specific local radio compatibility situation. Spectrum for MFCN may only be allocated if the uninterrupted operation of existing users is ensured.

UNOFFICIAL MACHINE TRANSLATION

- When using frequencies, compliance with the relevant European Commission harmonisation decisions must be ensured.
- In the interests of efficient use of frequencies, agreements between licence holders are necessary. The aim of these agreements is to ensure the undisturbed operation of licence holders in adjacent bands.
- In the case of synchronised networks, there is generally no need for a guard band between the frequency block of one licence holder using TDD and the frequency block of an adjacent licence holder. In the case of unsynchronised and semi-synchronised operation, European studies on synchronisation in the 26 GHz band (ECC Report 307) may be taken into account.
- Any necessary protection zones should be agreed between neighbouring licence holders and should be implemented using the same amount of spectrum from each holder's allocation.
- Any deviations require bilateral or multilateral agreements between the relevant licence holders and must be notified to the regulatory authority prior to commissioning.
- Authorisation holders are free to plan their networks within the boundaries of the site for which the frequencies have been allocated.
- The regulatory authority does not generally define a maximum permissible field strength at the boundary of the allocated area. Licence holders are obliged to ensure the effective and interference-free use of their networks (for example, by constructing their network in such a way as to minimise interference when using the allocated frequencies). This can be achieved, for example, through low transmission power, low antenna height and appropriate antenna orientation.
- Where licence holders are unable to reach the agreement necessary for the efficient use of frequencies whilst minimising interference, the regulatory authority shall set a field strength limit of 65 dBµV/m/200 MHz at a height of 3 metres at the boundary and beyond the boundary of the allocation area.
- The applicant must define their requirements for frequency allocation in a frequency utilisation plan, which contains a credible description of frequency requirements based on the planned use of the frequencies. In particular, the applicant must demonstrate that they will ensure the efficient use of the frequencies.
- An individual authorisation may be revoked if the frequencies have not been put into use within one year of allocation, or if the frequencies have not been used for the purpose for which they were allocated for a period of more than one year.
- Frequencies will be allocated in blocks of 200 MHz or multiples thereof.
- Blocks in multiples of 50 MHz up to a size of 150 MHz will be allocated for individual use of frequencies requiring a smaller bandwidth. The frequency utilisation plan must clearly justify both the quantity of frequencies requested and any request for the allocation of a specific sub-band.
- There is no upper limit on the size of the area for which a frequency allocation may be requested. The frequency utilisation plan prepared by the applicant must clearly demonstrate that it will be possible to utilise the frequencies throughout the entire area for which the applicant is requesting an allocation within one year.
- Many fixed links are operated in the band.
- In the event that the required bandwidth is not available as a contiguous block for a specific location due to existing allocations, the regulatory authority expects applicants to utilise aggregation, which is available in modern mobile systems.
- When planning the application, it is possible to take into account the fact that the use of aggregation may lead to a reduction in the transmission capacity of the systems used. If necessary, additional frequencies (one 50 MHz block) may be allocated upon subsequent request, in addition to the originally planned bandwidth.
- The allocation of frequencies for indoor use (provided the building has sufficient electromagnetic shielding to prevent interference) is possible even if the site is already covered by frequencies allocated to multiple sites. This is also subject to and the responsibility of negotiation between the licence holders concerned.
- If the use of more than one base station indoors is planned, it is sufficient to specify only one reference base station for the purposes of the allocation application. This must be the base station with the highest transmission power. The application must also include the planned maximum height of the indoor antenna. The coordinates of the centre of the building must also be specified. This allows for the flexible use of base stations in buildings, the details of which must be set out in the frequency usage plan.
- Frequencies may be allocated until 31 December 2040 at the latest.
- Details of the allocation sites, together with details of the allocated frequencies and the names of the licence holders, will be provided to third parties with a legitimate interest (e.g. geographically adjacent uses, cross-border spectrum use). This ensures that the efficient and interference-free use of frequencies for local applications can be optimised through negotiation requirements and agreements with the frequency holder.
- The amount of the fee for the allocation of frequencies is determined using the following formula¹¹: $Fee (\text{€}) = 1000 + B \cdot t \cdot 0.63 \cdot (6 \cdot a^1 + a^2)$
where

⁽¹¹⁾ For example

- the fee for the allocation of a 200 MHz block for a period of 10 years covering an urban area of 0.3 km² amounts to €3,268
- the fee for the allocation of an 800 MHz block for a period of 10 years covering a residential area of 4 km² amounts to €121,960

UNOFFICIAL MACHINE TRANSLATION

- 1000 – base amount in euros (€)
 - B – bandwidth in MHz (at least 50 MHz)
 - t – allocation period in years (e.g. 15 years)
 - The base factor of 0.63 EUR was determined in accordance with the fees set for local spectrum use in the 3.7–3.8 GHz band, taking into account the different bandwidth requirements and propagation conditions. It was assumed that residential and transport sites in the Federal Republic of Germany are particularly suitable for 5G applications. On this basis, a base factor of €0.63 was set for the 26 GHz band, taking into account technical innovations in 5G applications in practice.
 - a – area in square kilometres (km²)
 - a1 – residential and transport land
 - a2 – other types of land
- As of 4 April 2024, a total of 19 applications for the allocation of frequencies for local 5G networks had been submitted, and 19 frequency allocations for local 5G networks had been granted.

Frequency band	24.25–27.5
Total width of allocated band (MHz)	3,250
Number of auction blocks	N/A
Block size (MHz)	50/200
Coverage	Local, with the possibility of covering multiple locations
Maximum allocation per applicant	800 MHz
Frequency allocation period	from the date of allocation until 31 December 2040
Development criteria	<ul style="list-style-type: none"> • submission of a frequency usage plan by the applicant • Use of the frequencies across the entire area for which the application for frequency allocation was submitted, within 12 months of allocation
Allocation price (€)	according to the specified formula

2.3.8 Sweden

Frequencies in the 24.25–25.10 GHz band are allocated by means of individual authorisations upon application.

Frequency band	24.25–25.10 GHz
Total width of the allocated band (MHz)	850
Number of auction blocks	N/A
Block size (MHz)	50
Coverage	local, limited to the building or part of the building for which the licence is granted
Maximum number of blocks per applicant	8 (400 MHz)
Frequency allocation period	until 31 December 2026, with the option of a 5-year extension
Development criteria	launch of the transmitter within 6 months of the allocation taking effect

Further conditions for the use of frequencies:

- Individual authorisation is issued for indoor use only; signal radiation to the exterior must be attenuated by the walls and ceiling of the building.
- The total radiated power of a single cell must not exceed 23 dBm/200 MHz; in the case of multi-sector base stations, this condition applies to each sector.
- The operation of base stations must comply with the following BEM conditions.

UNOFFICIAL MACHINE TRANSLATION

Frequency band 24.25 – 27.5		Maximum average radiated power per cell
power limit in the transition of the block during synchronised operation	0 to 50 MHz outside the block within the 24.25–27.5 GHz band	12 dBm/50 MHz
basic power limit during synchronised operation	more than 50 MHz outside the operator's block within the 24.25–27.5 GHz band	4 dBm/50 MHz
additional basic limit for base stations put into service before 1 January 2024	23.6–24.0 GHz	-3 dBm/200 MHz
additional basic limit value for base stations put into service from 1 January 2024	23.6–24.0 GHz	-9 dBm/200 MHz

- The total radiated power for terminal equipment must not exceed 23 dBm; terminal equipment may only be operated in the area for which a licence to use the allocated frequencies has been issued.
- The supplementary basic power limit for terminal equipment must meet the following conditions:

Frequency band (GHz)	Date of commissioning	Maximum radiated power
23.6–24.0	before 1 January 2024	1 dBm/200 MHz
	after 1 January 2024	-5 dBm/200 MHz

- The holder of an individual licence is responsible for frequency planning in the area for which the licence was issued.
- Where unavoidable, the holder of an individual authorisation is obliged to ensure synchronisation with existing holders of individual authorisations for frequencies in the 24.25–27.50 GHz band in the relevant area.
- Synchronisation and frame structure must be adapted to existing and future terrestrial broadband networks in the 25.10–27.50 GHz band.
- The holder of an individual licence is obliged to adapt the location and parameters of transmitters so as to avoid causing harmful interference to existing holders of individual licences in the 24.25–25.10 GHz band in the given location.
- The holder of an individual licence is entitled to protection against holders to whom an individual licence was granted at a later date; the frequency band is shared with other holders of individual licences provided that the holder of the individual licence is not subject to harmful interference.
- The holder of an individual licence is obliged to put into operation at least one transmitter in the defined geographical area using the allocated frequencies no later than 6 months from the date on which the individual licence takes effect.

2.3.9 United Kingdom

The regulatory authority has published a consultation document entitled 'Making mm-wave spectrum available for new uses'. The document sets out rules for the allocation and use of spectrum in the 26 GHz and 40 GHz bands. The 26 GHz band is divided into a lower segment (25.1–26.5 GHz) and an upper segment (26.5–27.5 GHz). The division of the band into two sections reflects restrictions on the introduction of new uses of frequencies for approximately five years, during which time certain fixed links will continue to operate in the 25.1–26.5 GHz section in high-density areas.

In 68 major cities where the highest volume of mmWave deployment is expected ('high-density areas'), frequencies will be allocated as:

- local allocations on a 'first come, first served' basis, using the principle of spectrum sharing
- city-wide licences via auction.

Elsewhere in the United Kingdom ('low-density areas'), where deployment is expected to be less widespread, local allocations will be made on a 'first come, first served' basis, utilising the principle of spectrum sharing.

The launch of the frequency allocation process is expected in the second quarter of 2024.

UNOFFICIAL MACHINE TRANSLATION

Frequency band	25.1 – 26.5 GHz and 26.5 – 27.5 GHz
Total width of the allocated band (MHz)	1,400 in the lower band 1,000 in the upper band
Number of auction blocks	7 in the lower band 5 in the upper band
Block size (MHz)	200
Coverage	sub-national (covering 68 cities with high population density)
Maximum number of blocks per auction participant	
Frequency allocation period	15 years
Development criteria	None
Starting price per block (GBP)	2,000,000

Further conditions for the use of frequencies:

- The licences to be auctioned will combine all 68 high-density areas, so that each licence will entitle the holder to use frequencies in all high-density areas.
- Allocations utilising the principle of spectrum sharing will be available:
 - In all high-density areas where 650 MHz of the 26 GHz band (24.45–25.1 GHz) will be available for low-power use.
 - In low-density areas, the 26 GHz band (24.45–27.5 GHz) (and the 40 GHz band 40.5–43.5 GHz) will be available for use at low and medium power levels, subject to coordination with existing users.
- The maximum transmission power limit will be set at:
 - 36 dBm / 200 MHz TRP for medium-power base stations.
 - 25 dBm / 200 MHz TRP for low-power indoor and outdoor base stations, with an antenna height limit of 10 m for low-power outdoor base stations.
- Allocations utilising the principle of low-power frequency sharing in the 24.45–25.1 GHz band will allow allocation holders to deploy up to three outdoor transmitters within each allocation to protect Earth exploration satellite services (EESS). Allocation holders wishing to deploy more than three outdoor transmitters within a 50-metre radius will require an additional allocation.
- Channel widths will be 50 MHz, 100 MHz, 200 MHz, 400 MHz and 800 MHz, with an annual fee of £80 per 100 MHz of spectrum, with a minimum fee of £80 for channel widths of 100 MHz or less.
- The regulatory authority will coordinate the deployment of medium-power base stations using the principle of sharing (which will only be permitted outside high-density areas). A minimum distance between low-power base stations will be required. All new licence holders will be required to comply with a field strength limit at the boundary of high-density areas.
- Conditions will be established to mitigate the risk of harmful interference between all existing fixed links in the 26 GHz band and licence holders (following the auction) in high-density areas for as long as both are authorised to use frequencies in the 26 GHz band. Coordination areas will be defined around fixed links in high-density areas. In these areas, new licence holders for high-density areas will be required to coordinate new deployments with the regulatory authority. These new deployments will be subject to approval by the regulatory authority. For new deployments outside these coordination areas, neither coordination nor approval by the regulatory authority will be required.
- The regulatory authority will issue a notice of proposed cancellation of all fixed links operating in the 26 GHz band that are either (i) in high-density areas, or (ii) in the vicinity of high-density areas and are likely to be affected by harmful interference from services deployed in high-density areas. Affected holders of authorisations to operate fixed links will have a period of at least 30 days to submit objections. Holders of authorisations to operate fixed links will have at least five years from the date of the final notice before the revocation of their authorisations takes effect.
- For the purposes of coordination between licence holders (following an auction) and holders of authorisations to operate fixed links in the 26 GHz band, the licence holder shall first consult the map of coordination zones published by the regulatory authority to check whether the area in which they plan to operate falls within a coordination zone. If so, the licence holder is obliged to submit an application for coordination for mobile base stations to the regulatory authority. However, if the location where they plan to operate is not within a coordination zone, the licence holder may commence operations without submitting any application for coordination to the regulatory authority.
- The following have been set for licence holders (based on the auction):
 - A mean field strength limit of 62 dB μ V/m/(200 MHz), at the boundary of high-density areas, for transmissions from the licence holder's medium-power base stations. Licence holders may alternatively use the SSB field strength limit (set by the regulatory authority) or the maximum field strength limit (the derivation of which is described), as the regulatory authority considers these limits to be equivalent to the median field strength limit.
 - Peak field strength limit of 93 dB μ V/m/(200 MHz), at the boundary of high-density areas, for transmissions from all medium-power shared-access base stations.

UNOFFICIAL MACHINE TRANSLATION

- Minimum distances between low-power base stations and the boundary of high-density areas:
 - (i) 50 m for low-power indoor use and (ii) 100 m for low-power outdoor use for both shared access allocation holders and auction licence holders.
- Frequency leasing is not permitted.
- The allocation does not include any development criteria.
- The allocation does not include a national roaming obligation, but the imposition of such an obligation in the future is not ruled out.
- The allocation/licence holder is obliged to commence operations within 6 months of the allocation taking effect and to continue operations continuously thereafter.

2.3.10 Greece

A spectrum auction took place in December 2020, covering frequencies in the 700 MHz, 2 GHz, 3400–3800 MHz and 26 GHz bands.

The subject of the auction in the 26 GHz band was the 26.5–27.5 GHz frequency band.

Frequency band	26.5–27.5 GHz
Total width of allocated band (MHz)	1000
Number of auction blocks	5
Block size (MHz)	200
Coverage	Nationwide
Maximum number of blocks per auction participant	2
Frequency allocation period	15 years (with the option to extend by 5 years)
Development criteria	submission of a report on the progress of network construction once every 6 months
Starting price of the block (€)	3,240,000.00
Purchase price (€)	
Cosmote (2 blocks)	6,481,000.00
Vodafone-Panafon (2 blocks)	6,480,000.00
Wind (1 block)	3,245,051.00

Further conditions for the use of frequencies:

- Authorisation holders are obliged to use the allocated blocks in accordance with the relevant harmonisation decisions of the European Commission.
- The frequencies are allocated for the installation, operation and use of terrestrial systems capable of providing wireless broadband electronic communications services.
- Authorisation holders are entitled to choose, without restriction, the technology they will use in accordance with the relevant harmonisation decisions, provided that their systems do not cause interference to other authorised users of the frequencies and provide adequate protection to systems in adjacent frequency bands.
- The electronic communications network operated must comply with the following parameters:
 - Probability of connection interruption less than 2%, calculated at the radio interface (wireless interface).
 - Probability of connection interruption less than 3%, calculated at the radio interface (wireless interface).
 - Network availability over a year should be greater than or equal to 99.5%, and must not be less than 95% for any continuous period of 48 hours.
 - The network must support the “Cell Broadcast Service” in accordance with 3GPP TS23.041, as required, through which it is possible to inform users located in a specific geographical area by sending instant messages to mobile user terminals in accordance with the provisions of the relevant legislation.
- Upon request by an entity wishing to operate as a mobile virtual network operator, the licence holder is obliged to negotiate in good faith the provision of any type of access (e.g. indicative capacity leasing) to its network and to provide such access on reasonable terms in accordance with competition rules. The agreement must not restrict the commercial policy of the mobile virtual network operator.
- The licence holder is obliged to publish on its website the conditions (excluding prices) for granting access to its network, as well as the technical specifications and characteristics of the network for the purposes of granting access.
- Upon a request submitted by a new entrant seeking access to national or regional roaming, the licence holder is obliged to negotiate in good faith regarding the provision of access to its network and to grant such access on reasonable terms, in accordance with the provisions on the protection of competition. The agreement must not restrict the commercial policy of the new mobile communications network provider.
- Access to national roaming is limited to five years from the date on which the new entrant begins providing the service, whilst regional roaming must be provided for the entire duration of the allocation in areas where the new entrant has not built a network.
- Upon request by an entity operating in a vertical sector, the licence holder is obliged to negotiate in good faith with that entity regarding the provision of any type of access to its network (e.g. indicative capacity leasing)

UNOFFICIAL MACHINE TRANSLATION

or the lease of frequencies, and to provide access on reasonable terms for use by an entity operating in a vertical sector, in accordance with the provisions on the protection of competition.

- The licence holder has the right to conclude commercial contracts concerning:
 - the use of passive infrastructure, subject to a simple notification to the regulatory authority;
 - the use of active infrastructure, including active radio network equipment in rural areas, subject to the obligation to provide information on the conclusion of the contract to the regulatory authority within twenty days of its signing.
- Agreements on the sharing of active infrastructure, including active radio network equipment in urban and semi-urban areas, are subject to prior approval by the regulatory authority.
- If the regulatory authority concludes that, in a particular region, the development of infrastructure is subject to insurmountable financial or practical obstacles, as a result of which it is not possible to ensure end-users' access to services, it may impose obligations on the licence holder relating to:
 - sharing of passive infrastructure;
 - the obligation to conclude a local roaming access agreement; or
 - the obligation to share active infrastructure.
- Upon request by another licence holder, the licence holder is obliged to conclude an infrastructure sharing agreement in areas of special interest (such as heritage sites and national parks) in the public interest.
- The licence holder is obliged to cooperate with all licence holders in the 26.5–27.5 GHz band in resolving any harmful interference between their networks. Licence holders are also responsible for the mutual coordination of spectrum boundaries.
- The licence holder is obliged to agree with all licence holders in the 26.5–27.5 GHz band on the basic principles of synchronised operation of their networks (synchronisation framework), other technical parameters and the process for their review. In the event of interference problems due to a lack of synchronisation of networks in the 26.5–27.5 GHz band, the regulatory authority may define the basic principles of synchronised operation of networks in the band.
- A licence holder may deviate from synchronised operation by agreement of all parties concerned or on the basis of the non-protection/non-interference principle.
- The licence holder is entitled to choose the technology to be used, provided that the relevant provisions of the licence are complied with and, at the same time, it is ensured that the systems do not interfere with other authorised users of the frequencies and that adequate protection of frequencies in the adjacent band is ensured.
- The total or partial transfer or lease of frequencies is subject to the relevant rules.

2.3.11 Slovenia

In April 2021, a spectrum auction took place, which included frequencies in the 700 MHz (FDD and SDL), 1500 MHz, 2100 MHz, 2300 MHz, 3600 MHz and 26 GHz bands.

The subject of the auction in the 26 GHz band was the 26.5–27.5 GHz frequency band.

Frequency band	26.5–27.5 GHz
Total width of the allocated band (MHz) Number of auction blocks	1000 5
Block size (MHz) Coverage	200 Nationwide
Maximum number of blocks per auction participant	4 (800 MHz)
Frequency allocation period	15 years
Development criteria	provision of services via the allocated frequencies in at least one major city within 5 years of the allocation of frequencies
Starting price per block (€)	
Purchase price (€)	345,000.00
A1 Slovenia (400 MHz) Telekom Slovenije (400 MHz) Telemach (200 MHz)	690,267.00 690,000.00 326,834.00

Further conditions for the use of frequencies:

- The frequencies are allocated for the purpose of installing, operating and using terrestrial systems capable of providing wireless broadband electronic communications services.
- The licence holder is obliged to offer services to end-users on the allocated frequencies in at least one major city within five years of the frequencies being allocated. The provision of a commercially available terrestrial wireless broadband electronic communications service means that this service is provided via base stations covering at least 75% of the population of a given major city, and the commencement of frequency use means that services must be provided via at least one base station in each urban area.

UNOFFICIAL MACHINE TRANSLATION

- Fulfilment of the obligation to offer services depends on the market availability of terminal equipment and base station equipment. Where terminal equipment and base station equipment for a specific frequency band are not available, the licence holder shall provide relevant evidence. The regulatory authority shall extend the deadline for compliance with the requirements on the basis of the relevant evidence.
- The provision of 5G technology means that the licence holder supports 3GPP Release 15 or a later specification (ETSI EN 301 908-x standards).
- In order to ensure the efficient use of radio spectrum, improve coverage and reduce the environmental impact, the regulatory authority will support the following sharing options:
 - sharing of passive or active infrastructure or spectrum aggregation;
 - national roaming agreements;
 - joint deployment of infrastructure for the provision of networks and services based on the use of frequencies.
- Active sharing and spectrum aggregation are permitted provided that they do not result in a restriction of competition at the infrastructure level (e.g. active sharing of elements and spectrum aggregation are permitted when passive sharing is insufficient, for example in challenging areas and when deploying small cells).
- Areas and situations where spectrum sharing, active facility sharing and national roaming are permitted are defined.
- If the regulatory authority concludes that, in a particular region, infrastructure development is subject to insurmountable financial or practical obstacles, as a result of which it is not possible to ensure end-users' access to services, it may impose obligations on the licence holder concerning:
 - sharing of passive infrastructure;
 - the obligation to conclude a local roaming access agreement; or
 - the obligation to share active infrastructure.
- Authorisation holders are obliged to use the allocated blocks in accordance with the relevant harmonisation decisions of the European Commission, the ECC and the CEPT.

2.3.12 Croatia

In July and August 2021, a spectrum auction took place, which included frequencies in the 700 MHz, 3600 MHz (at national and regional level) and 26 GHz bands.

The subject of the auction in the 26 GHz band was the 26.5–27.5 GHz frequency band.

Frequency band	26.5–27.5 GHz
Total width of the allocated band (MHz)	1,000
Number of auction blocks	5
Block size (MHz)	200
Coverage	Nationwide
Maximum number of blocks per auction participant	2
Frequency allocation period	15 years (with the option to extend by 5 years)
Development	-
Starting price of the block (HRK)	7,500,000.00
Purchase price (HRK)	
EOLO Spa (200 MHz)	7,500,000.00
Telemach Hrvatska d.o.o. (200 MHz)	7,688,135.00
Hrvatski Telekom dd (400 MHz)	15,000,000.00
A1 Hrvatska d.o.o. (200 MHz)	7,500,000.00

Further conditions for the use of frequencies:

- The regulatory authority will allow dynamic frequency sharing such that licence holders in the 26 GHz band will be permitted to use twice the amount of frequencies allocated to them under their licence, provided that other licence holders in a given area are not utilising the frequencies allocated to them.
- General and technical conditions for terminal equipment and base station equipment are set out in the frequency spectrum utilisation plan.
- Licence holders must cooperate to prevent harmful interference between TDD networks.
- Licence holders may jointly agree on the use of an appropriate frame structure and time synchronisation. Depending on the extent of 5G technology deployment and the situation in border areas, the regulatory authority (following prior public consultation) may amend the conditions for the synchronised mode of operation of TDD networks to ensure the efficient use of frequencies.
- If licence holders cannot agree on a solution to prevent harmful interference in semi-synchronised and unsynchronised modes of TDD network operation, the regulatory authority shall determine appropriate technical conditions to ensure seamless operation for all licence holders.

UNOFFICIAL MACHINE TRANSLATION

- Frequencies are allocated for the purpose of installing, operating and using terrestrial systems capable of providing wireless broadband electronic communications services.
- Authorisation holders are required to use the allocated frequencies in accordance with the relevant harmonisation decisions of the European Commission, the ECC and the CEPT.
- The frequencies are intended for mobile and fixed communications networks in accordance with ECC/DEC/(18)06, (EU) 2019/784 and (EU) 2020/590.

2.3.13 France

In January 2019, the Ministry of the Economy and Finance and the national regulatory authority published a call for proposals entitled “The Government and Arcep call for the creation of 5G experimental platforms in the 26 GHz band”. The call forms part of a pro-innovation approach. It aims to establish 5G experimental platforms in the 26 GHz frequency band, open to third parties, with the aim of encouraging all stakeholders to explore the possibilities offered by this frequency band and to identify new applications that this band enables.

The 26.5–27.5 GHz band is allocated to fixed and mobile services. The call

is addressed to:

- entities wishing to acquire spectrum in the 26 GHz band to create open experimental platforms (small-scale 5G networks) and make these platforms available to third parties;
- entities wishing to test new use cases for innovative technology and service companies, including start-ups and ‘vertical’ players (healthcare, energy, smart cities, etc.).

By making frequencies available for experimental platforms for innovative technology and service companies, the government aims to remove two barriers to innovation: high costs and a lack of the technical skills necessary to build and operate networks, particularly for entities with no experience in the electronic communications sector.

In return for opening up the infrastructure to third parties, the following will be provided:

- authorisation to use frequencies in the 26 GHz band for a period of up to 3 years;
- a regulatory environment that enables the testing of innovations by exempting them from traditional regulatory obligations;
- visibility at national and international level.

In October 2019, 11 projects were selected and granted authorisation to use frequencies in the 26 GHz band. Entities whose projects were selected must have a functional 5G experimental network in place by 1 January 2021 at the latest and make this network available to third parties, who will be authorised to use these networks for 5G experiments. Frequency holders are required to publish the terms of access to the experimental network and submit a detailed report to the regulatory authority on the experiments carried out within the platform, in particular the name of the third party or third parties conducting the experiments.

According to currently available information, there are currently 4 licences issued in the 26 GHz band:

Licence holder	Size of allocated block (MHz)	Date of allocation	Validity period of the allocation
SNCF SA	200	1 March 2022	3 years
Orange	1000	15 March 2023	3 years
Atomic Energy and Alternative Energy Commission	400	24 May 2023	2 years
TDF	400	16 June 2023	1 year

UNOFFICIAL MACHINE TRANSLATION

2.3.14 USA

In January 2019, the auction of spectrum in the 28 GHz band was concluded. The subject of the auction was the 27.5–28.35 GHz frequency band.

Frequency band	27.5 – 28.35 GHz – unpaired (27.500 – 27.925 GHz 27.925 – 28.350 GHz)
Total width of the allocated band (MHz)	850
Number of auction blocks	2 (2 × 425 MHz) 27.5 – 27.925 GHz – 1,536 licences 27.925 – 28.35 GHz – 1,536 licences
Block size (MHz)	425
Coverage	district (1,536 districts; 2 auction blocks will be available for each district)
Maximum number of blocks per auction participant	a maximum of 1850 MHz of spectrum in the millimetre wave band (combined 24 GHz, 28 GHz, 37 GHz, 39 GHz and 47 GHz bands) per licence holder
Duration of frequency allocation	10 years from allocation
Development criteria	-
Starting price of the block (\$)	from \$200 to \$810,000 ¹² calculated according to district type \$0.002/MHz/capita \$0.0004/MHz/capita \$0.0002/MHz/capita
Purchase price (\$)	702,572,410
33 successful bidders were awarded 2,965 licences	

Further conditions for the use of frequencies:

- The licence holder may provide any services permitted under the fixed or mobile allocation.
- Licence holders must declare the status of their network as part of their application for renewal of the allocation. Licence holders providing a mobile service or a point-to-multipoint service must demonstrate that they provide reliable signal coverage and service to at least 40 per cent of the population in the relevant location, and that they operate equipment for the provision of services to end-users or for internal use in that location. Authorisation holders providing a point-to-point service must demonstrate that they operate four links through which they provide services to end-users or use them for internal purposes, provided that the population of the locality in question is equal to or less than 268,000. Where the population of the locality exceeds 268,000, a licence holder providing a point-to-point service must demonstrate that they operate at least one link and provide the service for every 67,000 inhabitants in the locality. For the purposes of declaring the status of a point-to-point network, the point-to-point link must operate with a transmission power greater than +43 dBm. Declarations of network status through which multiple types of services are provided will be assessed on a case-by-case basis. If the licence holder is also the holder of a licence to provide a fixed satellite service and utilises frequencies from the UMFUS band¹³ in conjunction with a satellite earth station, they may demonstrate compliance with the requirements by proving that the earth station is operational and utilises the frequencies specified in the licence. This provision may only be used to demonstrate compliance for the district in which the earth station is located. Failure to meet these requirements shall result in the automatic revocation of the licence.
- Bidders are entitled to a discount on the final purchase price of the acquired frequencies, provided the following conditions are met:
 - A bidder with average annual gross revenues not exceeding \$55 million over the previous three years is entitled to a 15% discount on their winning bid.
 - A bidder with average annual gross revenues not exceeding \$20 million over the previous three years is entitled to a 25% discount on their winning bid.
- A bidder may apply for a 15% discount on its winning bid under the following conditions:
 - They are a commercial provider of electronic communications services and, together with their controlling interests in affiliated companies, have fewer than 250,000 subscribers (a combination of wireless, fixed, broadband and cable users).
 - It operates predominantly in rural areas defined as districts with a population density of 100 or fewer people per square mile.
- Bidders are required to take into account the operations of existing licence holders in the 28 GHz band when developing business plans, assessing market conditions and evaluating the availability of equipment for services in the millimetre wave band. Active licences in the band

¹² the sum of the reserve prices for all auction blocks amounts to \$39,862,700

UNOFFICIAL MACHINE TRANSLATION

¹³ The Upper Microwave Flexible Use Service

UNOFFICIAL MACHINE TRANSLATION

The 28 GHz band covers 1,696 full counties and one partial county. Detailed information on existing licences is publicly available in the Universal Licensing System (ULS) via interactive database searches and downloads.

- In addition to existing licence holders, bidders should take into account the implications of sharing schemes for the 28 GHz band.
- Each applicant should closely monitor the regulatory authority's statements regarding existing users and spectrum sharing in the 28 GHz band.

UNOFFICIAL MACHINE TRANSLATION

2.3.15 Summary overview of selected allocation parameters in the 26 GHz band

	IT	EST	FIN	ESP	AT	DK	GER	SWE	GRE	SLO	HR	FRA	UK	USA
Frequency band (GHz)	26.5 – 27.5	24.7 – 27.1	25.1 – 27.5 24.25 – 25.1	24.7 – 27.5	25.5 – 25.9 26.5 – 27.5	24.65 – 27.5	24.25–27.5	24.25 – 25.10	26.5 – 27.5	26.5 – 27.5	26.5 – 27.5	26.5–27.5	25.1 – 26.5 26.5 – 27.5	27.500 – 27.925 27.925 – 28.350
Total allocated bandwidth (MHz)	1000	2400	2400 (national level) 850 (local level)	2400 (national level) 400 (regional level)	1400	2850	3250	850	1000	1000	1000	1000	1400 1000	425 425
Block size (MHz)	200	400	800	200	200	400 (3 blocks) 200 (7 blocks) 250 (1 block)	50 200	50	200	200	200	200	200	425
Coverage	Nationwide	Nationwide	Nationwide and local	Nationwide and regional	Nationwide	national	local	local	national	national	national	local (experimental use)	sub-national (covering 68 cities with high population density population)	district
Frequency allocation period	until 31 December 2037	-	until 31 Dec. 2033	20 years, with the option to extend for a further 20 years	until 31 December 2046	until 31 January 2042	until 31 Dec. 2040	until 31 Dec. 2026 with the option of extension for a further 5 years	15 years (with the option to extend by 5 years)	15 years	15 years (with the option to extend by 5 years)	up to 3 years	15 years	10 years
Development criteria	Within 48 months of the allocation of frequencies, build a broadband radio network using the allocated frequencies in all provinces	-	-	-	minimum number of locations covered (depending on the size of the allocation) by a specific date	-	the use of frequencies throughout the area for which the application for frequency allocation was submitted, within 12 months of the allocation	commissioning of the transmitter within 6 months of the date on which the allocation takes effect	submission of a report on the progress of network roll-out once every 6 months	provision of services via the allocated frequencies in at least one major city within 5 years of the frequency allocation	-	-	-	-
Licence holders	mobile operators	mobile operators	mobile operators	operators	mobile operators	mobile operators	natural persons/ legal entities	natural/ legal entities	mobile operators	mobile operators	operators	individuals/ legal entities		operators
Method of allocation	auction	auction	auction	auction	auction	auction	upon request	upon request	auction	auction	auction	on request	auction (sub-national) / on request (shared use of frequencies)	auction

2.4 Practical examples of shared spectrum use

According to the document 'RSPG Strategic Plan for 5G in Europe – Second RSPG Opinion on 5G Networks (RSPG18-005 FINAL)', access to higher frequency bands (such as the 26 GHz band) creates scope for new forms of sharing. Recommendations regarding spectrum sharing are set out in the RSPG opinion on spectrum sharing (RSPG21-006 FINAL), which is mentioned in Chapter 1.4 of this document.

This chapter briefly describes practical examples of approaches to sharing in the USA, the United Kingdom and Italy.

FCC (USA) – Citizens Broadband Radio Service (CBRS)¹⁴

CBRS is a private, two-way, short-range voice communication service for personal or commercial use by the general public¹⁵. In 2015, the FCC adopted rules for the shared commercial use of the 3550–3700 MHz band (3.5 GHz band). The FCC introduced a three-tier access and authorisation framework that enables shared use of frequencies at both federal and non-federal levels.

Access and operations will be managed by an automated spectrum coordinator (Spectrum Access System – SAS). When managing spectrum access, the SAS may incorporate information from the Environmental Sensing Capability (ESC), a sensor network that detects transmissions from Department of Defence radar systems and transmits this information to the SAS. The SAS and ESC must be approved by the FCC.

The SAS will coordinate operations between users across three levels of spectrum access in the 3.5 GHz band:

- incumbent access (Level 1),
- priority access – PAL (Level 2) and
- General Authorisation Access (GAA) (Level 3).

Incumbent access users include authorised federal users in the 3550–3700 MHz band, terrestrial stations of the fixed satellite service (downlink) in the 3600–3650 MHz band and, for a limited period, licence holders for wireless broadband access in the 3650–3700 MHz band. Incumbent access users are protected from harmful interference from Priority Access Licensees (PALs) and General Authorised Access (GAA) users.

The priority access tier consists of Priority Access Licensees (PALs), who will be licensed on a district-by-district basis through competitive bidding. Each PAL comprises a 10 MHz channel in the 3550–3650 MHz band. PALs are renewable licences issued for 10 years. Up to seven PALs may be licensed in any given district, with a maximum of four PAL channels per licence holder. PALs must ensure protection and accept interference from incumbent access users, but must be protected from GAA users.

GAA users are authorised to operate throughout the 3550–3700 MHz band. GAA users must not cause harmful interference to incumbent access users or PALs and must accept interference from these users. GAA users are also not entitled to protection against interference from other GAA users.

FCC (USA) – Automated Frequency Coordination (AFC)¹⁶

On 23 April 2020, the FCC issued a rule for the 6 GHz band, creating 1,200 MHz of spectrum in the band for unlicensed use, enabling data rates of up to 10 Gbps. In the United States, the 6 GHz band is used for satellite uplinks and also by licence holders providing microwave links for the telecommunications sector, public safety, transport and other applications (including MVNOs, which have deployed thousands of point-to-point microwave links for network backhaul).

The FCC regulations define two classes of access points:

- standard radiated power (36 dBm eirp) and
- low indoor radiated power (30 dBm eIRP).

The FCC has also published a further notice regarding a proposed rulemaking for an additional class of equipment with very low radiated power (14 dBm eIRP).

¹⁴ Source: <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview>

¹⁵ Commercialised services were marketed under the 'OnGo' brand for various applications, ranging from rural broadband connectivity and enterprise-wide mobile coverage within buildings to sports stadiums and private networks

¹⁶ Source: <https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses-0>

UNOFFICIAL MACHINE TRANSLATION

Operation of an access point with standard power is permitted only under the control of an Automated Frequency Controller (AFC), which ensures the protection of existing fixed microwave links by establishing exclusion zones on a geographical and frequency basis. Before transmission begins, the AFC system determines the available frequencies and the maximum permissible power for each frequency band within its geographical coordinates. All devices are required to register with the AFC system by providing the following parameters:

- geographical coordinates,
- antenna height,
- FCC identification number, and
- manufacturer's unique serial number.

Contact between the access point and the AFC to obtain the current list of available frequencies in a given location is required at least once a day. Security measures prevent access to the AFC by systems that have not been approved by the FCC. This prevents:

- unauthorised parties from modifying the equipment so that it operates in a manner that does not comply with the regulations, and
- the misuse or unauthorised acquisition of data, and the unauthorised insertion of data or modification of stored data.

AFC will be simpler than SAS. The FCC will designate one or more AFC system operators who will be authorised to charge users. A group comprising representatives of interested parties has been established to manage the system requirements and standards of the AFC system.

OFCOM (UK) – Local licensing, shared access to spectrum supporting mobile technology

Ofcom has introduced two new forms of spectrum licensing designed to facilitate access to the spectrum for a wider range of users on a shared basis:

- Shared Access Licence – provides access to four frequency bands that support mobile technology.
- Local Access Licence – allows other spectrum users access to frequencies already allocated to mobile network operators in areas where mobile network operators are not utilising the frequencies allocated to them.

Local access has the potential to support growth and innovation across a range of sectors, such as manufacturing, business, logistics, agriculture, mining and healthcare, including the operation of private voice and data networks within a locality, or the provision of wireless broadband connectivity in rural areas using fixed wireless access (FWA).

The local access licence provides access to spectrum that has been allocated to mobile network operators but which is not being used and is not expected to be used within the next three years. Interested parties may apply to Ofcom for a licence. If the application is successful, provided that the mobile network operator does not raise any valid objections, the applicant, upon payment of a licence fee of £950, will be granted the right to use the frequencies for a period of three years. The applicant may request a different term, which can be agreed with the existing licence holders.

Local access licences are available in any frequency band subject to the rules on spectrum trading (the 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 1900 MHz, 2100 MHz, 2300 MHz, 2600 MHz and 3.4 GHz bands). As the list of frequencies subject to trading rules changes in the future, so too will the list of frequencies covered by local access licences.

A local licence will cover the deployment of transmitters only within a defined locality or within the area defined in the licence. Depending on the application received, Ofcom may authorise a single base station, multiple base stations or a local area.

Shared access licences are available in four frequency bands that support mobile technology (the 1800 MHz, 2300 MHz, 3800 to 4200 MHz and 24.25–26.5 GHz¹⁷ bands).

Entities may apply to Ofcom for coordinated access (which ensures that no harmful interference occurs) to frequencies on a 'first come, first served' basis. The licence fee reflects Ofcom's costs in issuing the licence.

Where mobile terminals are deployed in the 3.8–4.2 GHz band, licence holders are required to keep accurate records of all mobile terminals and the addresses of the sites or buildings where they are authorised to operate the equipment. No national shared licence is envisaged for this band.

¹⁷ In the 24.25–26.5 GHz band, shared access licences are available only for low-power indoor use

UNOFFICIAL MACHINE TRANSLATION

Two types of licence are available:

- Low-power licence – entitles the user to deploy as many base stations as required within a circular area with a radius of 50 metres, including associated fixed, portable or mobile terminal equipment connected to the base stations and operated within the defined area. Users are authorised to move base stations within the licensed area without the need for further coordination by Ofcom.
- Medium-power licence – authorises a single base station and associated fixed, portable or mobile terminal equipment connected to the base station.

The low-power licence is suitable for industrial and business users who wish to use their own private networks to support voice and text applications or other wireless data applications.

Users who require the flexibility to locate base stations anywhere within a larger area may apply for multiple low-power licences.

The medium-power licence is suitable for users who require transmission from the base station over longer distances but do not anticipate needing to change the base station's location once it has been installed. This could suit fixed wireless access (FWA) service providers in rural areas, as well as industrial or business users with base stations spread over a larger area (such as ports, agriculture or forestry). Another use case is the extension of mobile coverage in rural areas.

Medium-power base stations are generally permitted only in rural areas. Their higher power and transmission range could, if deployed in urban areas, potentially interfere with the operation of a large number of low-power users.

A shared access licence is granted for an indefinite period, provided the user pays the licence fees annually and does not breach any of the licence conditions. At the applicant's request, Ofcom may issue a short-term licence (less than one year).

AGCOM (ITA) – Shared use of the 26 GHz band (Club use)

With the aim of increasing flexibility in the use of frequencies, AGCOM has introduced the allocation of individual, but not exclusive, rights to use frequencies in the 26 GHz band (so-called club use). Under this model, each of the five licence holders (each of whom has been allocated 200 MHz) may dynamically utilise the entire band (up to 1 GHz) in areas where the frequencies are not being used by other licence holders. Each licence holder has a priority right to the 200 MHz block allocated to them. Licence holders may, in order to prevent harmful interference, entrust a third party with the management of frequency usage.

Club usage represents an approach to spectrum sharing imposed by the regulatory authority, which selects a predefined number of licence holders who must coordinate amongst themselves to ensure coexistence within the band. The club usage model falls within the scope of Dynamic Spectrum Sharing (DSA) and, in simple terms, can be regarded as a form of Opportunistic Spectrum Access (OSA) among licence holders.

According to information from 2021⁽¹⁸⁾, the Ministry of Economic Development has launched a tender for the supply of a tool enabling dynamic access to frequencies (in the 26 GHz band). This is expected to be a web-based platform that will allow licence holders to assess whether frequencies are in use and, if not, whether they can be used by another licence holder. The tool will make it possible to identify available frequencies and potential conflicts with other licences, in order to ensure effective spectrum management. If interference is identified, all licence holders will receive an update via email. Users will be able to upload data about their network into the system for the purpose of calculating their network coverage. The calculations will take into account data on other licence holders' networks (these will be entered into the system as separate files that are not directly accessible to other licence holders). The possibility of using frequencies will be subject to the result of the compatibility analysis.

¹⁸<https://atdi.com/managing-dynamic-spectrum-access/>

2.5 Cases of use of millimetre wave bands for the provision of electronic communications services

2.5.1 5G FWA test – Romania ¹⁹

Test objective:

To test 5G FWA in European conditions with the aim of gathering information regarding performance, installation and customer feedback.

Verification of a planning tool developed by Samsung, based on beam tracing analysis. The tool utilises artificial intelligence and computational power to accurately predict coverage in a given area.

Participating entities:

- Orange Romania
- Samsung Electronics Co., Ltd.

Equipment used

- commercial 5G FWA Radio Access
- virtualised RAN
- access units
- CPE
- Cisco Virtual Packet Core and Orange Romania infrastructure
- two access units; each access unit was connected to the network via an optical link:
 - ‘cell 15’ located on the roof of a building at a height of 22 metres, facing the main city street
 - “Cell 17” located on a 15-metre tower at the top of a hill
- both indoor and outdoor subscriber terminal equipment was used

Frequency band used:

- 26.65 – 27.5 GHz

Channel bandwidth:

- 500 MHz

Location:

Florești, a rapidly growing residential area north of Cluj (Romania’s second-largest city); an area with a significant number of customers using 4G FWA.

¹⁹<https://images.samsung.com/is/content/samsung/assets/global/business/networks/insights/case-study/5g-for-fixed-wireless-access-orange-romania-case-study/5g-for-fixed-wireless-access-orange-romania-case-study.pdf>

UNOFFICIAL MACHINE TRANSLATION

Test results:

operating conditions of the subscriber equipment	ID of Samsung subscriber terminal	Cell designation	Distance from the access unit (m)	type of subscriber terminal (indoor/outdoor; LoS/NLoS)	BRSRP (dBm)	DL/UL speed (Mbps)	SINR (dB)	latency (ms)
Good conditions	1	Cell 15	160	outdoor/LoS	-74	856/330	22	11
	2	cell 15	530	outdoor/LoS	-76	917/354	24	12
	3	cell 17	321	outdoor/LoS	-75	860/114	24	12
	4	cell 17	763	outdoor/LoS	-77	901/140	22	11
	5	cell 17	390	outdoor/LoS	-79	918/153	22	12
moderately good conditions	6	Cell 15	781	outdoor/LoS	-84	621/170	N/A	12
	7	cell 15	722	outdoor/LoS	-85	952/169	22	12
	8	cell 17	1119	outdoor/LoS	-84	954/70	21	11
poor conditions	9	cell 17	321	indoor/LoS	-93	667/67	20	12
	10	cell 17	452	indoor/LoS	-94	491/137	17	9
	11	cell 17	358	indoor/LoS	-96	711/18	13	9
	12	cell 17	560	indoor/LoS	-98	939/141	12	15
	13	cell 17	475	indoor/LoS	-98	807/132	15	14
	14	cell 17	847	outdoor/NLoS	-100	342/4	11	12
	15	cell 17	400	indoor/NLoS	-102	521/64	0	11

- Feedback from participants was largely positive; some participants reported a better experience than with current fixed broadband services
- Cell 15 has better throughput, higher data volumes, better RSRP and CQI
- Cell 17's performance was degraded due to NLoS conditions and the distance at which the subscriber terminals were located
- Both indoor and outdoor subscriber terminals located under LoS conditions provided solid DL performance almost regardless of conditions, whilst UL performance was more dependent on conditions – this is due to beamforming for DL
- Outdoor subscriber terminals located under NLoS conditions demonstrated DL performance comparable to the current level of services provided via optical connections
- The loss during the outdoor/indoor transition affected the RSRP, with values between -90 and -100 dBm. Even in this case, the downlink performance was acceptable, but the uplink performance was insufficient
- The radio frequency planning simulation is consistent with the results obtained in the field

2.5.2 5G Test of 5G usage in the millimetre wave band – Finland²⁰

Test objective:

To test 5G uplink speeds with a view to using them to provide ultra-fast, low-latency services to enhance the visitor experience at the site.

Participating entities:

- Elisa
- Nokia Mobile Networks
- Qualcomm Europe, Inc.

Equipment used

- commercial 5G network – Elisa

²⁰<https://www.nokia.com/about-us/news/releases/2022/06/21/nokia-and-elisa-achieve-over-2-gbps-5g-uplink-speeds-on-mmwave-with-qualcomm-solutions/#:~:text=with%20Qualcomm%20solutions-.Nokia%20and%20Elisa%20achieve%20over%20%20Gbps%205G,on%20mmWave%20with%20Qualcomm%20solutions&text=Espoo%2C%20Finland%20%E2%80%93%20Nokia%2C%20Elisa.Arena%20in%20Tampere%20in%20Finland.>

UNOFFICIAL MACHINE TRANSLATION

- AirScale base station in the 26 GHz band – Nokia
- 5G end devices Snapdragon® X65 5G Modem-RF with fourth-generation Qualcomm® QTM545 mmWave antenna modules
- Carrier Aggregation technology comprising four 100 MHz sub-carriers

Frequency band used:

- 26 GHz

Channel width:

- 4 channels of 100 MHz

Location:

Nokia Arena, Tampere, Finland; one of the first arenas equipped with 5G in the millimetre wave band.

Test results:

During a live demonstration, an uplink speed of 2.1 Gbps was achieved.

Uplink capabilities have a significant impact on the roll-out of new applications utilising edge computing, such as media broadcasting or high-definition streaming. Once the service is deployed, it will pave the way for local data services, such as real-time streaming of ultra-high-definition 8K video to multiple users and augmented reality content for smartphones or wearable devices. Visitors to the arena will also be able to watch live performances with 360° camera coverage via virtual reality devices. Broadcasters will benefit from improved image capture to support live coverage (in ultra-high quality) and content streamed to mobile devices and televisions. At the same time, 5G technology will support the optimisation of operations and the security of critical functions, such as safety.

2.5.3 Multi-gigabit milestone for 5G in the millimetre wave band – USA²¹

Test objective:

To demonstrate the range and connection speeds that 5G in the mmWave band can provide to households and businesses.

Participants:

- UScellular – the fourth-largest wireless network operator
- Qualcomm Technologies, Inc
- Ericsson
- Inseego Corp.

Equipment used

- Commercial FWA network
- Commercial HW Antenna Integrated Radio (AIR) 5322 equipped with software for extended range – Ericsson
- Inseego Wavemaker™ PRO 5G outdoor CPE FW2010e with Qualcomm® 5G Fixed Wireless Access Platform Gen 1 featuring the Qualcomm® Snapdragon™ X55 5G Modem-RF System and the Qualcomm® QTM527 mmWave antenna module
- Carrier Aggregation technology comprising four 100MHz sub-carriers

Frequency band used:

- mm waves (no further specification)

Channel width:

- N/A

²¹<https://newsroom.uscellular.com/uscellular-qualcomm-ericsson-and-inseego-address-digital-divide-with-multi-gigabit-extended-range-5g-milestone-over-mmwave/>

Location:

Janesville, Wis.

Test results:

- at a distance of 7 km (the furthest 5G FWA connection in the mmWave band in the US), a sustained average downlink speed of 1 Gbps, a sustained average uplink speed of 55 Mbps and an instantaneous peak downlink speed of over 2 Gbps were achieved
- At a distance of 1.75 km without line of sight, a sustained average downlink speed of 730 Mbps and a sustained average uplink speed of 38 Mbps were achieved

2.5.4 Test of 5G usage in the 24 GHz band – Finland²²

Test objective:

To demonstrate the range and speed of 5G connections in the millimetre wave band

Participants:

- Nokia Mobile Networks

Equipment used

- Solutions for enhancing 5G coverage in the mmWave band
- AirScale baseband
- AirScale 24 GHz mmWave radio
- Nokia FastMile 5G PoC CPE

Frequency band used:

- 24 GHz

Channel width:

- 8 channels aggregating 800 MHz

Location:

OuluZone Test Centre, Oulu, Finland

Test results:

The test achieved speeds of 2.1 Gbps downlink and 57.2 Mbps uplink over a distance of 10.86 km.

2.5.5 5G usage test – Norway²³

Test objective:

Exploring the potential applications of the speed, capacity and latency of millimetre-wave frequencies from the perspective of consumers, businesses and industries. Testing coverage and capacity indoors, outdoors and in densely populated areas.

Participating entities:

- Telia Norway
- Ericsson

Equipment used:

- Radio AIR5322 – Ericsson

²²<https://www.rcwireless.com/20230627/5g/nokia-claims-download-speed-record-in-finland-using-mmwave-spectrum>

²³<https://www.ericsson.com/en/news/3/2022/telia-and-ericsson-test-high-band-5g-for-unlocking-enterprise-use-cases>

- Baseband 6630 – Ericsson

Frequency band used:

- 26 GHz

Channel width:

- 8 channels aggregating 800 MHz

Location:

Oslo, Trondheim and Lillestrøm

Test results:

Download speeds of nearly 4 Gbps were achieved during the test.

2.5.6 High-speed internet services in the 5G mmWave band – USA²⁴

Service description:

High-speed internet connection service with speeds of up to 300 Mbps for households and the business sector in parts of 10 locations (Home Internet+).

Participating entities:

- UScellular – the fourth-largest wireless network operator
- Qualcomm Incorporated
- Inseego Corp.

Equipment used

- FWA network
- Inseego Wavemaker™ FW2010 outdoor 5G CPE with Qualcomm® 5G Fixed Wireless Access Platform Gen 1 featuring the Snapdragon® X55 5G Modem-RF System

Frequency band used:

- mm waves (no further specification)

Channel width:

- N/A

Location:

- East Moline and Rock Island, Ill.
- Bettendorf, Cedar Falls, Davenport, Dubuque and Waterloo, Iowa
- Yakima, Wash.
- Beloit and Janesville, Wis.

Test results:

Standard commercial service

²⁴<https://newsroom.uscellular.com/uscellular-qualcomm-inseego-launches-5g-mmwave-high-speed-internet-service-in-10-cities/>

3 Spectrum utilisation models for vertical sector needs

In its opinion entitled 'RSPG Opinion on Further Spectrum Needs and Guidance for the Rapid Deployment of Future Wireless Broadband Networks (RSPG21-024 FINAL)', recommends that Member States promote consistent approaches to making spectrum available for the vertical sector in the millimetre wave band, with the possibility of use for local access in the 26 GHz and 42 GHz bands.

The identification and development of services for vertical sector applications is the responsibility of stakeholders, who should not be restricted by regulation beyond what is necessary. These services are characterised by a high degree of diversity, which makes it difficult to utilise them via a single frequency band or a single network configuration.

The 5G standard appears to be the most natural candidate for vertical sector applications, but it is not the only available solution. Depending on specific use cases, other technologies may also be utilised, such as low-power technologies that enable extensive coverage at reduced data rates, which fall into the LPWAN category and are operated in unlicensed bands.

When assessing potential applications for the vertical sector, economic aspects must be taken into account alongside technical ones. In fact, the heterogeneity of the vertical sector's needs is determined not only by the diversity of individual sectors and activities, but also by differences between companies in terms of size, organisational and operational capabilities (including issues related to human resources and associated skills) and economic differences.

With regard to the introduction of wireless connectivity to support processes and services, where the use of radio spectrum requires individual authorisation, the allocation of frequencies ensures direct control by the user (an entity operating within the vertical sector) over the allocated frequencies. The user thus obtains the right to use the frequencies (e.g. as a traditional mobile operator).

An alternative solution, from the user's perspective, could be to acquire the right to use frequencies by leasing them from an entity that holds the right to use frequencies (e.g. a mobile operator). This approach is already permitted in the Czech Republic in other 4G/5G bands and is also used in a number of other European countries.

Another option for making frequencies available to the vertical sector is the use of frequency bands under a general authorisation. An example is the operation of a campus or industrial network inside a shielded building, where interference with other users cannot occur.

In all the cases mentioned, the vertical sector entity assumes responsibility for the correct use of frequencies in accordance with the applicable regulatory framework and for the construction and management of the infrastructure that utilises the relevant frequencies for its operations.

Another way in which the vertical sector utilises frequencies is by procuring a 'turnkey' solution from an electronic communications network or service provider. Such a provider may be a mobile network operator, a mobile virtual network operator in various forms (service provider, Enhanced Service Provider, etc.), or an FWA (Fixed Wireless Access) operator. The solution provided may take the form of wholesale access, roaming, a virtual private network, or network slicing with different infrastructure levels, which may also operate in unlicensed bands.

Other possible solutions for the vertical sector include the construction and operation of passive network infrastructure (preparation of sites, space for equipment, antennas, etc.), making this infrastructure available to an electronic communications network operator and subsequently utilising the services provided by that operator, or 'purchasing' access to the radio network from an electronic communications network operator.

The choice of a specific option depends on the vertical entity's requirements regarding the security and confidentiality of transmitted data (e.g. related to the need to protect the operation of production plants and information concerning their parameters or production volumes). Meeting these requirements leads to the construction and operation of infrastructure independent of public networks operated by electronic communications network operators.

UNOFFICIAL MACHINE TRANSLATION

Conversely, for the use of connectivity services across large areas outside the premises of the vertical sector entity (for example, to connect equipment used by maintenance company staff carrying out field operations), it may be more appropriate to rely on the extensive coverage provided by a public network, e.g. through wholesale access services.

Based on the above options, it is possible to identify four potential models for providing wireless connectivity for the vertical sector, which differ in their varying degrees of isolation from public networks.

The maximum degree of isolation is achieved by establishing and operating a private network that is completely separate from the public network, or by connecting the private network to the public network via secure interfaces that allow, for example, coverage to be extended through roaming agreements or equivalent technical methods.

Models based on the use of public network elements, utilising access to the relevant frequency band at the wholesale level, can be divided into three groups according to the degree of isolation, depending on the level of cooperation between the private and public networks:

- In the first case, this involves sharing access network infrastructure, where the vertical entity uses only the public network's RAN (Radio Access Network) (or via RAN slicing, if available), or MORAN (Multi-Operator RAN) or MOCN (Multi-Operator Core Network) under a RAN sharing agreement, provided the vertical entity holds a licence to use the frequencies.
- In the second case, in addition to RAN sharing, the vertical entity also utilises the operator's network control plane (authentication, authorisation, mobility management, relationship management, etc.).
- In the third case, the vertical entity makes full use of operator-controlled access, transmission and connectivity, whilst the role of the vertical entity is limited to application-layer management (unless it uses the operator's application platform).

When utilising public network elements, traffic related to the private network can be isolated at the logical level, or by using network slicing enabled by 5G technology.

Should a vertical entity decide to use a service provided by a network operator, other actors may enter the value chain, acting as intermediaries between vertical entities and public network operators. These are primarily entities involved in the planning, construction or management of networks designed to provide connectivity services, to which other entities may connect to modify and adapt connectivity services within the framework of specialised services for the vertical sector.

The connectivity needs of vertical sector entities can be met not only by operating their own infrastructure or purchasing connectivity services from traditional operators (mobile operators and FWA operators, who typically operate on a national or regional scale), but also through services offered by entities specialising in providing services to the vertical sector. These entities may build and manage their own network or, conversely, purchase wholesale services from traditional operators.

A specialised network operator may directly manage radio frequencies or may use the services of a traditional operator, purchasing them at wholesale level for the purpose of providing services to the vertical sector.

Another link that could be a participant in the value chain is an asset provider – an entity involved in the creation and management of passive network infrastructure (site preparation, including power supply and equipment spaces, cabling and antennas). A vertical sector entity, a specialised network operator or a traditional network operator would then be responsible for 'network roll-out', i.e. the installation and activation of transmission equipment and its connection to the network. An asset provider could, for example, be a company that constructs a shopping centre and also handles the installation and management of passive network infrastructure.

4 Approaches to shared use of frequencies

According to Recital 119 of the Code, given the growing demand for radio spectrum and new applications and technologies that require a more flexible approach to and use of radio spectrum, Member States should promote the shared use of radio spectrum by establishing the most appropriate authorisation regimes for each case and appropriate and transparent rules and conditions. Shared use of radio spectrum contributes to its efficient and effective use by allowing multiple independent users or devices to access the same radio spectrum band under different types of authorisation regimes, with the aim of ensuring the availability of additional radio spectrum resources, increasing the efficiency of use and facilitating access to radio spectrum for additional users.

Shared use may, for example, take place on the basis of general authorisations (i.e. licence-exempt use) and may, under specific conditions, allow multiple users in different geographical areas or at different times to share, access and use the same radio spectrum.

It may also take place on the basis of individual authorisations for the use of radio frequencies and be based on rules such as licensed shared access (licensed shared access), where all users (existing and new users) agree on the terms of shared access under the supervision of the competent authorities (i.e. the regulatory authority for radio spectrum management) so as to ensure a minimum guaranteed quality of radio signal transmission. Where Member States authorise shared use under different authorisation regimes, they should not set excessively different durations for such use under the different authorisation regimes.

According to Article 2(26) of the Code, shared use of radio spectrum means access by two or more users to the same radio spectrum bands on the basis of a defined sharing mechanism, authorised under a general authorisation, an individual authorisation for the use of radio spectrum, or a combination thereof, including regulatory approaches such as licensed shared access, designed to facilitate the shared use of a radio spectrum band, whereby such access is subject to a binding agreement between all parties concerned in accordance with the sharing rules set out in their rights to use the radio spectrum, so as to ensure predictable and reliable sharing mechanisms for all users, without prejudice to the right to competition.

In accordance with Article 45(2) of the Code, Member States shall promote the harmonisation of the use of radio spectrum for electronic communications networks and services throughout the Union, in line with the need to ensure its efficient and effective use and with a view to delivering benefits to consumers, such as competition, economies of scale and the interoperability of networks and services. In doing so, they shall act in accordance with Article 4 of the Code and Decision No 676/2002/EC, inter alia:

- promoting the shared use of radio spectrum between similar or different types of radio spectrum use in accordance with competition law;
- applying the most appropriate and least burdensome authorisation system in accordance with Article 46 in order to maximise flexibility, sharing and efficiency in the use of radio spectrum.

The need to develop spectrum sharing, given its potential to increase the efficiency of radio spectrum use and provide incentives for innovation, is addressed in a separate RSPG document entitled 'RSPG Opinion on Spectrum Sharing – Pioneering Initiatives and Bands' (RSPG21-006 FINAL) of 10 February 2021, the content of which is described in the introductory chapter of this document.

The background that formed the basis for the preparation of the document "RSPG Opinion on Spectrum Sharing – Pioneering Initiatives and Bands" is summarised in a separate document entitled "RSPG Report on Spectrum Sharing – A Future-Oriented Survey" (RSPG21-016 FINAL) dated 10 February 2021 and are described below.

In general, spectrum sharing can be defined as the joint use of the same frequencies by more than one user:

- at the same time in different geographical areas;
- in the same geographical area at different times;
- at the same time and in the same geographical area.

UNOFFICIAL MACHINE TRANSLATION

The use of signal transmission techniques that enable signal separation in a multi-user environment can be considered a tool enabling spectrum sharing. Multiple users may share spectrum for similar or different purposes (e.g. fixed links and satellite earth stations, or government users and commercial users). Spectrum sharing may involve the same or different levels of priority among users or groups of users.

Spectrum sharing can be implemented in various ways depending on the type of frequency band, the allocation method, and the services available in that frequency band. In many frequency bands, spectrum sharing is generally implemented between spectrum users, such as licensed operators who have obtained licences (frequency allocations), whilst in unlicensed frequency bands, spectrum sharing is implemented at the user level, using technologies implemented in the relevant equipment (product standardisation), or through additional operating conditions provided by the equipment operators. Developments in radio technologies may contribute to enabling spectrum sharing in licensed bands across multiple levels of spectrum users, who may be authorised in different ways within the same frequency band. These technological developments make it possible to introduce new forms of spectrum sharing that offer more efficient use of the spectrum. As a result, it can be assumed that in the future, sharing could be regarded as the norm rather than the exception.

The availability of information on radio frequency usage is a key prerequisite for creating the conditions for the efficient use of radio frequencies, including the implementation of viable models for radio frequency sharing and functional models for trading (i.e. the transfer of rights to use frequencies) and leasing radio frequencies. This information is of fundamental importance for creating the conditions for radio spectrum sharing, both in harmonised bands designated for the provision of electronic communications services and in private network bands or unlicensed bands. Information on the under-utilisation of a particular frequency band, on the one hand, and on the extent of systems requiring protection, on the other, can help new entrants to enter the market. Except where information is shared voluntarily, for the purposes of radio spectrum sharing, the actual need and scope of the data made available, as well as the specific ways in which and to whom the data is made available, be assessed by the regulatory authority on a case-by-case basis, particularly where the rules for radio spectrum sharing in a specific frequency band are defined in advance. It is important that, when defining the methods of information sharing and the scope of the information shared, related legal aspects are also taken into account, for example in the areas of cybersecurity, protection of trade secrets, personal data protection, etc.

When establishing rules to increase the transparency of radio spectrum use by the competent regulatory authority, issues relating to the protection of personal data, the protection of critical network infrastructure and trade secrets, amongst other things, should be assessed. The establishment of publicly accessible databases requires the adoption of internal organisational and technical measures designed to minimise the risk of unlawful data processing, including cybersecurity measures and technical audits.

The careful publication of information on radio spectrum usage can be a source of benefits and opportunities for various radio spectrum sharing scenarios. It can create the conditions for self-coordination and self-regulation by radio spectrum users, thereby minimising the risk of harmful interference, which has a positive impact on the efficient use of radio spectrum. It can also help reduce the costs of effective spectrum management by providing radio frequency users with data and tools to address the consequences of harmful interference through mutual communication, negotiation and agreement.

Other positive benefits of publishing information on spectrum usage include:

- facilitating the deployment of 5G and wireless access systems (WAS) and the authorisation of femtocells;
- generating a significant amount of information usable in the telecommunications sector for the development, manufacture and distribution of equipment and other technologies;
- increasing transparency in environmental matters and in the regulation of electromagnetic emissions.

4.1 Radio spectrum sharing technologies

According to the document 'RSPG Report on Spectrum Sharing – A Forward-Looking Survey' (RSPG21-016 FINAL) dated 10 February 2021, various technologies can be used for radio frequency sharing depending on the sharing requirements, including the specific quality requirements of a particular user or service. Technologies suitable for radio frequency sharing can be divided into several groups:

- Traditional technologies based on spectrum sensing, cognitive technologies or spread spectrum technologies for 'underlay' transmissions, where the risk of interference with other services is minimal due to low radiated power.
- Technologies not originally intended for radio spectrum sharing, but whose use can contribute to effective radio spectrum sharing, such as techniques to mitigate the effects of harmful interference (e.g. smart antennas including beamforming, cooperative intelligent radio networks (CIRN), filters, etc.).
- Technologies associated with the development of 5G (such as network slicing).
- Other technologies originating from the broader information and communications technology sector, such as artificial intelligence and blockchain.

4.1.1 Technologies based on ‘spectrum sensing’

More ‘traditional’ spectrum-sharing techniques are related to multiple access techniques already used in many short-range devices (SRDs) and, more generally, in unlicensed bands to mitigate harmful interference and enable the coexistence of devices within the same frequency band. These solutions include those based on ‘Listen Before Talk’ (LBT), ‘Dynamic Frequency Selection’ (DFS) and ‘Detect and Avoid’ (DAA). However, this is conditional on the fact that the user of the end device cannot disable the functionality of these techniques in any way.

Managing coexistence between different services or between multiple providers of the same service, as well as the maximum number of devices sharing a given frequency, is a key aspect of certain smart metering applications. Here, the challenge of using frequencies on an unlicensed basis whilst ensuring a minimum quality of service is addressed at the application level.

4.1.2 Cognitive technologies

Cognitive technologies enable a radio system, in order to achieve predefined objectives in the area of radio frequency sharing, to dynamically and autonomously adjust its operational parameters and protocols based on acquired knowledge of the operational environment and the results of the learning process.

Some cognitive spectrum-sharing technologies are based on the implementation of geolocation databases, which can provide devices with information to identify parts of the frequency spectrum available for sharing in order to protect existing services. This information may relate to frequencies that can be used at a specific time and/or in a specific location and under specified transmission parameters (e.g. maximum transmit power). Geolocation information on the availability of shared frequencies may be stored directly in the device via a distributed approach or in a centralised (e.g. regional) database, which is then queried by the devices²⁵.

Cognitive spectrum-sharing technologies may be based on the principle of ‘spectrum sensing’, whereby a device detects frequency usage to determine the availability of frequency channels for autonomous transmissions without the need for integration or connection to a database. On the other hand, spectrum sensing may face a number of technical challenges compared to geolocation database solutions. For these reasons, spectrum sensing technologies are sometimes used in conjunction with geolocation database technologies in a hybrid approach aimed at improving sharing efficiency whilst ensuring protection against harmful interference.

Further development of cognitive radio systems may contribute to more efficient spectrum sharing, particularly with regard to the ability of devices to identify frequency channels available for sharing and, consequently, to utilise or release them appropriately, in order to prevent or limit harmful interference.

The use of cognitive technology appears to be the most promising for achieving more efficient spectrum sharing, which is utilised in most situations. One typical scenario where such an approach can be applied is a licensed band, within which the introduction of a new service (licensed or unlicensed) would be permitted without the need to release the band. Another scenario could involve the use of the released band by unlicensed devices, where cognitive technologies enable the introduction of ‘light licensing’ rules.

4.1.3 Beamforming

In the case of smart antennas, adaptive beamforming potentially increases the possibilities for spectrum sharing between multiple users and radio access technologies. Although spatial reuse of spectrum is not a new concept in wireless communication systems, advances in beamforming technologies, which dynamically provide adaptive beams as opposed to area-covering beams, can significantly reduce interference and thereby increase the degree of spatial spectrum sharing, particularly for millimetre-wave bands. In the case of 5G, this would facilitate the use of network slicing scenarios.

4.1.4 Dynamic frequency allocation between technologies

Mobile operators are able to implement dynamic frequency allocation between devices using different radio access technologies based on current conditions and network load (dynamic spectrum sharing – DSS). This is a spectrum-sharing technique within a single operator, which is currently being implemented by mobile operators and suppliers.

²⁵ A typical example of a geolocation database is the database for access to ‘Television White Spaces’ (TVWS) in the 470–790 MHz band or the Citizens Broadband Radio Service (CBRS) – Chapter 2.4 of this document

4.1.5 Receiver performance

Adequate receiver performance is important for facilitating spectrum sharing, for facilitating the introduction of new sharing schemes, for expanding sharing opportunities, and for ensuring the efficient use of spectrum. Adequate receiver performance is essential to ensure the protection of radio equipment from emissions from services in adjacent bands. A positive consequence may be a reduction in guard bands between services.

Filtering techniques

Improvements in filtering techniques and the filters themselves have been crucial for the introduction of new applications and for achieving more efficient spectrum utilisation. These improvements have enabled the use of strict block edge masks (BEMs) necessary for compatibility with adjacent bands where particularly sensitive applications are used.

Application layer coexistence

These are technologies that enable interoperability at the protocol/application layer, thereby allowing different technologies to coexist in unlicensed bands. Examples include, for instance, technology for ITS (Intelligent Transport System) in the 5.9 GHz band and WiGig in the 60 GHz band (57–71 GHz), or those utilising techniques to mitigate harmful interference, such as Adaptive Power Control (APC). Such APC seeks to keep the overall probability of harmful interference sufficiently low to make unlicensed use attractive to 5G application providers, such as fixed wireless access solutions or backhauling and fronthauling to and from high-capacity small cells using 5G technology.

5G-related technologies

In the case of 5G networks, several forms of spectrum sharing (including roaming) are possible, which could utilise network slicing mechanisms. Although network slicing is not in itself a spectrum-sharing technology, it has the potential to enhance the feasibility of certain innovative spectrum-sharing scenarios.

Spectrum sharing based on 5G network slicing for licensed bands allows a single licensed mobile network operator to provide other mobile network operators and/or service providers with dedicated 5G slices. This solution enables the sharing of various 5G bands between licensed operators and/or service providers. For example, a mobile network operator may share its allocated frequencies and infrastructure with other mobile network operators and may provide them with 5G network layers suitable for meeting their customers' requirements (mMTC or eMBB). A specific example could be a sharing agreement between two mobile network operators, where one operator is allocated frequencies only in the lower bands and the other operator is allocated frequencies only in the mid-band: network layers can be allocated to both operators in both networks, which in practice leads to spectrum sharing in both bands. Another example is an agreement between all mobile network operators to pool their allocated frequencies in one or more bands for the purposes of 5G stacking. A further example could be a 'neutral host' (e.g. for small cells in higher frequency bands), in which spectrum sharing can be managed through network stacking.

A specific example could be a mobile network operated in the 26 GHz band by a single operator or a single equipment provider, through the pooling of all frequencies available in that band and the subsequent provision of access to other mobile network operators via 5G layers. In practice, mobile network operators would lease their rights to use the frequencies to a network operator (or equipment provider) who installs and maintains the equipment and then makes the layer available to each participating operator.

5G slicing can also be used in situations where a 5G network operator provides access to other operators offering the same or different services. A specific example is a mobile network operator using frequencies in lower bands, employing different layers with varying prioritisation for different applications, dedicated to URLLC, mMTC and eMBB for MFCN and PPDR applications. 5G slicing can also be used to meet the needs of vertical sectors.

Another significant aspect of 5G systems is the use of a combination of unlicensed and licensed frequency bands to provide end-users with higher network capacity.

Technologies originating in artificial intelligence and blockchain applied to CR models

The latest developments in spectrum management are linked to the application of technologies such as artificial intelligence (AI) and blockchain in the context of spectrum sharing, particularly in approaches based on a cognitive approach.

AI-based techniques are not in themselves spectrum-sharing mechanisms, but they can significantly support the efficient use and sharing of spectrum by improving and accelerating coordination processes and providing dynamic access to specific frequencies in a manner that responds to the needs of specific services (duration of use, range, capacity, etc.).

UNOFFICIAL MACHINE TRANSLATION

Access to spectrum could be provided, for example, on demand or opportunistically, whilst preventing harmful interference by utilising information fed into the system (particularly information not generally used in conventional cognitive systems, such as weather conditions, local spectrum usage, and peak operating periods (rush hour traffic)), thereby enabling the most suitable parameters and technical constraints for dynamic spectrum access to be determined in a highly sophisticated manner.

The use of artificial intelligence in combination with spectrum sensing and database techniques could create the conditions for almost instantaneous frequency allocation for ad hoc mobile access requirements (for example, for Internet of Things applications).

Detailed data on spectrum usage can be managed on cloud platforms. Artificial intelligence could identify significant patterns from large data streams containing a live map of frequency occupancy. The results could be used to support updates to the frequency database, so that application requirements could be met to the greatest possible extent at any given time in any location covered by the database. The same approach can be used for the deployment of small cells, which are typical of 5G.

Artificial intelligence techniques, such as machine learning and deep learning, are also being applied to advanced spectrum-sharing schemes. Such artificial intelligence techniques can be used, for example, to create models of the dynamic behaviour of various users in a cognitive radio network with multiple primary and secondary services. Artificial intelligence techniques can be used to address issues related to traffic routing in ad-hoc cognitive radio networks, with the aim of prioritising the path with the most balanced and/or lowest frequency utilisation by primary services.

Blockchain technology, which falls under the category of Distributed Ledger Technology (DLT), can be used for spectrum sharing. DLT is a decentralised form of database that is not under the control of a single party. For this reason, it offers a secure, resilient, reliable and transparent method of verifying, recording and manipulating data across all network nodes/users, thereby keeping distributed records up to date.

The use of blockchain technology can extend the typical benefits of DLT to the field of shared spectrum usage, for example in terms of:

- decentralisation, by eliminating the need for trusted third parties such as licence holders, frequency managers and database administrators;
- transparency, thanks to improved localised visibility of spectrum usage and verifiability of activity for the effective enforcement of spectrum sharing rules;
- permanence and immutability, as permanent records prevent unauthorised interference, facilitate accurate monitoring and enforcement, and can ensure the unambiguous application of rules;
- availability, thanks to more reliable access to shared spectrum databases;
- security, as wireless systems require strong protection against attacks and secure records support the reliable enforcement of the sharing regime.

When using blockchain for spectrum sharing, several factors need to be taken into account:

- Unlike fixed network equipment, mobile devices are subject to constraints regarding power consumption (in the case of battery-powered devices) and processing capacity. These constraints limit the potential for using mobile devices as nodes within the blockchain.
- For the purposes of operating the blockchain and verifying transactions, a suitable set of frequencies must be continuously available to secure communication between nodes, which places increased demands on management and reduces the net available capacity of the network.
- The stochastic nature of wireless channels may require the adaptation of blockchain protocols to improve system reliability, which leads to a higher cost-benefit ratio for the use of this technology compared to database-based technologies.

4.2 Options for frequency coordination in the 26 GHz band

Software tools for coordinating frequency usage and allocation have been available for at least the last 30 years. These tools are used to assist regulatory authorities in allocating frequencies using a database of occupied and free frequencies. Frequencies, or bands, are structured according to the national frequency table and, if they are in the database, can be assigned to relevant services such as fixed, mobile, satellite, broadcasting, etc.

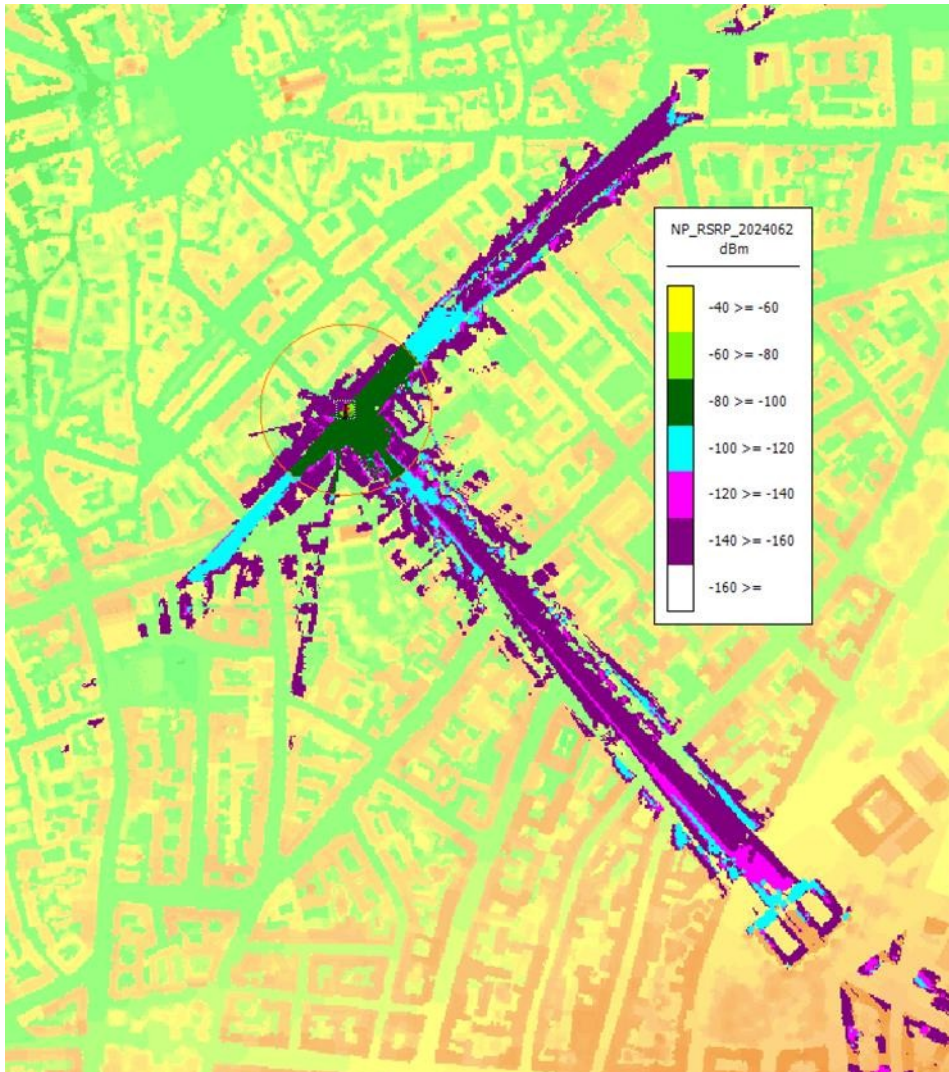
Compared to the 3.5 GHz band, the 26 GHz band involves an additional 17 dB/km of free-space path loss and significantly increased diffraction losses, which essentially creates significant shadows behind any obstacle (i.e. diffraction at obstacles is minimal). Whilst the band is suitable and traditionally used for relatively long distances assuming line-of-sight within fixed services, traditional terrestrial mobile communications or local communications in rugged environments with obstacles are considerably limited. In the case of 5G networks, this leads to the need for a significant increase in network density compared to lower

UNOFFICIAL MACHINE TRANSLATION

bands to ensure comparable mobile signal coverage. Additional losses during radio wave propagation limit the area in which services can be provided, so applications suitable for this band are restricted to a specific service area.

Given the originally envisaged potential of the 26 GHz band, a simulation of signal range (coverage) was carried out on Wenceslas Square in Prague, which represents a potentially high-density area in terms of the number of connected 5G terminals (smartphones). The coverage diagram below represents a rough estimate showing the received signal strength indicator (RSSI) for a single 5G NR base station installed on a wall located on Wenceslas Square in Prague at a height of 4 m. An omnidirectional (omni) antenna is used. The service radius (operating area) is no greater than 100 m (dark green).

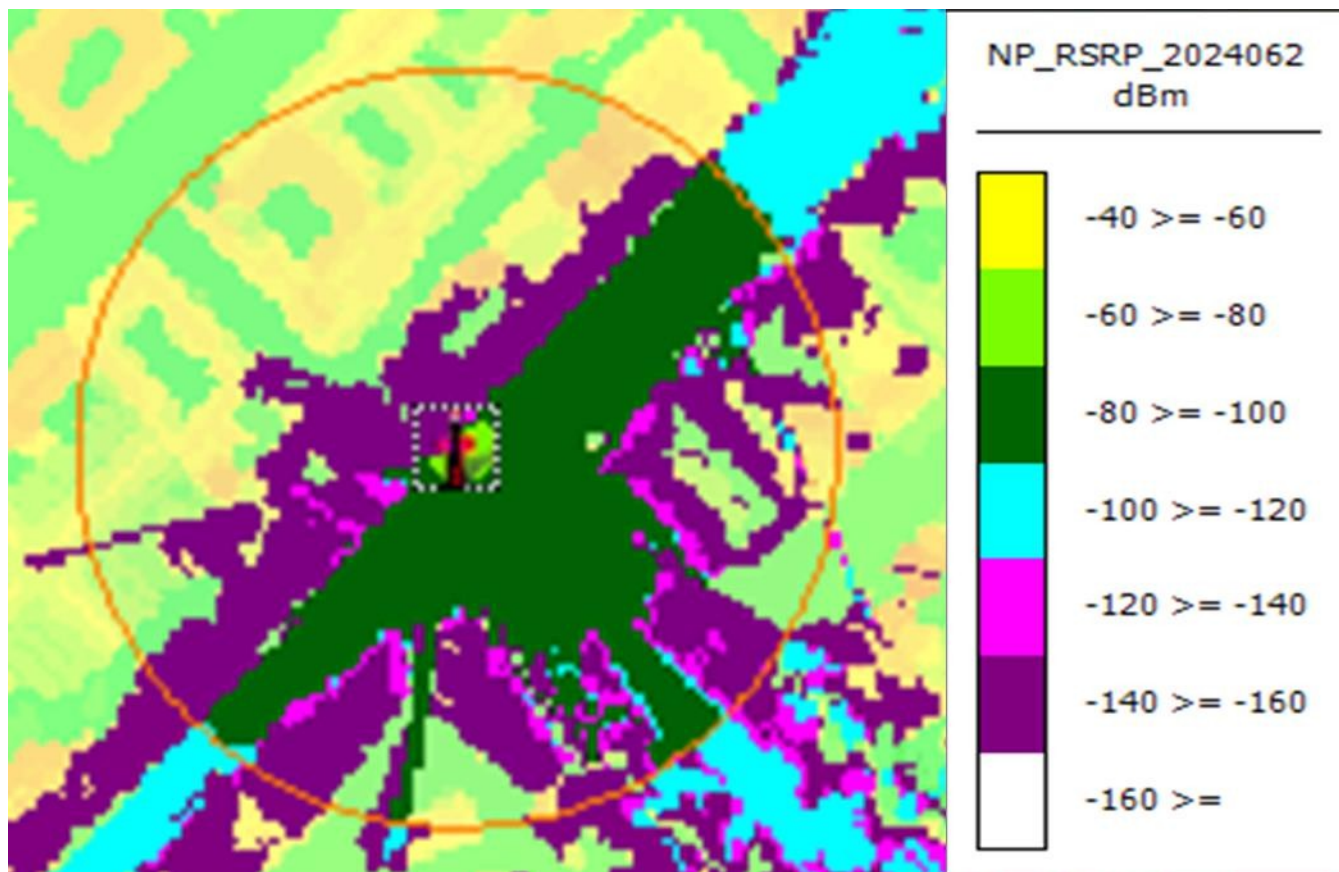
Figure 1: Coverage map of a 26 GHz 5G NR base station in the centre of Prague



UNOFFICIAL MACHINE TRANSLATION

To use the high-speed data service, users would need to be within the light green area (Figure 2).

Figure 2: Coverage map of a 26 GHz 5G NR base station in the centre of Prague – detail of high-speed data service availability



The specific achievable data speeds depend on the bandwidth of the channel used. For specific targeted coverage, a more detailed analysis can be carried out to illustrate the types of coordination scenarios likely to arise in such urban areas.

The following conclusions can be drawn from the simulation results:

- the geographical area of high-speed data service coverage (light green area) in the simulation area represents a fraction of the base station's operational area (dark green area),
- to ensure the availability of high-speed data services across the entire operational area, it is necessary to install several times more base stations, thereby increasing the demands on the use of radio frequencies and their mutual coordination to prevent harmful interference, and consequently the overall regulatory requirements and costs,
- Depending on the specific location (the presence of obstacles to signal propagation), installing two or more base stations at a sufficient distance from one another can prevent mutual interference, even if the distance between these stations is less than their coverage area.
- by locating a base station inside a building, where the building structure prevents radiation from escaping outside the building, mutual interference between base stations located in the same geographical area and inside different buildings can be prevented,
- the use of radio frequencies in the 26 GHz band is not suitable for covering a continuous area in a built-up area; it is significant in terms of ensuring connectivity in a relatively small geographical area with higher demands on connection speed and capacity (hotspot), whereby the appropriate placement of base stations can ensure coverage of the same geographical area by several base stations (two or more operators operating base stations in the same geographical area) with a low risk of mutual interference,
- Placing a base station indoors can prevent interference beyond the building's boundaries; however, to locate and ensure the operation of two or more base stations inside a building, mutual coordination must be ensured to prevent harmful interference.

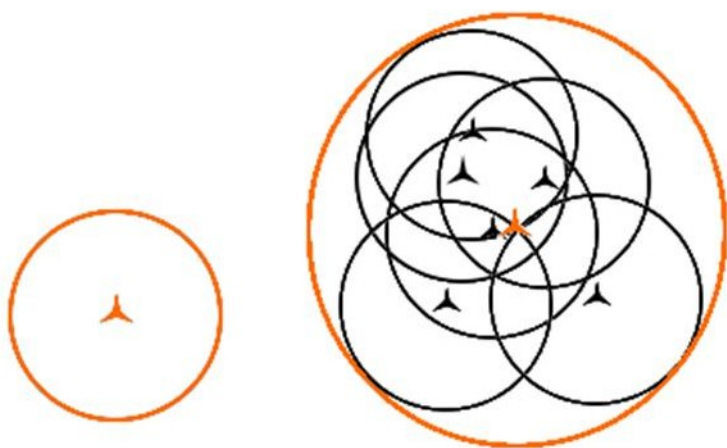
Frequencies around the 26 GHz band are dominated by (and have historically been allocated to) fixed terrestrial links (in the Czech Republic in the band below 26.5 GHz) and satellite connectivity. Mobile or nomadic radio communications represent a newer use of this band, or rather the potential for such use, and require caution when integrating them into the existing environment, particularly where the practical coverage of the service is small but the potential for interference in open space, where the affected service has a significantly high receiving antenna gain, is relatively high.

UNOFFICIAL MACHINE TRANSLATION

A prudent approach is the geographical separation of the two mutually interfering services. In many cases, this is possible because fixed links have narrow-beam antennas and, with care, can be shared with small systems with limited geographical coverage, as these two services are highly unlikely to interact. However, this would require careful coordination, which increases costs and complexity on the part of spectrum management.

Ideally, small systems with limited geographical coverage (shops, warehouses, campuses) could be authorised on the basis of the transmission point (i.e. the location where these systems are situated) and a radius, where frequency reuse is primarily governed by the protected service area (and interference zone) around the point or points. At the edge of the area, a maximum permitted interference signal level is specified, which the frequency user must not exceed. An example of this is shown in the following diagram, where black circles indicate several examples of different operational areas of a local mobile or FWA network, whilst the interference area is outlined in orange. Another similar local network area would only be defined after a certain separation distance.

Figure 3: Simple assignment of a point and radius versus assignment of multiple points and radii (using a shared frequency); the circle represents the interference contour, not the service radius



This approach balances, on the one hand, the regulatory authority's powers in the area of network planning and coordination and, on the other, grants users the ability to adapt the network to their needs. This could be extended to a scheme involving the reuse of cell frequencies or predefined geographical areas limited by terrain or some form of mapping. In the United Kingdom, licensed areas measuring 50 x 50 km take the form of 'designated area' authorisations, for example in the case of Business Radio (VHF/UHF). Within the defined area, the licence holder is free to do as they please, provided that nothing they do exceeds a fixed signal level at the boundary of the defined area and the technology used is approved for use in the relevant frequency band. This allows licence holders to change the parameters of their system within their defined area (or multiple defined areas) without first having to consult the regulatory authority. The regulatory authority need not know what is happening in this area, but the licence holder must demonstrate that they are able to ensure that no harmful interference is caused to neighbouring users. Demonstrating the ability to prevent harmful interference should include evidence of the use of professional planning tools at the site in question or proof that professional planning is provided under a contract with a service provider. However, the specific approach depends on the regulatory authority and the level of effort required to implement such a measure should harmful interference occur. A less formal regulatory authority may not enforce these requirements until harmful interference occurs. In such a case, the conditions set out in the individual authorisation would apply. These may, for example, include acceptable signal-to-interference-plus-noise ratio (SINR) levels or another suitable metric that determines the degree of radio channel sharing between different networks (users).

A similar approach could be used for granting individual authorisations in the 26 GHz band, given that the coverage area for a single location would be relatively small (compared to lower frequency bands), and it would therefore be necessary to consider the size of the area required by the authorisation holder. Depending on the size of the required area, it would be possible to determine whether such an approach would be appropriate or not.

As regards frequency allocation, this requires knowledge not only of the transmitter but also of the sensitivity and C/I (Carrier to Interference) ratio of the relevant receivers. Modern frequency management should be based on frequency coordination dependent on constraints and interference derived from the carrier-to-interference ratio (C/I+Noise+Margin), from which the required service (operational) areas can also be predicted. Frequency allocation based solely on the minimum noise level is inefficient, as the defined area extends unnecessarily far to the point where the desired signal reaches the noise level (or a fixed margin above ambient noise) and is difficult to protect. It is more effective to define and protect a minimum quality of service level, consisting of the required C/I plus a margin above the prevailing noise floor, to account for attenuation. This area can be termed a 'protected

UNOFFICIAL MACHINE TRANSLATION

area', as the regulatory authority will seek to maintain a minimum C/I for the protected service within this area, which is relatively easy to predict and define. Such an approach to frequency allocation allows for denser frequency usage and reuse in radio systems, particularly digital ones, without negatively impacting the user experience, and generally increases the efficient use of spectrum.

The protected area is one of two areas in frequency allocation that would be used to calculate the spectrum fee and to determine the quality of the allocated frequency; the other is the interference zone, which is the area of influence of network operation on other users of the band, as specified in the allocation or individual authorisation. This area must be smaller than the interference zone. Small areas facilitate the deployment of more efficient antennas and the effective configuration of their radiation patterns. For example, small 'local' systems using a paging antenna (circularly polarised with an azimuth of -90 degrees and significantly reduced radiation towards the horizon) could have significantly lower spectrum usage fees compared to the same system with a dipole or collinear antenna. The protected area is also used to define parameters such as channel sharing, where the regulatory authority may allow two or more licence holders to share the entire protected area or part of it based on transmission time or other factors (with a positive impact on lower spectrum usage fees). For example, in the United Kingdom, this is represented by shared and exclusive licences, where the name derives from how many users share the protected area, rather than the channel or the interference zone around it.

Software tools used for spectrum licensing

Within the framework of spectrum management and frequency licensing tools, there are advanced tools with a large user base and several sets of workflows for the 26 GHz band, so there are ready-made configurations available for customisation or for use as they are, with the option of later customisation or harmonisation.

A spectrum management suite may include specialised tools for assessing and approving licence applications, including a workflow guide integrated into the tool, which proves very useful when dealing with processes that may not be run on a regular basis.

For example, a fully featured, customisable tool for managing frequency allocations and a computational-graphical tool for frequency planning and mitigating harmful interference are available.

Both of these tools are currently used by the Czech Telecommunications Office (ČTÚ), and other regulatory authorities have already worked with them to create frequency allocation processes in the 26 GHz band tailored to their own regulatory conditions. It is clear that the existing adaptations are specific to the respective regulatory authorities, but generally they are similar in scope, and some are more general, less complex, and can be easily applied to the needs of the CTU with little or no adaptation.

The decision on which path to take, whether to develop an adaptation from scratch or to adopt/adapt an existing process model, rests with the regulatory authority. The arguments for and against are set out below.

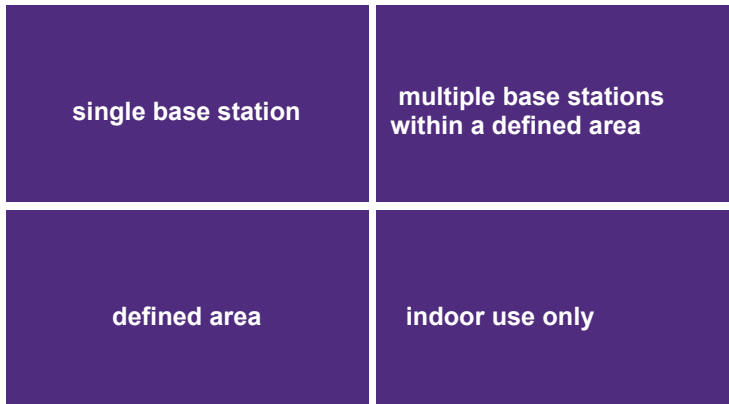
The main argument against using an existing model would be if the models did not support the technology that the regulatory authority is considering introducing (or allowing to operate) in this band. It should be noted that the technology itself is not particularly important, as the frequency allocation tool is primarily based on coordination using existing technical parameters or rules. The main objective is therefore to define the types of frequency usage through conditions for frequency use and to determine their physical configuration.

The classification of configuration types for planning software is usually carried out by defining authorisation products to which these configurations will correspond, so that there would be 'point/location and radius' assignments, which may be generic for devices with fixed power and sensitivity; thus, specific technologies, such as paging (unlikely in the 26 GHz band), would require a central transmitter and a radius that needs to be protected. Generally, this type of system has a protected service area where interference should not exceed a specific limit and interference radius.

Other types of authorisation could represent variations of this approach (see figure below), allowing the use of multiple base stations within an area under a single authorisation, thereby extending the protected zones and interference zones. Interference zones will vary depending on the technology. There is also the option of issuing individual licences for indoor use only, which includes a limited limit on indoor radiated power. Individual approaches may also be suitable for specific applications and mobile usage scenarios. Possible scenarios for the allocation of licences for the use of frequencies in the 26 GHz band are summarised in the following figure.

UNOFFICIAL MACHINE TRANSLATION

Figure 4: Scenarios for the allocation of authorisations for frequencies in the 26 GHz band



Scenarios for granting authorisations for the use of radio spectrum shall be determined by the regulatory authority and should be described in the radio spectrum utilisation plan.

One of the available software planning tools is specifically designed to carry out activities related to the issuance of frequency licences and uses predefined workflows that guide the administrator through the entire process. A common interface allows the administrator to perform all licence management tasks in one place.

When processing an application for a licence, the software tool compiles the relevant technical parameters from the application and passes them to another system for analysis. Once the application has been analysed and returned to the application processing system, a decision can be made on how to proceed. This process ensures accuracy and systematically guides frequency allocation staff through each step.

This automation, utilising pre-defined coordination, frequency allocation criteria and processes, reduces the need for in-depth engineering expertise in the licence allocation process, for example in the field of radio network coexistence simulations. This is particularly true in bands such as the 26 GHz band, where services sharing frequencies are likely to use different technologies and specialist knowledge would normally be required for each type of technology.

When determining technical parameters, a degree of technology neutrality is applied, whereby it does not matter which technology the licence holder wishes to use, provided that the regulatory authority records the technical parameters more precisely (e.g. radiated power, channel bandwidth, antenna characteristics, out-of-band emissions, etc.) to ensure that safe coordination and coexistence can be achieved without harmful interference. However, technological neutrality entails more complex planning for the regulatory authority; nevertheless, an automated tool for spectrum coordination and authorisation issuance significantly reduces the complexity of this process.

The available software tool includes modules for coordination, specifically using the Harmonised Coordination Method (HCM) in Europe, which enables standardised reporting of technical parameters so that the relevant authority can assess the potential of the proposed licence holder to cause interference. The tool can import HCM files and work with them natively, whilst coordinating the system in question with local records.

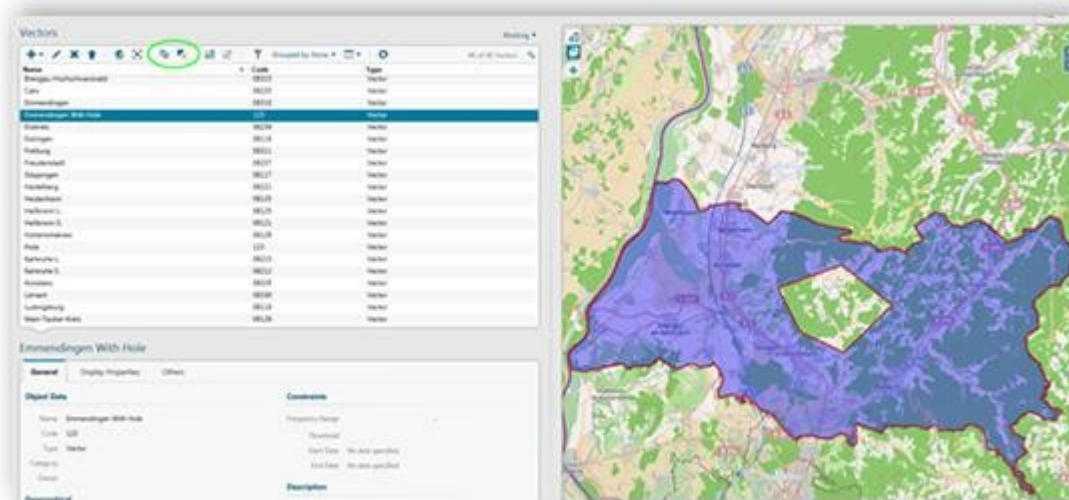
Tools for channel planning and allocation (use case)

Spectrum planning software tools can be used to visualise and edit various frequency band plans.

Exploration using the tool enables the management of frequency allocations, mobile frequency allocation plans and channel plans in general. It is possible to define areas in which, for example, certain frequencies are available. This allows the administrator to determine which frequencies in a specific band can be allocated when processing a licence application.

UNOFFICIAL MACHINE TRANSLATION

Figure 5. Management of geographical frequency allocation – graphical output from the frequency planning and allocation tool



Comparative analysis of frequency allocation options

As regards the use of a tool for the automated allocation of frequencies in the 26 GHz band, its introduction may be useful for the regulatory authority's purposes as early as the first phase of the band's opening. Individual assignments of points and radii can initially be recorded in a spreadsheet or in Google Earth/Maps, but as the interference environment grows and users are no longer easily geographically isolated, some form of automation with evaluation is required. However, given the increase in the number of areas and base stations, the risk of rejecting frequency allocation applications may rise, thereby increasing the need to subsequently assess such applications manually to determine whether rejection is truly necessary or not.

If only a manual procedure based solely on graphical evaluation of frequency allocations were used, this could limit the efficient use of the band due to greater than necessary geographical separation between coordinated stations or networks. It is therefore advisable to implement an automated tool, if possible as early as the initial phase of band opening.

Putting an automated system online (i.e. its implementation by the regulatory authority) can be a complex and slow process. To ensure the correct approach, it is therefore important to understand the potential demand and growth in usage within a newly released frequency band, such as the 26 GHz band, well in advance of the band's release or opening. This also means that the various potentially conflicting technologies and deployment types likely to be used must be analysed in advance to ensure that frequency allocation and coordination processes are sufficiently robust.

The CTO anticipates three use cases in the 26 GHz band, at least initially. The task of the tool's developers would be to enable the issuance of authorisations for these three cases, to coordinate them with one another and with other existing services and users of the band, and to enable the operation of new services and networks.

The CTO has identified three potential uses of the band:

- Fixed Wireless Access (FWA) (initial primary use) – this is considered a way of utilising the band; the technologies used would likely correspond to the profile used by Cambium Networks' cnWave technology, which is based on the 5G NR radio standard; therefore, it requires a larger protection radius, as user equipment will be fixed in position, with gain antennas potentially located outdoors, at a minimum height of 3–10 m above ground level. Here, a local conventional 5G network may have a greater impact in terms of interference than would be the case with conventional 'telephone' mobile network user devices.
- 5G in outdoor environments (potentially MNOs, but more likely campus systems).
- 5G indoors (it is unlikely to be the main initial application, but there is significant scope for automation systems using 5G as a form of mobile Wi-Fi, for example in industry or medicine). Indoor use may not require a high level of protection and, in many cases, will in any event form part of a campus with outdoor network elements. In such a case, indoor operation should be considered part (a subset) of outdoor use, but with a smaller protected radius (assuming attenuation through windows and building structures in accordance with ITU-R Recommendation P.2109 as an additional protection factor).

UNOFFICIAL MACHINE TRANSLATION

If we consider both together (outdoor and indoor use), there is a possibility that both modes will be deployed under the same licence at the same location, and if only 5G is deployed indoors, the licence conditions will remain the same, but with reduced service protection (C/I, SINR). Thanks to TDD synchronisation, this service can coexist with FWA and may even support 'mobile or nomadic' FWA, provided the FWA is protected. However, this implies a greater separation distance between radio stations than would be required for a standard 5G mobile installation.

In terms of the approach to frequency allocation, four scenarios have been identified:

- scenario 1 – frequency allocation for a specific base station,
- Scenario 2 – frequency allocation for a defined operational area (including the interference area), for multiple base stations and terminals,
- scenario 3 – allocation of a specific frequency block,
- Scenario 4 – allocation exclusively for indoor use.

The advantages and disadvantages of each scenario are listed below.

UNOFFICIAL MACHINE TRANSLATION

1) Frequency allocation for a specific base station

Advantages

- a) Easy authorisation
- b) All parameters under the control of the regulatory authority
- c) Possibility of assigning multiple channels without unnecessary complexity

Disadvantages

- a) If part of the administration is transferred to the licence holder (for example, ensuring that emissions are limited outside the designated area), the regulatory authority's administrative costs are partially reduced.
- b) In the event of persistent harmful interference, the responsibility for imposing remedial measures lies with the regulatory authority.

2) Allocation of frequencies for a defined operational area (together with the interference area), for multiple base stations and terminals

Advantages

- a) Easy administration if software tools for planning and coordination are implemented.
- b) The licence holder has a certain degree of freedom when deploying a larger number of base stations within a defined (operational) area

Disadvantages

- a) This type of approach/allocation usually assumes certain parameters for the transmitters used, but defining the boundary conditions is difficult depending on the type of potential network affected by interference (victim), so it is only suitable where the technologies are essentially similar.
- b) Deployment is not as straightforward as it might seem at first glance; the licence area is often much larger than it would be for a technical specification.
- c) If the licence holder is unable to specify the details of the service parameters required, the licence area may be too small (cost savings for the licence holder) or too large (spectrum hoarding or a desire for a lower C/I ratio, which means potentially suffering harmful interference if the licence area is too small).
- d) If multiple channels are allocated, the licence issued could become impractical if the allocated channels do not correlate with the allocated area.
- e) The regulatory authority must be able to carry out measurements to confirm in practice that the boundary conditions are met.
- f) The licence holder may use several sites according to their needs without the regulatory authority's prior approval, and the boundary conditions will vary depending on the type of network being interfered with.
- g) The need for the licence holder to systematically provide the regulatory authority with information on the locations covered and the parameters of the equipment in operation.

UNOFFICIAL MACHINE TRANSLATION

3) Allocation of a specific frequency block

Advantages

- a) Similar to the case of a defined operational area, except that the licence is not issued for a specific operational area (a licence at regional or national level is assumed), but for a specific frequency or frequency block.
- b) Multiple channels or a defined bandwidth, which the licence holder could further subdivide to suit their chosen technology, would normally be allocated to the licence.
- c) The regulatory authority does not need to approve the location of base stations in advance, provided that a boundary condition is met.
- d) It allows the licence holder flexibility to deploy as many sites and frequencies as are needed to meet their specific service requirements.
- e) Typically, these allocations are intended for some form of internationally defined service, such as 3GPP or broadcasting technologies.

Disadvantages

- a) Holders of licences for adjacent frequencies or blocks will be required to coordinate with one another.
- b) The need to set up a regulatory environment that allows for the coordination of stations. A suitable form is, for example, ex-post reporting on installed transmission stations.
- c) Demanding in terms of implementation and administration (e.g. responding to under-utilisation of frequencies – spectrum hoarding), including the potential preparation of an auction. The issue of setting development criteria, etc.
- d) In the event of persistent harmful interference, the responsibility for imposing remedial measures lies with the regulatory authority.
- e) Disadvantage for smaller operators (smaller coverage area)

4) Allocation exclusively for indoor use

Advantages

- a) Easy authorisation limited to a point and radius with a smaller protected radius, taking into account the fact that the site will have multiple base stations at various indoor locations.
- b) Treating systems with multiple indoor nodes as a single virtual outdoor site gives the licence holder the freedom to move equipment around the site without having to reapply for a licence.

Disadvantages

- a) These may be complex installations involving multiple antennas and points.
- b) It is necessary to consider whether, when allocating, it is easier to treat this location as a point and a radius, i.e. without special consideration, only with a smaller 'service area' (protected area).

Practicality and implementation challenges, including timelines

The quickest way to establish a functional frequency allocation process in the 26 GHz band is, for example, to use existing software already available to the CTO and to apply the existing 26 GHz frequency allocation workflow, which has been developed and tested by another regulatory authority. Opting for an existing configuration within the currently used system would be quicker and would also speed up the deployment of this specific configuration. Having more customers using the same configuration will help to ensure that this configuration is rolled out over time. A larger user base means extensive real-time testing and faster identification of issues or improvements, to the benefit of all users. Such a solution could, for example, encourage cooperation between regulatory authorities.

The next step could be for the CTO to collaborate with the software team of the coordination software supplier to understand the specific timelines for implementing such a solution into the existing system. This requires taking into account all aspects of software integration, such as:

- Phase 1 – Planning
- phase 2 – design
- Phase 3 – deployment
- Phase 4 – testing
- Phase 5 – launch

UNOFFICIAL MACHINE TRANSLATION

To ensure a suitable solution for the issuance of individual licences, it would be necessary to procure software for licence issuance and frequency planning that would provide the CTO with all the necessary technical tools, national and international coordination calculations, and frequency allocation options, so that the issuance of individual licences in the 26 GHz band could be launched in the future.

Given the expected use cases for the 26 GHz band (local networks) and the simultaneous creation of opportunities for mobile network operations, a flexible and simple regime for issuing individual licences would enable the CTO to fulfil its obligations in a technologically neutral, flexible, transparent and efficient (in terms of cost and time) manner.

In the interests of transparency and the effective management of frequencies, it is necessary for the CTO, for the purposes of maintaining the database of allocated radio frequencies (Section 15 of the Electronic Communications Act), define, in particular, the content of the data file for each individual authorisation to be entered into the database, the scope of data from the file to be published, and the access rights of entities (applicants for frequency allocation, frequency holders, other entities) to the database. The published information should provide applicants for frequency allocation and existing frequency holders with relevant data for identifying free and occupied frequencies in a specific geographical area, information on other frequency holders for the purposes of coordination or the elimination of harmful interference, or other information that may be used for other purposes. However, such a procedure is only possible provided that, when defining the methods and scope of making the information available, the relevant legal aspects have also been taken into account, for example in the areas of cybersecurity, protection of trade secrets, protection of personal data, etc.

In addition to the mandatory and standard data (i.e. frequency, channel bandwidth, maximum radiated power, radiation direction, elevation, etc.), an individual authorisation may also contain the following elements for scenarios 1 to 4 described above:

- detailed radiation patterns, or other technical parameters (noise figure, etc.);
- delineation of a protected area where the C/I ratio is to be maintained for a defined level of service, i.e. the regulatory authority undertakes to ensure that other licence holders do not exceed the specified C/I in this area;
- delineation of the interference zone which the licence holder may use for communication, but where they cannot claim protection.

When calculating the spectrum usage fee, it is possible to take into account both areas, as well as the radiated power, antenna type (or radiation characteristics), channel bandwidth and, where applicable, other data.

Looking ahead, it is advisable to encourage users to employ suitable antennas or their radiation patterns so that frequency utilisation can be optimised. In the interests of efficient frequency utilisation and in view of technological developments, it is advisable for frequency users to share their operational experience with the regulatory authority.

5 Analysis of approaches to frequency allocation in the 26 GHz band

A key criterion in deciding on the most appropriate approach to frequency allocation (not only in the 26 GHz band), as one aspect of spectrum management, is the creation of conditions for the efficient use of frequencies in a specific frequency band.

For 5G networks, MFCN and other applications in the mobile radio service, the 24.25–27.5 GHz band has been harmonised in Europe. In the Czech Republic, bands below 26.5 GHz are used by the fixed radio communication service. The 26.5–27.5 GHz band, which is currently not in permanent use in the Czech Republic apart from experimental operations for both 3GPP mobile networks and FWA, is suitable for making available for MFCN use.

In countries outside the Czech Republic, no operational or investment models have yet been developed in the 26 GHz band that would lead to the construction and operation of more extensive 5G networks.

In order to make frequencies from the 26 GHz band available to potential interested parties, the scenarios described in Chapter 4.2 of this document may be used for the purposes of granting rights:

- scenario 1 – allocation of frequencies for a specific base station,
- scenario 2 – allocation of frequencies for a defined operational area (together with an interference area), for multiple base stations and terminals,
- scenario 3 – allocation of a specific frequency block (i.e. allocation of radio frequencies),
- scenario 4 – allocation exclusively for indoor use.

Given the spectrum manager's role in, amongst other things, creating conditions for the efficient use of radio frequencies, it is necessary to establish the conditions in the 26 GHz band for the emergence and development of a market for services and technologies within the foreseeable future, whilst supporting various spectrum users, including public networks and private and industrial networks.

Creating conditions for the efficient use of radio frequencies relates, among other things, to the following issues:

- What part of the frequency band will be allocated or made available?
- How can frequencies be allocated, or under what conditions can they be made available?
- What might be the geographical coverage of the allocated frequencies?

For each of the above issues, possible solution scenarios are identified in the following chapters of this document. The advantages and disadvantages of each scenario are identified. The advantages and disadvantages of the individual scenarios should serve as a basis for deciding which of the scenarios is most suitable in terms of the efficient use of frequencies (or other aspects of spectrum management). Depending on the preferred objectives for the management of the 26 GHz band, the scenarios may be applied alternatively, sequentially (in succession), or as a combination. In the case of sequential application, it is advisable to take into account the need or possibility of defining a timeline for the implementation of the individual scenarios.

5.1 Which part of the frequency band will be allocated or made available?

At European level, the 26 GHz band is harmonised as the 24.25–27.5 GHz band²⁶, representing a 3.25 GHz segment.

Article 54(1)(b) of the Code requires Member States to adopt, by 31 December 2020, where necessary to facilitate the roll-out of 5G networks, to adopt, by 31 December 2020, all appropriate measures to enable the use of at least 1 GHz in the 24.25–27.5 GHz band, provided that there is clear evidence of market demand and the absence of significant obstacles that would prevent the migration of existing users of the band or the release of the band.

An analysis of the current state of utilisation of the 26 GHz band shows that between 850 MHz and 3250 MHz has been allocated in the 26 GHz band in the individual countries analysed.

According to PV-P/2/10.2020-10, five contiguous 200 MHz blocks are defined in the 26.5–27.5 GHz segment of the 26 GHz band, with the Authority specifying the conditions for the use of the 24.25–27.5 GHz bands, including conditions for coexistence with the fixed service, based on market demand and experience with IMT/5G experimental operations, and will specify planning procedures, conditions for authorising the use of radio frequencies and other parameters. No individual licences have currently been issued in this sub-band, and it is therefore available for IMT/5G operations.

In contrast, according to PV-P/2/10.2020-1, the 26 GHz band in the 24.25–26.5 GHz sub-band is currently used by the fixed service and the inter-satellite service. The use of this sub-band for IMT/5G operations would require the relocation of the services currently using this sub-band to another band or other bands, or the introduction of some form of shared frequency use that would allow for the simultaneous operation of IMT/5G and existing services.

Based on the above, three possible scenarios for the use of the 26 GHz band are under consideration:

- Scenario 1 – Opening up the currently unallocated 26.5–27.5 GHz band – The Czech Telecommunications Office (ČTÚ) will allow only the 26.5–27.5 GHz band to be used for IMT/5G and FWA
- Scenario 2 – opening up the entire 24.25–27.5 GHz band whilst maintaining the current usage in the 24.25–26.5 GHz band - The CTO will allow the entire 24.25–27.5 GHz band to be used for IMT/5G purposes, with the 26.5–27.5 GHz band also being used for FWA services. In the 24.25–26.5 GHz band, existing services will be operated alongside IMT/5G in the future (shared use of frequencies)
- Scenario 3 – making the entire 24.25–27.5 GHz band available – releasing the 24.25–26.5 GHz band from existing services - The CTO will allow the entire 24.25–27.5 GHz band to be used for IMT/5G purposes, with the 26.5–27.5 GHz band designated for FWA. Existing services in the 24.25–26.5 GHz band will be moved to alternative bands, and the band will subsequently be made available for IMT/5G purposes without the need for shared use of frequencies.

²⁶ Decision 2019/784 and Decision 2020/590

UNOFFICIAL MACHINE TRANSLATION

Scenario 1: Making the currently unlicensed 26.5–27.5 GHz band available

Advantages

- a) The band is available almost immediately
- b) The Authority does not need to implement any additional measures to release the band
- c) No measures are required to ensure coordination with other services in the band
- d) Creation of conditions for the emergence of a market for products and services
- e) No entity is subject to an obligation to release the frequency band
- f) No compensatory measures are required for entities that would be required to release the band
- g) A basis for justifying the release of further frequencies in the band based on actual market demand

Disadvantages

- a) Shortage of available frequencies where demand is (locally) higher than the available frequencies
- b) Need to prepare a strategy for implementing additional measures to release the 24.25–26.5 GHz band at a later date, should demand exceed available spectrum (e.g. measures for shared use of spectrum in the 24.25 – 26.5 GHz and/or for the migration of existing services to alternative bands)

Scenario 2: Making the entire 24.25–27.5 GHz band available – retaining existing usage in the 24.25–26.5 GHz band

Advantages

- a) The band above 26.5 GHz is available almost immediately
- b) The Authority does not need to implement any additional measures to release the band in the range above 26.5 GHz
- c) No entity is affected by the obligation to release the frequency band
- d) No compensatory measures are required for entities that would be adversely affected by the release of the band
- e) A basis for justifying the release of further frequencies in the band based on actual market demand

Disadvantages

- a) Establishment of technical parameters to prevent harmful interference in those parts of the band where multiple services will be operated simultaneously
 - i. measures relating to the wireless broadband electronic communications services
 - ii. measures relating to existing frequency holders
- b) Introduction of measures enabling shared use of frequencies in the 24.25–26.5 GHz band, including software for frequency management and the issuing of individual authorisations
- c) Need to amend existing individual measures for the use of frequencies in the 24.25–26.5 GHz band by existing services
- d) The need to prepare a strategy for implementing measures at a later stage if the technical parameters for preventing harmful interference prove insufficient (e.g. releasing the band from existing services)

UNOFFICIAL MACHINE TRANSLATION

Scenario 3: Opening up the entire 24.25–27.5 GHz band – releasing the 24.25–26.5 GHz band from existing services

Advantages

- a) Creation of a large section of the frequency band usable for wireless broadband electronic communications services

Disadvantages

- a) Conducting a feasibility study on the relocation of existing services from the 26 GHz band
- b) Preparation of a strategy for the 'relocation' of existing services from the 24.25–26.6 GHz band to the band defined under point (a), utilising
 - i. compensation for holders of existing services and/or
 - ii. the expiry of individual authorisations held by existing service providers
 - iii. the temporary introduction of measures enabling shared use of frequencies in the 24.25–26.5 GHz band, including software for frequency management and the issuance of individual authorisations
- c) The time, cost and procedural complexity of the process of migrating existing services from the 24.25–26.6 GHz band to the newly designated band
- d) Postponement of the use of the 26 GHz band for wireless broadband electronic communications services until the entire frequency band has been fully released

5.2 How can frequencies be allocated, or under what conditions can they be made available?

The legal instruments governing the use of frequencies are regulated at three levels: international, regional and national.

Table 3: The different levels of regulation of frequency use

Level	Key activities	Entity
International	allocation	ITU
regional	allocation	regional groups (e.g. CEPT)
national	assignment	national regulatory authorities
	authorisation	

On a global scale, frequencies are regulated by the International Telecommunication Union (ITU) – a specialised agency of the United Nations that establishes international frameworks for frequency management with the aim of ensuring harmonised, equitable, efficient and effective access to frequencies without harmful interference. This access is ensured through the Radio Regulations (RR), an international treaty that governs the allocation of frequency bands to various radio services, with binding effect on all ITU member states.

Cross-border coordination of radio frequency use is essential to prevent the risk of harmful interference. Therefore, various organisations (APT, ASMG, ATU, CEPT, CITELE and RCC) coordinate spectrum management at regional level to address specific regional needs and ensure harmonisation between neighbouring countries.

At European level, the key players in the field of spectrum management are the European Commission (EC) and the Electronic Communications Committee (ECC), which is part of the European Conference of Postal and Telecommunications Administrations (CEPT), and, to a lesser extent, the European Telecommunications Standards Institute (ETSI). The ECC develops common policies and harmonises spectrum allocation, the European Commission issues binding regulations (compatible with ECC decisions) and ETSI sets equipment standards.

At national level, Member States have sovereignty over the use of radio frequencies within their territory. Regulatory authorities responsible for spectrum management may adopt various regulatory policies for the allocation of spectrum rights in order to accommodate different interests, including the introduction of

UNOFFICIAL MACHINE TRANSLATION

new technologies, promoting competition among market players, facilitating market entry for new entrants, and ensuring consumer protection. The field of spectrum policy is an area of shared competence between the EU and the EU Member States. This means that legislation may be enacted by both EU and national authorities.

According to the ITU Radio Regulations, the basic national obligations and requirements (functions) relating to spectrum management are as follows:

- planning and regulation of spectrum management,
- financing of spectrum management, including fees,
- allocation and reservation of frequency bands,
- authorisation of frequency use,
- domestic negotiations and consultations,
- international and regional cooperation, including coordination and notification,
- standards, technical specifications and equipment authorisation,
- monitoring of frequency use,
- enforcement of compliance with rules on the use of frequencies,
- other supporting functions of spectrum management.

According to the ITU's World Bank Telecommunications Regulation Handbook, there is a convergence in the types of frequency authorisation regimes applied in individual countries. Approaches to frequency authorisation can be divided into two categories: individual authorisations and general authorisations.

Report ECC 132 examines various authorisation and licensing regimes for the purposes of frequency management. It provides a basis for understanding the different terminologies and approaches used in the regulation of radio applications. It examines the types of regulatory or licensing frameworks that can be used to ensure the efficient and interference-free use of frequencies in various applications.

Table 4: Overview of authorisation regimes according to ECC Report 132

individual authorisation		General authorisation	
individual authorisation	simplified form of individual authorisation	General authorisation	General authorisation
<ul style="list-style-type: none"> • individual frequency planning/coordination • traditional process for granting individual authorisation 	<ul style="list-style-type: none"> • individual frequency planning/coordination • simplified process compared the traditional process • limitation on the number of licence holders 	<ul style="list-style-type: none"> • no individual frequency planning/coordination • registration or notification • no limit on the number users or need for coordination 	<ul style="list-style-type: none"> • no individual frequency planning/coordination • no registration or notification

Globally, there is a clear shift towards the use of general authorisations, although individual authorisations are still used, particularly in cases where demand for a specific frequency band exceeds its availability (for example, bands for mobile networks, where rights are granted to specific entities on the basis of competitive tendering).

Comparison of authorisation with other bands

In some European countries, licensing approaches have already been developed for other frequency bands that support applications for mobile (MFCN) and fixed wireless access (FWA). Ofcom is focusing on options for sharing access to a range of different frequency bands through consultations on sharing, which include the 1800 MHz, 2300 MHz, 3.8–4.2 GHz and 26 GHz bands.

Specific parameters under consideration in the consultation include:

- transmission power limits (discussions are currently underway on whether to increase the average power when authorising shared access in the 3.8–4.2 GHz band),
- local coordination agreement,
- antenna parameters,
- in-building gain (a parameter that can help improve indoor and outdoor sharing),
- coordination of synchronisation,
- fee levels,
- criteria for exemptions,
- requirement to keep records of terminal equipment,

UNOFFICIAL MACHINE TRANSLATION

- online authorisation allocation,
- distribution model,
- information on spectrum availability.

The following table compares licensing approaches across different frequency bands, with the aim of identifying potential cases where access to the 26 GHz band could benefit (or not) from approaches applied (or under consideration) in other frequency bands. The table lists some of the relevant usage parameters and highlights potential key differences.

Table 5: Licensing approaches in selected frequency bands

Usage parameter	1800 MHz (UK)	2300 MHz (UK)	3.8–4.2 GHz (Europe)	26 GHz
low and medium power applications	yes	yes	yes	yes
outdoor and/or indoor use	indoor and outdoor	indoor and outdoor	primarily outdoor	both indoor and outdoor, depending on the application
coverage of rural areas	yes	certain locations	no	no
Authorisation method	individual authorisation with shared use (upon application)	individual authorisation with shared use (upon application)	individual authorisation with shared use (upon request)	national/regional individual authorisations (auctions), local individual authorisations upon application
coordination at local level	yes	yes	yes	yes
loss when passing through a building	12 dB	12 dB	14 dB	14 dB
fee for individual authorisation	nominal annual fee	nominal annual fee	nominal annual fee	nominal annual fee
automated solution for issuing permits	yes	yes	yes	yes

The table clearly shows that there are certain similarities in the licensing approach in other shared bands, and in the local licensing option for the 26 GHz band. There are some key differences between the licensing approaches in other bands and in the 26 GHz band, such as:

- nationwide licences for the entire 26 GHz band (Estonia, Finland, Spain, Austria, Denmark, Greece, Slovenia) granted through auction,
- all local networks (Germany, Sweden),
- a hybrid approach including the identification of high-density areas for auctions and local individual licences (United Kingdom, Italy).

The various approaches taken by European countries to authorising the 26 GHz band suggest that specific national considerations and requirements are at play. This means that, for example, given that the 26 GHz band is identified in Europe as a pioneering 5G band, this band has been made available by many countries based on the traditional approach to nationwide authorisation via auction. This is a tried and tested approach to spectrum allocation, even though the technical characteristics of the band are not suitable for deployment over a wide area. However, some countries have understandably introduced an additional layer of authorisation due to the limited propagation characteristics, which clearly allow, for example, spectrum sharing outside small districts in major urban areas.

Regulatory practice based on current legislation in the Czech Republic distinguishes between three basic methods of making frequencies available to, or allocating them to, users:

1. a general authorisation, which sets out the conditions for the use of radio frequencies without restricting them to a specific entity, and
2. individual authorisations, which allocate radio frequencies to a specific entity and which cannot be used on the basis of a general authorisation, where this is necessary to: a) prevent harmful interference, b) ensure the technical conditions for the quality of electronic communications services, c) ensure the efficient use of the radio spectrum, d) the fulfilment of public interest objectives, e) experimental purposes, f) ensuring the use of the radio spectrum in question due to its specific characteristics. Any entity may submit an application for authorisation.
3. where the number of rights to use radio frequencies has been limited, individual authorisations to use radio frequencies may be granted on the basis of radio frequency allocation.

An analysis of the current state of 26 GHz band usage shows that frequencies in the 26 GHz band are allocated, or have been allocated, in individual countries in the form of individual authorisations, whilst auctions as the sole method of frequency allocation were

UNOFFICIAL MACHINE TRANSLATION

used in 10 out of a total of 14 countries. Individual authorisations on a 'first come, first served' basis are used in four countries, whilst this is the sole method of frequency allocation in three countries (France, Germany and Sweden).

None of the countries analysed permits the use of frequencies in the 26 GHz band under a general authorisation.

The allocation of spectrum in the 26 GHz band on the basis of individual licences is supported by the RSPG's second opinion on 5G networks, according to which the preferred authorisation method in the 26 GHz band should be the individual licence regime, given the need to limit harmful interference.

According to Recommendation 2020/1307, the roll-out of 5G wireless networks would benefit from flexible authorisation regimes that support investment in wireless networks and ensure the efficient use of spectrum. Whilst Member States should generally use competitive procedures, such as auctions, to grant rights to use scarce frequency bands, in certain cases these procedures may limit the potential for investment in dense 5G wireless networks, as well as the flexibility and resulting efficiency of spectrum use. Individual authorisations for the use of harmonised millimetre-wave bands, using an accelerated administrative procedure that is open, objective, proportionate and non-discriminatory and follows transparent criteria and procedures, could be considered a best practice.

An important tool for the efficient use of spectrum in the 26 GHz band is the possibility of spectrum sharing. This approach is highlighted in the RSPG's opinion on spectrum sharing – pioneering initiatives and bands, in which the RSPG states, among other things, that when allocating new rights of use, Member States should consider spectrum sharing between existing and new users through innovative and more dynamic solutions. Member States could consider such spectrum-sharing solutions that enable the vertical sector and other spectrum users to gain access to spectrum on a mutually beneficial basis. The RSPG further states, in relation to spectrum sharing, that Member States will need to assess the potential impact of the measures introduced on competition and, wherever appropriate and useful, conditions for sharing may be applied in order to achieve more efficient use of spectrum, in particular to meet coverage targets or to accelerate network roll-out, increase coverage, increase capacity and improve service quality. Allocation holders must be informed in advance of the technical conditions and parameters of such a spectrum sharing arrangement.

Based on the above, three possible scenarios for the allocation or making available of frequencies are under consideration:

- scenario 1 – allocation/making available of frequencies from the 26 GHz band on the basis of a general authorisation
- Scenario 2 – Allocation/availability of frequencies from the 26 GHz band on the basis of an individual licence following an application
- Scenario 3 – Allocation/availability of frequencies in the 26 GHz band on the basis of a competitive tender

Scenario 1: Allocation/availability of frequencies in the 26 GHz band on the basis of a general authorisation

Advantages

- a) Minimal administrative burden for frequency users

Disadvantages

- a) High regulatory costs for the regulatory authority
 - i. High number of entities in terms of frequency use and management
 - ii. High number of entities in terms of monitoring compliance with obligations related to frequency use
 - iii. Lack of an overview of the number and identity of spectrum holders
 - iv. High risk of harmful interference
- b) Low efficiency of spectrum use – setting strict technical parameters to prevent harmful interference

UNOFFICIAL MACHINE TRANSLATION

Scenario 2: Allocation/availability of frequencies in the 26 GHz band based on individual authorisation upon application

Advantages

- a) Frequencies can be used by any user, i.e. promotion of competition
- b) Possibility to set clear rules for frequency use in individual authorisations
- c) Enforceability of obligations set out in individual authorisations
- d) Possibility of introducing an automated system for the allocation and coordination of frequency use

Disadvantages

- a) Implementation of the CTO's procedures for the coordination and planning of radio stations and networks
- b) Administrative burden on applicants
- c) Need to implement measures to prevent spectrum hoarding
- d) Regulatory costs for the regulatory authority
 - i. A high number of entities in terms of frequency allocation and management
 - ii. a large number of entities in terms of monitoring compliance with obligations relating to the use of frequencies

Scenario 3: Allocation/availability of frequencies in the 26 GHz band on the basis of a tender

Advantages

- a) Possibility of setting development criteria to ensure the efficient use of frequencies as conditions of the tender
- b) Possibility to set clear rules for the use of frequencies prior to their allocation for a relatively long period
- c) Allocation of frequencies for a long period
- d) Frequency holders' interest in using their frequencies as efficiently as possible
- e) The possibility of establishing measures to prevent spectrum hoarding
- f) Enforceability of obligations set out in individual licences
- g) The possibility of introducing an automated system for coordinating the use of frequencies
- h) The possibility of establishing rules for spectrum sharing
- i) Low number of entities subject to regulation, including monitoring of compliance with frequency usage rules

Disadvantages

- a) Making frequencies available to a limited group of entities
- b) Financial burden on spectrum holders if the price for spectrum allocation is one of the selection criteria
- c) Time-consuming and administratively burdensome preparation and implementation of the selection procedure
- d) Long-term frequency allocation reduces the ability to respond to technological developments in the use of the band

5.3 What might be the geographical coverage of the allocated frequencies?

According to the RSPG's second opinion on 5G networks, the 26 GHz band will be used in areas of very high demand, such as transport hubs, entertainment centres, industrial or retail complexes (creating islands of very high capacity). Given its characteristics, the roll-out of 5G in the 26 GHz band is envisaged to provide local coverage, whilst the RSPG states that, due to its characteristics, the band will not be used to provide coverage for large areas.

An analysis of the current state of 26 GHz band usage shows that frequencies in the 26 GHz band are allocated on a national basis in eight countries, on a local or regional basis in five countries, and in one case have been made available as a combination of national and regional allocations.

UNOFFICIAL MACHINE TRANSLATION

In terms of the geographical scope of coverage of the allocated frequencies, three scenarios can be identified:

- Scenario 1 – national coverage – the licence holder obtains a licence to use a defined section of the frequency band across the entire territory of the state
- Scenario 2 – Local variant A – the licence holder obtains authorisation to use a defined section of the frequency band within a specific geographically defined area, with the geographical definition of the area based on standard administrative divisions (e.g. region, district, city, municipality)
- Scenario 3 – Local Option B – the licence holder obtains a licence to use a defined section of the frequency band within a specific geographically defined area, with the geographical definition of the area determined by the technical parameters of the network built/operated by the licence holder

Scenario 1: Nationwide coverage of frequencies in the 26 GHz band

Advantages

- a) Minimal administrative burden for licence holders – a single licence for the entire territory
- b) Low regulatory costs for the regulatory authority – a small number of entities subject to regulation, including monitoring of compliance with frequency usage rules
- c) Frequency holders' interest in using their frequencies as efficiently as possible
- d) Use of spectrum to increase the capacity of the existing mobile network anywhere across the whole territory
- e) Use of spectrum to ensure the availability of high-speed internet connectivity in areas without fixed high-speed network coverage anywhere across the country
- f) Utilisation of economies of scale when purchasing equipment
- g) A simple charging policy – a single rate

Disadvantages

- a) Making frequencies available to a limited group of entities
- b) Limited range of solution providers for the vertical sector
- c) Offering of standardised solutions for the vertical sector – lack of solutions specific to a particular sector or customer
- d) Risk of inefficient spectrum utilisation

Scenario 2: Local Option A

Advantages

- a) Use of frequencies to increase the capacity of the existing mobile network in a defined area
- b) Use of frequencies to ensure availability of high-speed internet connectivity in areas without fixed high-speed network coverage within a defined area

Disadvantages

- a) Higher administrative burden for spectrum holders compared to Scenario 1 – a separate application for spectrum allocation for each location
- b) Uneven number of solution providers for the vertical sector – the number of providers in each location depends on providers' interest in that location
- c) Risk of frequencies not being allocated in locations where no provider expresses an interest in allocation
- d) Lower economies of scale when purchasing equipment compared to Scenario 1
- e) Greater complexity of the fee policy, taking into account the size of the area covered by the frequency allocation
- f) Higher regulatory costs for the regulatory authority compared to Scenario 1
 - i. A higher number of entities in terms of frequency allocation and management
 - ii. Higher number of entities in terms of monitoring compliance with obligations associated with the use of frequencies

UNOFFICIAL MACHINE TRANSLATION

Scenario 3: Local Option B

Advantages

- a) Development of specific solutions tailored to the individual needs of the vertical sector

Disadvantages

- a) Higher administrative burden for spectrum holders compared to Scenario 2 – a separate application for spectrum allocation for each location
- b) Risk of frequencies not being allocated in locations where no provider expresses an interest in allocation
- c) Lack of economies of scale when purchasing spectrum
- d) Greater complexity of the fee policy, taking into account the size of the area covered by the frequency allocation
- e) Higher regulatory costs for the regulatory authority compared to Scenario 2
 - i. A higher number of entities in terms of frequency allocation and management
 - ii. Higher number of entities in terms of monitoring compliance with obligations related to frequency use



Grant Thornton

www.grantthornton.cz

© 2024 Grant Thornton Advisory k.s. All rights reserved.

Grant Thornton Advisory k.s. is a member firm of Grant Thornton International Ltd. (Grant Thornton International). References to Grant Thornton refer to Grant Thornton International or to member firms. Grant Thornton International and its member firms are not an international partnership. Services are provided independently by individual member firms.