NATIONAL MEDIA AND INFOCOMMUNICATIONS AUTHORITY, HUNGARY

RADIO SPECTRUM STRATEGY

2021-2025

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1. The Radio Spectrum Strategy – Reason and Purpose

The development of the radio spectrum strategy of the National Media and Infocommunications Authority (NMHH) for the period 2021-2025 started in the autumn of 2019. The main objective of the 2021-2025 spectrum strategy is to ensure, through responsible spectrum management, that the availability and usability of the frequency assets, which is a limited resource for the development of the digital ecosystem, is not a bottleneck in the short or medium term.

The radio spectrum strategy is in line with the main guidelines set out in the "National Media and Infocommunications Authority Strategy 2018-2022" and also relies on the radio spectrum strategy for the period 2016-2020. Its vision and objectives are also in line with the relevant international strategic aspirations of the various European professional organizations and working groups in the field of civil and non-civil spectrum management that support the work of the ITU, CEPT, NATO and the European Council and the Commission. Its legal background is the European Electronic Communications Code (hereinafter: the Code)[1]**Hiba! A hivatkozási forrás nem található.**, as well as a number of national legislative acts, including Act C of 2003 on Electronic Communications (hereinafter: Electronic Communications Act), and decrees of the President of NMHH, and takes into account the national and international institutional environment involved in the regulation of the use of radio spectrum.

The document reacts to the changes over the previous strategic period (2016-2020): these include the changed economic and social environment, the appearance of new technologies, the changes that took place in national and international spectrum regulation and the results of the award procedures in the period. It examines changes in technologies and their use, market reactions, and the economic and social processes that affect them. In social public life, some of these attract particularly significant attention (such as the appearance and spread of 5G systems or the impact of the coronavirus pandemic), but the radio spectrum strategy seeks to take other factors into account as well and to form a comprehensive picture in its analysis of the situation and the expected effects on spectrum use.

NMHH also relied on the views of radio spectrum users to develop a comprehensive picture. While getting to know the views of certain market players, service providers, users, governmental bodies, authorities, etc., 35 personal interviews were conducted, and NMHH also collected market information in the framework of a workshop for about 100 people in order to provide an opportunity of an interactive opinion making for stakeholders involved.

The strategy organizes its target system around three pillars. Its first pillar is the "Radio spectrum users", as responsible spectrum management is basically designed to meet the needs of users in an optimal way. In order for this to happen, a sufficiently effective regulatory environment is needed, the development of which is also one of the main objectives of the strategy, which is systematized in the "Legal and institutional system" pillar. Finally, the third pillar, the limited resource itself, the available state assets, is the "Radio spectrum", which helps to achieve the objectives in the framework of a shared use of spectrum optimally tailored to the national ecosystem during the implementation of the strategy.

The overall and specific objectives of the strategy are to ensure the proper functioning of various radio applications, including mobile and fixed services, broadcasting, satellite and short-range applications, but also a number of specific and priority applications, such as

[1] Directive (EU) 2018/1972 of the European Parliament and the Council of 11 December 2018 establishing the European Electronic Communications Code

narrowband and broadband public protection and disaster relief systems, military applications, transportation systems, IoT (Internet of Things) solutions and many other applications. It is essential to ensure and maintain appropriate radio frequency measurement capabilities to ensure the expected operation and control of the listed systems, which are also suitable for measuring parameters relevant to official control and the protection of our health.

The aim of NMHH is to ensure as much as possible, through its responsible spectrum management, that the availability and usability of the limited resource frequency

- is not a bottleneck for the development of the digital ecosystem in any period of time,
- the systems based on its use and the services based on them are based on future developments,
- its use is technically and economically optimal, free of harmful interference, serves the public good with a high quality of service, keeping in mind the principle of technological neutrality and ensuring the protection of investments.

As a vision of spectrum strategy, NMHH defines that

- by applying the most advanced IT systems and technical solutions, the efficiency of national radio spectrum management will be continuously improved,
- its activities shall be guided by the promotion of efficient, professional and consumer-friendly use of radio spectrum and the promotion of technological development,
- it shall support innovation and through this the development of digital economy to strengthen Hungary's competitiveness,
- taking into account the efficiency of market competition in its measures and considering the opinions and needs of all interested parties, it strives to conduct competitive, comparative procedures to the satisfaction of all,
- as a responsible spectrum manager, it ensures the enforcement of public health aspects with the means at its disposal,
- it participates in the fight against climate change through spectrum management tools, and
- follows international standards for spectrum management in an exemplary manner and fulfils its obligations to cooperate with the authorities of neighboring countries and international organizations, while promoting national interests.

The aim of the spectrum manager is to reduce the effects of spectrum limitations and at the same time achieve the greatest social benefits during spectrum use. For all this:

- it must be ensured that the distribution of radio spectrum for electronic communication networks and services, the issuance of general authorizations for them and the granting of individual rights of use are based on objective, transparent, pro-competitive, non-discriminatory and proportionate criteria;
- it must be ensured that unused spectrum reaches users who are able to create the greatest social value with it, whether it is a market or non-market type of spectrum use;
- economical use of spectrum should be encouraged, which
    - results in cost savings for the user due to lower radio spectrum fees
    - can meet new usage needs due to redistributability
    - reduces the effects of spectrum limitations by expanding spectrum supply.

The NMHH continuously monitors the implementation of the objectives of the radio spectrum strategy in the monitoring system developed for this purpose, where the fulfilment of the objectives can be examined with the help of the indicators assigned to strategic objectives. In addition, the consistency of the strategy, its alignment with the objectives of various international, European Union and national strategies and the national fulfilment of the expected numerical parameters, most often determining radio coverage or subscriber data speed, can be continuously monitored.

2. Key considerations

2.1. Priority target areas

Priority target areas of the radio spectrum strategy[2]

1. **Meeting mobile spectrum demands**

   The availability and flexible use of radio spectrum necessary for the continuous development of mobile services must be ensured. Efficient spectrum use should be promoted.

2. **Meeting the demands of terrestrial broadcasting**

   The availability of the radio spectrum necessary for audio-visual and sound broadcasting, the continuous development of broadcasting and its anticipated demands must be ensured.

3. **Meeting the frequency demands of some key terrestrial applications**

   The possibility of using the parts of the spectrum necessary for programme making and special events (PMSE), rail transport (GSM-R, other), short range devices (SRD), and unmanned aircraft systems (UAS) must be ensured.

4. **Meeting the frequency demands of satellite services and applications**

   Geostationary and low-orbit satellites should be provided with the necessary spectrum and an appropriate national regulation should be developed in line with the National Space Strategy.

5. **Meeting PPDR and other government spectrum demands**

   In the case of primarily governmental and PPDR applications, the efficient use of spectrum must be promoted, and the spectrum demands for its operation and development, optimized according to user needs, must be met.

6. **Preserving the values of non-civil radio communications, considering their interests, ensuring the use of spectrum**

   The availability of radio spectrum for non-civil radio communications, in particular for military developments, must be ensured.

7. **Continuous satisfaction of user spectrum demands**

   Sufficient spectrum must be provided to meet current and recurring socio-economic spectrum demands (e.g. spectrum demands for new tasks and developments in the 5G vertical, for law enforcement, or for the digital transformation of the energy sector).

8. **Supporting the early introduction of modern, innovative technologies, facilitating the phasing-out of obsolete technologies**:

   The introduction of modern technologies and, at the same time, the elimination of obsolete technologies in order to increase efficiency must be supported.

9. **Ensuring a high quality legal framework for spectrum management with long-term predictability**

   The long-term predictability of the regulatory framework for spectrum management needs to be ensured. Legislative tasks must be performed to a high standard, taking into account harmonization obligations.

[2] for detailed description see chapters 10-12

10. **Maintaining a high-quality institutional system**

    The institutional framework of spectrum management must be made more flexible, stronger, more open to users, consumers, and the industry, and its national and international recognition and high standard must be preserved.

11. **Ensuring efficient spectrum use**

    The operating conditions for solutions that facilitate the efficient use of radio spectrum (e.g. geolocation database, shared spectrum use, simplified approval of secondary trading) need to be improved.

12. **Ensuring spectrum use without causing or being the subject of interference**

    The quality, the radio spectrum use without being subjected to or causing interference must be ensured, and new tasks related to radio frequency countermeasures must be performed to a high standard.

2.2. Key strategic objectives

The key strategic objectives are:

- The part of the spectrum with sufficient bandwidth for the public mobile service must be made available in three ranges: Below 1 GHz[3], between 1 GHz and the upper limit of the "6 GHz band", and above 24 GHz.
- MFCN (5G) spectrum in the appropriate bandwidth shall be made available primarily and/or indirectly to verticals.
- In order to implement 6G systems as soon as possible, the necessary preliminary tests must be carried out.
- A document analyzing the long-term future of television and sound broadcasting must be prepared, and the concept of MF, HF and VHF sound broadcasting must be developed.
- A regulatory concept for serving PMSE demands must be developed.
- The regulation of railway communication systems and short-range devices shall be examined and, based on the results of the tests, the necessary adjustments must be made.
- An appropriate regulation for UAS devices needs to be developed.
- The current use and future possibilities of 5.9-6.4 GHz band should be examined, on the basis of which, if necessary, authorization procedures and radio spectrum fees should be developed, taking into account the results of ongoing studies at international level.
- The international frequency coordination of the required geostationary and low-orbit satellite systems should be started and, if necessary, the NFFF should be modified.
- Decision-making document needs to be developed for spectrum use for PPDR.
- For national non-civil use, the relevant, necessary (individual) radio licenses must be issued, within the framework of NATO and the Zrínyi National Defence and Armed Forces Development Program.
- The necessary regulatory measures to remove obsolete or non-frequency-efficient technologies should be taken, if the conditions are met.

[3] During the strategy's implementation period, the Authority does not plan to make additional spectrum (in addition to that already in use) available to market participants below 1 GHz.

- Expert material on the frequency award and usage evaluation model required for the early introduction of innovative technologies, and, if necessary, draft legislation, should be prepared.
- The necessary legislation must be developed and amended in order to establish the national legal background of radio frequency countermeasures required for the performance of the tasks arising from the basic purpose of non-civil frequency users.
- National legislation promoting the harmonization of the use of radio spectrum by electronic communication networks and services needs to be drafted.
- In the framework of supporting international working groups, Hungary hosts meetings.
- Consultations and professional events should be held with market participants and other stakeholders.
- For educational purposes and in order to develop consumer awareness, communication campaigns should be held, especially in order to present the changes caused by the rapid development of mobile technology, the factual data available on the impact of spectrum use on health, and the results of our measurements.
- Harmonized annual measurement plans should be developed.
- The new measurement laboratory should be handed over.
- Scholarship and internship programs should be continued.
- FMS (and eKFGH) development goals should be set each year according to the planning deadline and incorporated into the financial plans.
- The STIR development goals should be set each year according to the planning deadline and incorporated into the financial plans.
- Measurement capabilities must be expanded, and an application that helps determining the exposure to electromagnetic radiation needs to be developed.
- A competitive procedure has to be prepared for the 32 GHz band.
- Spectrum usage efficiency indicators based on ITU recommendation should be examined in a national environment to evaluate different types of systems.
- On-demand measurements and interference tests shall be provided for SRD and mobile network applications.
- On-demand measurements and interference tests shall be provided for mobile network applications and other applications operating in the 700 MHz band.

For the detailed target system see point 12.

2.3. Schedule of planned frequency awards during the strategy's implementation period

Table Table 21 summarizes the awards of frequency bands planned during the implementation period, together with relevant scheduling data.

Table 21 Spectrum award schedule

Radio spectrum award schedule	900 MHz band	1800 MHz band	1500 MHz band	2300 MHz band	26 GHz band	32 GHz band
NFFF (current/planned) provisions	Annex 3 point 3.4	Annex 3 point 3.8	Annex 3 point 3.7	Annex 3 points 7 and 9	Annex 3 point 2.11	Annex 3 point 2.13
Distribution method	competitive procedure	competitive procedure	competitive procedure	competitive procedure	competitive procedure	competitive procedure
Available bands	880-915/ 925-960 MHz	1710-1885/ 1805-1880 MHz	1427-1517 MHz	2300-2370 MHz	24.25-27.5 GHz	31.8-33.4 GHz
Possible band use (applications)	MFCN, SUL	MFCN, SUL	MFCN-SDL	MFCN/PMSE	MFCN	digital PP, PMP
Band availability (reserved bands)	880-915/ 925-960 MHz	1710-1885/ 1805-1880 MHz			24.5-26.5 GHz	
EU obligation	2011/251/EU, (EU) 2018/637	2011/251/EU, (EU) 2018/637	(EU) 2015/750, (EU) 2018/661	There is no harmonized EU rule ECC/DEC/(14)02	Implementing Decision 2019/784/EU	there is no harmonized EU rule ERC/REC/(01)02
Technologies that can be used	GSM, UMTS, WIMAX, LTE Technology-neutral regulation development is in progress	GSM, UMTS, WIMAX, LTE Technology-neutral regulation development is in progress	Technology-neutral regulation	Technology-neutral regulation	Technology-neutral regulation	Fixed PP, PMP
Market demands assessment	13.12.2019	13.12.2019	13.12.2019	13.12.2019	13.12.2019	13.12.2019
Opening date	08.04.2022	08.04.2022			Draft: 2024	Draft: 2022
Date of award	Q1 of 2021	Q1 of 2021	After 2023	After 2023	Draft: 2022	Draft: 2021

3. Spectrum management tasks

Spectrum management plays an important role in the functioning and development of infocommunications and numerous other sectors (e.g. transport, healthcare, energy) as well. Under the Electronic Communications Act (effective from 21 December 2020 according to the Codex) and in line with Government policy, all management activities pertaining to the radio spectrum, from legislation to ensuring the conditions of interference-free operation, are to be carried out by the NMHH, which includes national and international radio spectrum management for electromagnetic waves (radio waves) up to 3000 GHz.

In addition to the provision of radio spectrum required for mobile telephone services, the best-known area of spectrum management, the conditions of interference-free use for a number of other radio services, civil and non-civil radio applications, radiocommunications, radio astronomy and other non-radiocommunication applications (traffic safety, medical diagnostics, medical implants, etc.) must also be ensured.

As part of its management activities, NMHH

- ensures the operating conditions of radio services and applications and manages tens of thousands of radio licenses for civil and non-civil purposes;
- continuously strives to perform its tasks to a high professional standard and is represented in many international organizations and committees;
- keeps abreast of new technologies, international standards, recommendations, resolutions, decisions, and agreements, and evaluates their applicability in Hungary;
- drafts the technical and legal conditions and engages in compatibility assessment and theoretical spectrum planning;
- oversees compliance with the rules on band usage, and cooperates in planning and preparing the launch of new and the phase-out of old technologies;
- performs continuous radio spectrum monitoring, and works toward monitoring and eliminating interference;
- provides the conditions for the use of governmental and other non-civil band demands, and engages in radio licensing and registration, maintains planning reporting obligations;
- has the task of allocating bands and preparing the conditions of band use, as well as drafting and continuously updating relevant legislation and other decrees pertaining to radio spectrum fees and spectrum management;
- performs official tasks related to secondary trade and rearranging bands;
- prepares, concludes, maintains and performs the coordination contracts and border zone agreements at both national and international levels;
- internationally coordinates radio stations and satellite systems;
- carries out radio spectrum competitive procedures by exercising state ownership.

4. Spectrum management framework

In accordance with EU regulations and resolutions passed at the WRC-19[4] the spectrum demands of mobile services, especially the 5G networks, must be met

- The radio spectrum necessary for mobile services and for the continuing dynamic development of mobile broadband services must be ensured, and during the reuse of expired spectrum parts, ensuring technology-neutral conditions of use shall be sought.
- Preparations must be started in due course and relevant tasks must be executed to enable the use of the 24.25-27.5 GHz frequency band for mobile (5G) purposes.
- Provision must be made for the use of the 32 GHz frequency band for fixed point-to-point and point-to-multipoint applications, and the necessary regulatory steps must be taken to migrate the 26 GHz band applications to be used for MFCN purposes.

Developments in Hungary's wireless telecommunication infrastructure and a rising level of innovation must be encouraged

- The implementation of the spectrum strategy must facilitate the country's rapid and continuous development in infocommunications.
- Complex awards models and mechanisms must be deployed to facilitate the early adaptation of the latest technologies, and efficient spectrum use must be promoted.
- The gradual phase-out of outdated and inefficient wireless technologies (e.g. 3G) must be encouraged.
- Fair market competition must be strengthened with the use of publicly accessible databases and enhanced transparency.
- By enhancing metrological activities and increasing transparency, tangible improvements in service quality must be facilitated.

Demands of narrow and broadband PPDR applications must be prepared for and met

- Spectrum demands required for the operation and development of PPDR applications must be met
- The conditions of uninterrupted operation of narrow-band PPDR systems must be fulfilled

Key regulatory frameworks for modern spectrum management must be provided

- Regulations facilitating an efficient radio spectrum use must be continuously updated, the conditions of operation must be improved and efficient operation must be ensured
- The legislative framework and conditions pertaining to spectrum management must be drafted and their high standard must be maintained

[4] World Radiocommunication Conference 2019, Sharm El Sheikh, 28.10.2019 - 22.11.2019

- Harmonization tasks relating to spectrum management must be performed to a high standard
- The early adoption of advanced innovative technologies must be encouraged and the utilization of their outcomes facilitated, while keeping a constant eye on benefits and striving to recognize and leverage new possibilities

Spectrum use free from harmful interference must be ensured

- As the primary objective, use of the radio spectrum must be available without being subjected to or causing interference
- With adequate regulations and careful planning, continuous development of measurement capabilities, measurements related to spectrum management must be continuously developed, with technological developments supporting spectrum management we must focus on the technological development in order to solve metrological tasks in a modern, professional and efficient way
- The new measurement laboratory needs to be put into operation and used to provide the most advanced measurement capabilities
- The use of modern, interference-proof technologies and devices ensuring interference-free operation must be encouraged.
- Efficient monitoring tools must be applied
- The possibility of interference-free use should also be promoted through a high level of international coordination

Spectrum-related management with ever-increasing efficiency must be ensured

- The institutional framework of spectrum management must be strengthened and made more resilient and more open towards users, consumers and the industry as a whole
- Communication tasks relating to spectrum management must be performed to a high standard
- The reputation and high quality of spectrum management must be retained both in and outside Hungary
- Management of the country's frequency assets requires a great degree of planning and calculation, as well as flexibility
- Reputation must be enhanced by increasing responsibilities and focusing on active participation both in Hungary and abroad
- By improving IT support, efforts must be continuously made to simplify and rationalize management processes
- Management must be made more open by involving market players and other entities, keeping them informed, and engaging in dialogue and active work relations
- In order to perform national and international tasks to a high standard, it is necessary to ensure the availability of sufficient specialists (scholarship program, succession planning, training)
- Ample spectrum must be made available to meet the continuously changing social and economic spectrum demands

- Available unused spectra must be assigned to market or non-market users who are capable of creating the greatest value for society
- A sparing spectrum use must be encouraged
- Unused and unallocated bands must be assigned according to a timetable, the award schedule of frequency assets must be prepared and kept updated on a continuous basis
- The use of unused but distributed bands must be strengthened on the secondary spectrum market by sanctions (or ultimately, by forced trade)
- The possibilities for new and innovative award solutions must be assessed
- Demands for frequencies on the medium and long term must be recognized in time
- International agreements promoting national interests and facilitating national use must be advocated, drafted and concluded.

5. International and national development of the economic and social environment

5.1. ICT and competitiveness

According to the World Economic Forum (WEF) and the International Telecommunication Union (ITU), a country's competitiveness correlates with the country's information and communication technology (ICT) development. Surveys show that countries with the highest global competitiveness indicators are also well represented in the field of ICT development, and vice versa: digitally more developed countries tend to be more competitive.

The impact of horizontal technologies and solutions for the transmission, processing and interpretation of large amounts of data generated by digitalization (e.g. IoT, 5G, Big Data, Artificial Intelligence applications, etc.) also extends to all sectors of the economy and public administration.

The main goal of the spectrum strategy in this situation may be to ensure, through responsible spectrum management, that the availability and usability of the limited resource is not a bottleneck for the development of the digital ecosystem, either in the short or medium term.

5.2. Global trends

Digital devices and services already extend to all subsystems of the economy and society, and based on the trends of recent years, we have every reason to assume that the digital transformation is irreversible and unstoppable.

While the size of the digital economy is increasingly outpacing the ICT sector, statistical recording remains a sectoral approach; therefore, in lack of a better measurement tool, the performance of the ICT sector (ICT manufacturing and ICT services) can be used to estimate the economic weight of digitalization. There are no exact methods for measuring the

difference between the digital economy and the ICT sector, but the examples in some studies[5] show the proportions and directions well:

- **automotive industry**: the value/market of integrated circuits in cars already exceeded USD 20 billion in 2016 and is expected to grow by 10% per year by 2025, which also assumes a proportional increase in the ICT capabilities of vehicle manufacturing for the installation and programming of integrated circuits;
- analysts also expect ICT tools and services used in **agriculture** to grow by more than 10% per year by 2025;
- a similar degree of digital transformation is taking place **in the financial sector**, **transport**, **logistics**, **energetics** or construction industry, and international research indicates that an increasing proportion of the companies involved carry out digital developments in the form of "insourcing" (i.e. with their own employees), which further increases the latency of the digital economy.

The rapid expansion of real-time data generated by IoT devices (**Big Data**) makes the use of Artificial Intelligence (AI) necessary to make the right decisions in real or near real time by processing information[6]. The development of artificial intelligence is expected to gain momentum in the next years: the increase in computing capacity, the availability of low latency data transmission with the development of 5G networks, the proliferation of sensors and the increase in the amount of data transferred with them will accelerate the development of artificial intelligence applications.

5.3. The international situation of the digital ecosystem

Many international organizations, institutions and market players publish various data sets, indices and research analyses on the global, regional and country development of digitalization, as well as its individual components:

- **Worldwide indicator systems** (such as UN, OECD, World Bank, ITU indicators and comparisons, or surveys by Forrester, IDC, Gartner or McKinsey)
- **Indicator systems** for a specific geopolitical **regional unit** (such as indicator and measurement systems developed and harmonised by the EU: DESI, DSI, CCS, etc.)
- **Indicator systems for a specific country** (these are mostly produced by the Hungarian Central Statistical Office (CSO) for Hungary, but many market players are active in this field as well).

The complex indicator system for EU countries is the Digital Economy and Society Index (DESI)[7]. DESI examines the digital development of member countries along five different dimensions.

According to the 2019 survey, high-speed internet coverage in the EU covers 83% of the households (2018: 79%), which in 2020, exceeding the EU average (86%), reached 90% in Hungary. 4G coverage is almost complete (97%) and has improved, especially in rural areas,

[5] *The weight of the digital economy in the Hungarian national economy (IVSz, 2019)*

[6] AI is the application and simulation of human intelligence's learning (information collection, systematization and use), reasoning (application of rules) and self-correction processes by computer systems. The most developed application areas of AI so far are expert systems, speech recognition and machine vision.

[7] https://ec.europa.eu/digital-single-market/en/scoreboard/hungary -

although there are significant differences in quality. Mobile broadband subscriptions are the fastest growing segment of the entire Internet access market, and today more than 70% of active SIM cards use mobile Internet.

DESI monitors the member states' readiness for 5G deployment through a five-dimensional "5G Scoreboard", examining whether each country has a 5G strategy, whether there are pilots and tests already available, how many cities have 5G service available, to what extent is the 5G spectrum distributed, and whether 5G "corridors" have been set up on international motorways to ensure 5G-supported transport of connected and autonomous vehicles. Although in the first half of 2019 Hungary was not lagging behind at the regional level, it was already behind the EU member states. Today, however, there are minor delays at the regional level as well.

5.4. Hungarian digital ecosystem

The national situation of digitalization is characterized by a special duality: while the weight of the digital economy in the national economy is already above the average, the use of digital devices and services by citizens and businesses lags far behind the EU average.

While, mainly due to the high share of exports, the digital economy also represents a high proportion of the Hungarian national economy in international comparison, the Hungarian digital ecosystem performs worse than the EU average according to international comparative analyses and statistics. Hungary ranks 21st out of 28 EU member states in the Digital Economy and Society Index (DESI) 2020. In the overall ranking, Hungary has advanced two places last year. This is due to the fact that Hungary performs better in the first (connectivity) and second (human capital) dimensions of the DESI than in the entire DESI, we moved to the 7th place in the connectivity dimension in 2020. In the third dimension (use of internet services) Hungary is close to the EU average, and in the fourth (integration of digital technology) and fifth (digital public services) dimensions it is well below the average. Hungary is in third place regarding the 5G readiness indicator with 61%. In Hungary, 49% of the 2090 MHz spectrum harmonised at EU level for wireless broadband has been allocated.

Both Hungary's relative position in each dimension and the good position in the "Connectivity" dimension suggest that the strongest element of the Hungarian digital ecosystem is the digital infrastructure, including the so-called super-fast and high-speed broadband coverage and the proportion of households using these services, as well as the 4G coverage and 5G readiness.

6. Strategic environment

The NMHH's radio spectrum strategy should be in line with other guiding national and international documents and strategies. On the one hand, it can be seen as the continuation of previous strategies, and on the other hand, its objectives are in line with current strategies. Accordingly, the radio spectrum strategy is aligned with several strategies and guidance documents.

Among these, the most substantial strategic documents in terms of spectrum management are the ITU Strategic Plan 2020-2023, ITU-R SM. Report no. 2015-1 on methods for determining long-term national strategies for spectrum use, Radio Spectrum Policy

Programme (RSPP)[8], RSPG Work Programme, “Connectivity for a Competitive Digital Single Market - Towards a European Gigabit Society” (Commission Communication)[9], 5G Action Plan (Commission Communication) [10] , Digital Agenda for Europe [11] , Digital Nation Development Program (DNFP), Digital Welfare Program (DJP), Hungary’s Electronic Communications Policy, NMHH Strategy 2018-2022, NMHH Spectrum Strategy 2016-2020, National Digitalization Strategy (NDS) [12] , Hungary’s position on the latest European strategies.

6.1. Relationship between spectrum management objectives and strategies

The relationship between the objectives of spectrum management and the dominant international and national strategic environment is shown in Table Table 61.

[8] It is important to note that in the light of the European Electronic Communications Code, a full review of the RSPP is needed, which is also included in the RSPG work plan and the Commission has announced its review plans.
[9] https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:52016DC0587&from=hu
[10] https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:52016DC0588&from=hu
[11] https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:52010DC0245&from=hu
[12] The draft of the new infocommunication framework strategy, NDS, which replaces the 2014 National Infocommunication Strategy, has been completed. It was not yet adopted by the Government at the time of the strategy development. https://2015-2019.kormany.hu/download/f/58/d1000/NDS.pdf

Table 61: Basic goals of the radio spectrum strategy in the context of social and national requirements

The basic goals of spectrum management until 2025	International	EU				National		
	ITU Strategy	Gigabit Strategy[13]	5G Act. Plan[14]	CEF2-Digital[15]	RSPG WP[16]	NDS[17]	MEHP[18]	NMHH Strategy
1. Flexible provision of the availability and use of radio spectrum necessary for the continuous development of mobile services, promotion of efficient use	✓	✓	✓	✓	✓	✓	✓	✓
2. Ensuring the availability of radio spectrum required for audio-visual and sound broadcasting, the continuous development and digitalization of broadcasting in line with the demands expected.	✓					✓		✓
3. Continuous satisfaction of frequency demands of priority terrestrial applications					✓		✓	
4. Meeting the frequency demands of satellite services/applications in line with the National Space Strategy	✓					✓	✓	✓
5. For primarily governmental and PPDR applications, facilitating the efficient use of spectrum and meeting the frequency demands for its operation and development			✓				✓	
6. Meeting the frequency demands for the development of non-civil radio communications							✓	
7. Supporting the early introduction of modern, innovative technologies, facilitating the phasing-out of obsolete technologies (for users)	✓	✓		✓		✓	✓	✓
8. Supporting the early introduction of modern, innovative technologies, facilitating the phasing-out of obsolete technologies (for legislation)					✓	✓		✓
9. Drafting and maintaining the legislative framework and conditions pertaining to spectrum management to a high standard					✓			
10. Ensuring high quality harmonization tasks in the field of spectrum management	✓			✓	✓			
11. Ensuring high quality communication tasks in the field of spectrum management	✓				✓	✓		✓
12. Keeping abreast of technological development with measurement activities facilitating spectrum management							✓	

[13] https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:52016DC0587&from=HU
[14] European Union's 5G Action Plan
[15] Connecting Europe Facility (CEF2) Digital programme of the European Union
[16] RSPG Work Programme
[17] Draft of the National Digitalization Strategy, https://2015-2019.kormany.hu/download/f/58/d1000/NDS.pdf
[18] Electronic Communications Policy of Hungary

13. The institutional framework of spectrum management must be made more flexible, stronger, more open to users, consumers, and the industry, and its national and international recognition and high standard must be preserved.			19			✓	✓	✓
14. Continuous and precise service of spectrum use and meeting the current spectrum demand at the highest level	✓		✓		✓		✓	✓
15. Making available ample spectrum to meet the continuously changing social and economic spectrum demands	✓	✓	✓	✓	✓		✓	✓
16. Ensuring quality radio spectrum use without being subjected to or causing harmful interference, and performing the tasks related to radio frequency countermeasures from non-civil users to a high standard							✓	
17. Improving the operating conditions of the solutions promoting the efficient use of the radio spectrum, ensuring its continuous operation		✓	✓				✓	

7. Legal and institutional environment

7.1. Legislative environment

In the context of changes in international frequency regulation, the following are particularly important and serve as a starting point for strategy making:

- Constitution and Convention of ITU
- International Radio Regulations
- The outcome documents of the World Radiocommunication Conferences (WRCs, most recently WRC-19)
- Documents of Regional Radiocommunication Conferences (most recently RRC-06)
- ITU-R recommendations
- EU legal acts, including EU Council, Commission and Parliament regulations, directives, decisions
- The CEPT ECC decisions, reports and recommendations
- Agreements signed at CEPT meetings.

Documents containing other relevant considerations:

- international coordination agreements
- materials from other international organizations (e.g. NATO, ICAO, Danube Commission, RAINWAT [19] , UIC, WHO, EBU, WorldDAB Forum, etc.) concerning frequency regulation.

One of the key outcomes of the WRC-19 meeting, which was closed on 22 November 2019, was an agreement reached on the identification of additional radio spectrum that could be used for IMT-2020 (5G mobile), while protecting the other services concerned. In addition, a number of decisions have been made on, among others, the regulation of geostationary and non-geostationary satellite systems, including orbital use, broadcasting and positioning services; high-altitude platforms (HAPS), rail and (intelligent) road communication systems.

The agenda for WRC-23 was adopted. This includes a review of the use of the E-band (80 GHz); examination of communications from Earth stations in motion (ESIM); high-altitude platform as IMT base stations (HIBS): use of the same frequency bands as terrestrial IMT base stations on HAPS for extended mobile broadband to underserved communities and remote areas; testing of aeronautical mobile applications; review of the Global Maritime Distress and Safety System (GMDSS); additional frequency assignments for IMT; reviewing the use of the 470-960 MHz (UHF) band.

With regard to the changes in the European regulatory framework, it is paramount that the **Code**, replacing the previously dominant regulatory framework for electronic communications at European level, entered into force on 20 December 2018, which Code is of key importance for the definition of a general European regulatory framework for radio spectrum. The member states have to implement the Code into their national law by adopting and promulgating the laws, regulations and administrative provisions necessary to comply with the Code **until 21 December 2020**.

[19] Regional Arrangement on the Radiocommunication Service for Inland Waterways

They shall communicate the text of those provisions to the Commission. The professional preparatory work for the implementation of the rules of the Code was started by the NMHH in 2019, the provisions corresponding to the above of the Electronic Communications Act shall enter into force on 21 December 2020.

The legal background of the Hungarian frequency management underwent a significant structural transformation in 2015 and, as a result of several years of preparatory process, the rules for the allocation and use of frequency bands have appeared in legislation (NFFF[20]). In addition to the Electronic Communications Act and the NFFF, the important national legislation governing radio spectrum management is as follows:

- NMHH Decree No. 1/2011 (III. 31.) on frequency reservation and usage fees;
- NMHH Decree No. 4/2011 (X. 6.) (Ápszr.) on the rules of auction or tender for obtaining entitlements to frequency use;
- NMHH Decree No. 7/2017 (VII. 28.) on radio equipment in the field of non-civil frequency management;
- NMHH Decree No. 11/2011 (XII. 16.) on certain official procedures for non-civil frequency management;
- NMHH Decree No. 12/2011 (XII. 16.) on the order of non-civil frequency management and on the organizations belonging to the scope of non-civil frequency management;
- NMHH Decree No. 7/2012 (I. 26.) (Pfgr.) on certain official procedures of civil frequency management;
- NMHH Decree No. 7/2013 (IX. 19.) on the secondary trade of radio frequencies;
- NMHH Decree No. 15/2013 (IX. 25.) on the amateur radio service.

7.2. Institutional environment

ITU has been operating along with United Nations for more than 150 years, with the task of facilitating international telecommunications cooperation. Act XLV of 2011 contains the consolidated version of the Constitution and Convention of the International Telecommunication Union, signed at the 1992 Additional Plenipotentiary Conference of Geneva, amended by the 1994 Kyoto, 1998 Minneapolis, 2002 Marrakesh and 2006 Antalya Plenipotentiary Conferences, and the text of the Optional Protocol of the International Telecommunication Association, promulgated by law, signed at the 1992 Additional Plenipotentiary Conference of Geneva, effective from 28 September 2011.

The European Conference of Postal and Telecommunications Administrations (CEPT) is a regional body of the ITU. Today, the number of members is 48. The CEPT's activities include cooperation on commercial, operational, regulatory and technical standardization issues. The basic aim of the CEPT is to strengthen relations between its members, to promote their cooperation and to help create a dynamic market in European postal and electronic communications. The CEPT Electronic Communications Committee (ECC) and its working groups will examine and develop policies for electronic communications activities in a European context, taking into account European and international laws and regulations in an efficient and transparent manner.

[20] NMHH Decree No. 7/2015 (XI.13.) on national frequency allocation and rules for the use of frequency bands

The European Telecommunications Standards Institute (ETSI) is a non-profit organization tasked with developing telecommunication industry standards for the long-term development of the ICT sector in Europe and beyond. The ETSI's scope of members is very diverse, from large and small companies from Europe and other continents of the world, to other stakeholders such as administrations (governmental and other public bodies), IT-, communications providers, manufacturers, research institutes and users. The Commission recognizes ETSI as an official European standards organization.

The North Atlantic Treaty Organization (NATO) was established in 1949 as a military alliance to preserve the freedom and security of its member states, and Hungary has been a member since 1999. The body responsible for the use of radio spectrum for allied purposes in NATO is the Civil/Military Spectrum Capability Panel (CaP3), which is an advisory and decision-making body responsible for the exclusive performance of radio spectrum management tasks. It supports the Military Committee (MC) and the cross-disciplinary C3[21] Board, which is responsible for policy issues, in meeting the radio spectrum needs of allied operations during states of emergency, in times of peace, crisis, and war.

At present, the regulation of radio spectrum in the 27 member states of the European Union is defined and affected by the following organizations within the EU's institutional system:

- European Parliament (EP)
- European Council[22] (EUCO)
- European Commission (EC)
- Body of European Regulators for Electronic Communications (BEREC)
- Communications Committee (CoCom)
- Radiospectrum Committee (RSC)
- Radiospectrum Policy Group (RSPG).

In the field of electronic communications, the independent regulatory authority of Hungary is the NMHH, which received its mandate directly from the highest legislative body, the Parliament. The NMHH is an independent regulatory body with national competence, which is subordinated exclusively to the law and is obliged to annually report on its activities to the Parliament. NMHH monitors and regulates the operation of the media, electronic communications and postal services markets in an unbiased and professional manner. The bodies of NMHH with autonomous power are: the President of the National Media and Infocommunications Authority, the Media Council of the National Media and Infocommunications Authority and the Office of the National Media and Infocommunications Authority.

The Office of NMHH is responsible for the performance of spectrum management tasks for civil and non-civil purposes, and for the creation of their spectrum management interests and harmony.

[21] Consultation, Command and Control

[22] Its members are the Heads of State or Government of the member states, the President of the European Council and the President of the European Commission

8. Radio spectrum user environment

8.1. Civil frequency use

There are currently 4 mobile network operators (MNOs) operating in Hungary with their own infrastructure that provide public services. A fifth operator (at 450 MHz) has been granted entitlement to frequency use until 2024 and is currently able to use the available resource primarily for government purposes. The commercial role of the network is not yet significant; however, it is suitable for supporting infrastructure applications (especially digitalization processes involving such infrastructures, data communication needs of energetics and smart metering systems and other public service subtasks to be served by such infrastructures, operation of such infrastructures). The networks with GSM-GPRS technology (mostly referred to as 2G) are no longer substantially supported by the three major MNOs; however, DIGI Kft. is also building a 2G network in addition to the LTE technology service (mostly referred to as 4G) in order to ensure uninterrupted voice calls. Vodafone Magyarország Zrt. currently operates 5G NSA technology in its network. At the time of the launching on 7 October 2019, 33 base stations were operating in Budapest, in districts V, VIII and IX[23]. Following the acquisition of the 3.6 GHz frequency usage license, Magyar Telekom Nyrt. has launched its 5G service in Budapest and Zalaegerszeg on 9 April 2020. Magyar Telekom Nyrt. mostly builds on its existing LTE network (5G NSA) and 5G test network, while the number of Vodafone Magyarország Zrt.'s 5G stations has not changed[24]. All national service providers have also set up test networks or test stations[25]. As of 30 September 2020, DIGI Kft. operates one 5G base station (which was activated on 18 November 2019). The construction of small-cell network components is not yet in progress anywhere.

The number of activated SIM cards and SIM cards using cellular data that allow access to mobile phone and/or mobile internet service has not changed significantly in recent years. The number of activated SIM cards per 100 inhabitants for the entire national population was 117 at the end of the period. There is a significant difference in the average monthly data consumption per SIM card between the two subscription types, with a post-paid subscription handling more than ten times as much call traffic as a pre-paid subscription. [26]With the emergence of VoLTE-enabled devices and the launch of VoLTE by all four operators, voice calls are being increasingly diverted from the 3G network to the 4G network, with nearly 40 percent of call traffic already taking place over the LTE network. 3G's share has fallen from four-fifths to one half since 2017.

The Authority is fulfilling its obligation under Article 54 of the Code and will take all necessary measures to facilitate the deployment of 5G by 31 December 2020.

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[23] Stations operating at 3.5 GHz provide outdoor coverage. The peak rate available is around 2 Gbps, with an average rate of 500-600 Mbps. Currently, another 100-250 base stations are being installed, focusing primarily on Budapest as a service area.

[24] Source: https://www.hwsw.hu/hirek/61642/magyar-telekom-5g-kereskedelmi-halozat-budapest-zalaegerszeg-ericsson.html

[25] Regarding the specific measurement data, a data rate of 1.5 Gbps could be achieved on the Magyar Telekom test network, while the delay remained below 10 ms. An experimental device (64x64 MIMO) was also able to achieve a data rate of 4.9 Gbps in 100 MHz bandwidth **Hiba! A hivatkozási forrás nem található.**.

[26] Source: "The National Media and Infocommunications Authority's Mobile Market Report" published on 23 November 2020 (https://nmhh.hu/dokumentum/216281/NMHH_mobilpiaci_jelentes_2015Q42020Q2.pdf).

At the auction held on 26 March 2020, Hungarian Telekom Nyrt. won 10 MHz twice in the 700 MHz band, 10 MHz twice in the 2100 MHz band, and 120 MHz in the 3600 MHz band. Telenor Hungary Zrt. acquired 5 MHz twice in the 700 MHz band, did not acquire a frequency in the 2100 MHz band, and bid successfully for 140 MHz in the 3600 MHz band. Vodafone Hungary Zrt. acquired 10 MHz twice in the 700 MHz band, 5 MHz twice in the 2100 MHz band, and 50 MHz in the 3600 MHz band. No service provider submitted a bid in the 2600 MHz band. The acquired entitlements to frequency use expire uniformly in 2035. These entitlements can be extended once for a period of 5 years without a competitive procedure and without the payment of another one-time fee. The NMHH encourages service providers with a discount from the radio spectrum fee to install 5G in places that are important not only from a market perspective to them, but also socially, such as e.g. the area of hospitals, universities, or major transportation routes.

Most of the entitlements to frequency use for the 900/1800 MHz bands expire in April 2022 and, taking into account the EU regulations, the entitlements to frequency use for the bands can be obtained through a competitive procedure for 15+5 years. The entitlements to frequency use acquired in 2014 expire in 2029 and 2034, respectively. The 900/1800 MHz band is currently in intensive use and will continue to be so, even after the prospectively justified shutdown of 3G, and its future use will depend on the rise of 5G. The competitive procedure will be completed in the first quarter of 2021 on the basis of preliminary plans. Documentation of the auction procedure already in progress at the time of the strategy development is available on the NMHH website[27].

In the 450 MHz frequency band, by means of a competitive procedure, MVM NET Zrt. built a network primarily for government purposes that also meets the demands of group communication and electronic communications services. The network has nationwide coverage, its utilization is not significant yet, regarding, among other things, the current status of the energy smart metering projects originally planned as the main application. The otherwise possible use for PPDR purposes has not been made because the Ministry of Interior has not yet made a decision on the use for such purposes.

Phase 1 of the GSM-R network, which implements the development of the GSM-R network, was finally completed in the spring of 2020 for the deadlines modified several times, Phase 2 of the project (“GSM-R2”) has started, and construction will remain on the agenda during the strategy’s implementation period. The national GSM-R systems currently under construction will certainly not be replaced during the strategy’s implementation period, until 2025, and its operation is also an obligation imposed by the EU.

The “PMR-like” use of 5G for private networking may be attractive to vertical representatives in the interference-free spectrum with guaranteed and better quality and lower latency (industrial IoT, URLLC in 3GPP Rel-16) than Wi-Fi networks. For example, in the case of vehicle manufacturing or industrial plants, private networks may be characterized by a well-defined geographical location and typically being within a building, and in agriculture by a larger area and outdoors. In the case of modern factories, adaptive, reconfigurable solutions play an important role. For wired connections, this would involve regular and costly cable retrofitting work, which can be eliminated by the 5G system’s wireless connections.

27

https://nmhh.hu/cikk/214650/A_900_MHzes_valamint_az_1800_MHzes_frekvenciasav_frekvenciahasznalati_jogosultsagaira_kiirt_arveres_dokumentumai

Terrestrial television broadcasting has lately been on a steady decline as far as available frequencies are concerned. After the analogue switch-off and the DD1 clearance, until September 2020, broadcasting in Hungary was also terminated in the 694–790 MHz (DD2) band. In broadcasting, Antenna Hungária Zrt. has been granted the entitlement to operating nationwide digital terrestrial television broadcasting networks for 12 years, based on which it is entitled to operate a broadcasting network with DVB-T/T2 technology in the 470-694 MHz frequency band until 6 September 2032. Looking further ahead, the further use of the 470-960 MHz band will be examined at the WRC-23 meeting and the broadcasting and mobile service demands of the band will be assessed for this meeting.

Based on the November 2019 data, in the distribution of television platforms, wired platforms are dominant: out of a total of 3,391,647 subscriptions, there are 2,579,299 wired (76%), 725,253 satellite (21.4%) and 87,095 terrestrial (2.6%) ones. Usage is constantly shifting into the direction of wired platform at the expense of the other two. It should be noted that the terrestrial platform does not include free services, only subscription services in these statistics.

Regarding sound broadcasting, in the band 174-230 MHz (VHF III.) until 5 September 2020, Antenna Hungária Zrt. operated a multiplex system T-DAB (DAB+) service in Budapest and its agglomeration, where it operated a total of 3 transmitting stations. In terms of population, the coverage of the service was approximately 30%. In the medium-wave band (300-3000 kHz), blocks have been designated for several radio applications, of which the most significant block (526.5 – 1606.5 kHz) has been designated for terrestrial broadcasting. A total of 10 sites are currently broadcasting with analogue AM-DSB modulation in the designated band. Under the current NFFF, the band 87.5–108 MHz is designated for analogue FM sound broadcasting primarily, with no digital technology currently available.

In addition to the radio applications so far, the amateur radio service should also be mentioned. According to the current NFFF, with the exception of the VLF band, frequencies that can be used for amateur radio purposes have been designated in all bands, both on a primary and secondary basis.

WAS/RLAN[28] networks can operate in the 2.4 GHz license-exempt band, the 5 GHz frequency band, and the 57–66 GHz band for multi-gigabit indoor use[29], in all three bands on a tertiary basis.

Typically IEEE 802.11 compliant networks operate in the two widely used license-exempt bands (the 2400–2483 MHz band and the 5150–5350 MHz and 5470–5725 MHz bands). Devices use the 2.4 GHz band by default, which is therefore significantly oversaturated in many places, with individual end-user devices typically interfering with each other. The use of the 5 GHz band is also constantly increasing.

Wi-Fi networks have been built in recent years, almost as a public utility, and are being set up for welfare purposes both indoors and outdoors, with hot-spot coverage and for off-load use. In the license-exempt bands, key representatives of the verticals (e.g. car companies) do not want to operate a private network supporting production, although the technical solution may otherwise work, Magyar Telekom Nyrt. currently operates a

[28] Wireless Access Systems, Radio Local Area Networks

[29] The band can operate Wi-Fi (IEEE 802.1ad WiGig), WirelessHD, SRD devices, but also mobile backhaul application and data transfer between satellites.

60 GHz demo system, which could be operated on other license-exempt frequencies as well.

SRD[30] devices are short-range and low-performance, one- or two-way information transmission devices (such as remote controls, wireless microphones, car keys, wireless projectors, video cameras, or even medical devices, etc.). In terms of their operating frequency bands, they occupy the widest spectrum, but the most popular license-exempt frequency bands are the 2.4 GHz, 5 GHz and 433 MHz bands, so interference with SRD devices – and vice versa, the interference caused by them – can be significant in many cases. Among the SRD applications, intelligent transport systems have recently become outstanding. In addition to the above, the SRD band around 868 MHz is used for example to operate LPWAN (LoRa, SigFox) networks.

8.2. Non-civil frequency use

The scope of non-civil frequency users is defined in NMHH Decree No. 12/2011 (XII. 16.) on the order of non-civil frequency management and on the organizations belonging to the scope of non-civil frequency management. Pursuant to Section 1 of the Decree, the scope of the Decree extends to the following organizations:

- non-civil spectrum management organizations,
- NATO led forces operating in the territory or airspace of the country, as well as NATO member countries and military organizations of other states participating in the Partnership for Peace proclaimed in Act LXVII of 1995 (hereinafter collectively: NATO users)
- organizations that, based on a legal obligation or written cooperation agreement, are cooperating with organizations specified in Section 2 in performing public tasks, especially disaster relief and public safety tasks (hereinafter: cooperators).

Non-civil frequency users in these terms: military (the largest user), national security services, the internal crime prevention and detection body, the counter terrorism body, the general police body, the professional disaster relief body, the penitentiary organization, customs and investigation bodies of the National Tax and Customs Administration, the closed law enforcement network, the K-600/KTIR Communication and Information System and with regard to the unified digital radio communications system (hereinafter: EDR) the government communications service provider. In addition to the above, non-civil frequency users include the body of the Parliamentary Guard.

In the regulation of non-civil use, the NJFA[31], which has been in force since 13 July 2015 and is decisive regarding military, was included in the NFFF, only a few parts have not yet been adapted due to the traditions of national spectrum use. The NJFA is drafting NATO's peacetime spectrum demand in the allocation of radio service and frequency band, which has been approved by the North Atlantic Council after consultation with civil administrations. A review of the NJFA takes place after each WRC, so it is an important fact that WRC-19 did not affect the most important NATO harmonized bands under the NJFA.

The situation in the 225-400 MHz NATO UHF band has remained unchanged over the last decade. Currently, a digital PAMR system (EDR) with TETRA technology operates

[30] Short Range Devices
[31] NATO Joint Civil and /Military Frequency Agreement

in Hungary in the 380-385/390-395 MHz dedicated, non-civil part of the band, on which the communication of the Hungarian emergency response services is basically implemented (voice, narrowband PPDR application). At the same time, users of the EDR include sectoral critical infrastructure components and high-threshold hazardous plants, such as those required to use EDR in Government Decree No. 346/2010 (XII.28.), and large national public service providers entitled to use EDR on the basis of an individual ministerial permit. The system is operated by Pro-M Zrt. (a subsidiary of NISZ Zrt.), a governmental communications service provider, and supervised by the Ministry of Interior. The frequency use license (radio license) of the EDR system is valid until 2026. A decision on its fate needs to be prepared during the term of this spectrum strategy. During the preparation of this decision, it should also be considered that the preparation of the termination of TETRA will also be necessary during the strategy period. According to certain information, the support of the system is provided until 2035; however, this would be expected to be very costly by the end of the term. After the termination of the TETRA, the band is expected to become part of the NATO UHF band again, thus it could mean spectrum expansion for military use.

Where the cooperation between member states is weaker, EU-level regulation of the PPDR systems is a matter for security policy. Although the TETRA technology operating in Hungary is now obsolete, it is also used on an international level; its replacement could be the use of a commercial service or the building of a new system or a hybrid solution offering a combination of the two. Regarding the issue, Pro-M Zrt. as the operator of the current emergency response EDR network, a governmental communications service provider, has prepared a strategy for the period 2019-2025, some parts of which can be viewed on the company's website. According to the information on Pro-M's website, TETRA is supported until 2035. In addition, a model agreed with current emergency response network users is planned to be developed to provide broadband data service. Relying on the dual devices providing the TETRA service and the LTE capability at the same time, by building its own core network infrastructure and using the currently available commercial mobile infrastructures, Pro-M Zrt. intends to use a "hybrid" system until it is able to implement broadband transmission on its own state-owned mobile emergency response network covering its dedicated, complex (voice, data, image, video) emergency response service.

8.3. Development of the main frequency users' demands

8.3.1. Civil use

There are various demands from market players in connection with spectrum management. It was suggested that the remaining 4G coverage and other obligations should be harmonized by the authority with the 5G requirements, and that it should be possible to comply with the previous 4G requirements with 5G (that is, to meet technology neutrality). In connection with the regulation, one service provider indicated that it would be a significant help in network building if local government licensing and other procedures could be speeded up in some way. This would be particularly important in the construction of small cell systems, as many parties need to be consulted there. Another service provider is of the opinion that the FMC (convergence of fixed and mobile networks) trends in the gigabit world should be taken into account when shaping the regulation. Accordingly, efforts should be made to eliminate the separation between fixed and mobile services (this issue also arises in the case of co-investments covered by the Code as well).

It is important to mention that simultaneously with the spectrum strategy, NMHH's measurement service strategy is being prepared, which adapts to the former, and the measurement service is trying to adapt to this; the deadline is almost the same (end of 2020). However, the conditions for adaptation need to be defined. It is important that sufficient time is available for the measurement service when opening each frequency band or introducing new services. This is when it is necessary to develop EMC measurements and to prepare for the necessary new measurements (acquisition of equipment, development of procedures, etc.).

The issue of radio frequency countermeasures by regulatory organizations needs to be addressed separately, a number of pitfalls could evolve, the legal rights of radio spectrum users must be taken into account (for example, possible actions due to material and moral damage resulting from the restriction of the use of the acquired frequency band caused by radio frequency countermeasures). Radio frequency countermeasures against UAVs or interference with them when communicating with SRD devices are difficult to grasp, as interference protection is not provided in the case of tertiary use, almost any interference signal is possible.

Opinions on radio spectrum fee vary between market service providers depending on the nature of their service and the situation of the service provider. Generally, however, all service providers consider the radio spectrum fee to be high and seek to reduce them. In the opinion of the service providers, the fee reduction would also be necessary in order for Hungary to remain at the forefront of the service in international comparison.

With regard to the current use of the bands, mobile network operators have indicated that they need at least the same amount of spectrum and that band rearrangements should be minimized[32], because it jeopardizes the security of the service provision (i.e. mobile operators would retain both the amount of spectrum and the position). Settlement of the situation in the 900 MHz and 1800 MHz frequency bands is considered to be the most important (there are several reasons for this, such as the large number of non-VoLTE-capable mobile devices in use and the large number of 2G and 3G M2M devices). The issues of these bands will be resolved with the frequency award at the end of 2020 and in the first quarter of 2021. After providing their basic frequency bands used in the service, the usability of additional bands, such as 1427-1492 MHz and 2300-2370 MHz, will be examined.

The competitive procedure for the 3.6 GHz frequency band was successfully concluded with the decision published on 1 April 2020, the spectrum demands are presented in this chapter. Based on the current information, it cannot be stated that there is a general demand from verticals for independent spectrum use. From a technical point of view, the 5G capability requirement of verticals can be met without the use of spectrum dedicated to them. It should be examined whether, in different frequency bands (e.g. 26 GHz, 2300 MHz, 3.8-4.2 GHz), if local entitlements to frequency use can be granted to representatives of the verticals, if required later. Spectrum demand was mainly indicated by car factories, emphasizing that in Germany their parent companies, as verticals, have acquired entitlements to frequency use in

[32] According to the service provider, a change in the raster allocation in the 900 MHz band will be necessary, but, if possible, this should be done with as little frequency reallocation as possible. It is not recommended to create a situation in which an existing service provider has to leave the 900 MHz band (this has never happened in Europe before, it has only occurred in Turkmenistan, see https://eurasianet.org/turkmenistan-mts-packing-up-and-leaving-further-dampening-investor-climate) **Hiba! A hivatkozási forrás nem található.**.

the 3.7-3.8 GHz frequency band and are developing their 5G private network-based communication systems used in production accordingly.

Mobile network operators have indicated that many of their base stations are connected with microwave technology and in the 26 GHz band among these. For this reason, the migration from 26 GHz to 32 GHz should be a longer process. To facilitate the process, the 32 GHz band should be made available as soon as possible. However, it was noted that with the increase in 5G penetration, the demand for microwave bands will also increase.

According to service providers, the construction of fiber optic in the backhaul network will only take place in a few places, and microwave technology, such as the E-band, will continue to play a significant role. Maintaining the E-band is important for implementing high-speed connections. It is currently possible to build a link with a data rate of 10 Gbps, but as the technology continues to evolve, devices with a speed of 20 or even 50 Gbps are already starting to appear, which will be needed in the near future.

In the UHF television band, which is primarily designated for broadcasting, the demands between the broadcasting company and mobile network operators are contradictory: the broadcasting company wants to keep the spectrum available for as long as possible in order to maintain terrestrial broadcasting (this is provided until 2032); however, the craving of MFCN for spectrum seems insatiable. The issue may affect spectrum management after 2030, but there will be preparatory studies as early as 2025. Even cable TV providers have indicated that they expect terrestrial broadcasting in the long run, as terrestrial broadcasting is one possible source of certain television and radio channels (primarily public service broadcasts).

Secondary spectrum trading may play an increasing role, especially in the case of MFCN bands, but this will require that the interests of the supply and demand side meet in the future, as this has not been the case so far, with a few exceptions. In addition to the above, there were also difficulties in sharing the spectrum. An example of this is the fact that the competition authority procedure of the spectrum sharing agreement concluded between two national mobile network operators for the 800 MHz band was launched in 2015, but no decision was made on the matter by 2020. With the emergence of 5G, the number of lease agreements to meet vertical needs will also increase.

8.3.2. Non-civil use

In the field of non-civil spectrum management, significant developments are expected in the following important areas during the next years. In these areas, the necessary spectrum management steps must be identified with active participation and governance:

- tasks related to the development of BB-PPDR systems, joint management of the frequency bands 380-385/390-395 MHz (currently used by TETRA), 410-430 MHz, 450 MHz and 700 MHz
- there is a non-civil 5G demand in the upper 1 GHz band of 26 GHz, so consultations are needed on the use of 26 GHz, especially as a decision was taken at WRC-19 to identify the band for IMT2020 purposes; in the implementation of WRC-19 resolutions, the interests of non-civil bands should be taken into account, in order to preserve positions in accordance with the demands

- preparations must be done to handle and satisfy the spectrum demands arising within the framework of the Zrínyi National Defence and Armed Forces Development Program
- in the NFFF, some time-bound items need to be examined and updated
- the frequency bands suitable for 4.4-5 GHz and other broadband applications shall be maintained
- as full radar coverage is almost impossible due to complex topographical conditions, the protection system needs to be complemented by mobile radar stations and gap-filling radars.
- progress is needed on the regulation of interference devices that allow frequency band interference and radio frequency countermeasures (jammers) (also for GNSS, mobile and UAS jammers)
- the conditions for the use of UAS for governmental (non-military) purposes should be examined and their regulation should be initiated.

In the non-civil field, the measurement activity also needs to change. It is important to point out that the non-civil area works in a different work order than the civil area, which are thus not always compatible.

8.3.3. Overall vision of broadband uses and their impact on spectrum demands

Among the broadband uses, MFCN uses are worth highlighting. The growing spectrum demand of MFCN would be served primarily in the higher frequency bands, but due to the more expensive investments in parallel with the narrowing coverage possibilities, the lower frequency bands should also be given priority. However, with regard to the 5G use of the 470-694 MHz band, it should be noted that spectrum expansion is not necessarily the most important, the use of mobile edge computing (MEC) technology may be more important. MEC can increase efficient spectrum use by reducing the need for longer-distance data transmission and by relieving networks.

According to some service provider expectations, 2G systems are expected to be operational for another 10 years in most parts of Europe[33], and are expected to be phased out beyond the time horizon of the present strategy in 2029-2030. As early as the 2030s, it is expected that 6G[34] networks will also be operational, which may be able to emulate the line-switched operation of 2G systems. In order to reduce operating costs and complexity, service providers are interested in having as few different generations of technology running simultaneously as possible.

Among the broadband applications, the spectrum demand of 5G technology should be pointed out. At WRC-19, about 11 GHz of bandwidth was opened to Europe and designated for IMT-2020 in the higher frequency bands **Hiba! A hivatkozási forrás nem található.**. It will probably take years to complete it with services and tools.

The convergence of Wi-Fi and MFCN applications, as well as **the differences in spectrum demand between rural and urban areas and along transport routes** through higher frequency uses **are expected to become even more significant,**

[33] The survival of the 2G service is also supported by the publicly trusted SMS service, however, it is a best effort service. For example, one of the typical, globally used forms of multifactor authentication is SMS sending. Incidentally, this service is expected to persist in the longer term as the SMS service is also defined in 5G systems (3GPP TS 29.540).

[34] https://www.itu.int/en/ITU-T/focusgroups/net2030/Documents/White_Paper.pdf

reinforcing the need for geographically differentiated servicing and utilization of frequency demand.

9. Technological environment

9.1. Mobile and fixed service, broadband wireless transmission

9.1.1. MFCN technologies (2G – 5G)

With the principle of cost-efficiency in mind, mobile network operators strive to serve the needs of their customers with as little technology as possible. At the same time, only considering the current conditions in Hungary, it can be stated that there are currently four basic mobile technologies in operation (and their various additions and modes) from 2G to 5G systems.

The use of 2G systems is still significant in Hungary. Many M2M and critical applications are working, so it is not timely to phase out or replace the system.

2G systems are expected to continue to operate after 2025. The phasing out of 2G systems is not expected until the functions it performs can be taken over by another system, so the coverage of sparsely populated areas, the handling of emergency calls, etc. must be solved. The 2G service was launched by one of the market providers in 2018 because 4G VoLTE devices were not widely available and it was able to provide voice service with this system. From 2025, this service provider also expects the likely decrease of 2G services in Hungary and worldwide.

With regard to 3G mobile network technology, the most important strategic issue currently on the agenda is the phasing out of this technology. For the low operating costs, service providers are interested in operating as few technologies as possible at once and gradually phasing out old, less spectrum-efficient technologies. The current effort is to shift traffic to 4G and later 5G networks, as well as the gradual phasing out of 3G technologies.

According to studies of a service provider, the number of devices with 3G capabilities at most used in its own network is below 200,000 and is constantly declining. In line with this, 3G data traffic and voice traffic are also declining. On the 3G network, less than 5% of all data concepts are processed, while the share of 4G traffic is already 94%.

The development of LTE systems can be traced in the standard versions released by 3GPP. Starting with Release 8, each of the standard versions had a number of new features.

In most networks, the frequency bands used for LTE technology are 1800 MHz (band 3), 2600 MHz (band 7), and 800 MHz (band 20), in the order in which they are listed.

In Hungary, MVM NET Zrt. also operates an LTE system in the 450 MHz band. Frequency band obtained for use by MVM NET Zrt.: 450.0 MHz – 457.38 MHz (uplink) and 460.0 MHz – 467.38 MHz (downlink). However, the LTE Band 31 frequency bands standardized by 3GPP for LTE450 applications are: 452.5 MHz – 457.5 MHz (uplink) and 462.5 MHz – 467.5 MHz (downlink), so the band won by MVM Net Zrt. currently does not exactly match the Band 31 band defined in the 3GPP standard.

5G mobile networks currently operate in the 3.4-3.8 GHz band in Hungary, and from 6 September 2020 it became possible to use the 700 MHz frequency band for MFCN purposes. In one of the service providers' view, current 5G business models are focused on enterprise customers, and coverage and applications are expected to grow only slowly. Due to the relatively fast device replacements, the residential device stock is expected to be able to handle 5G in a significant amount within 20-24 months[35], which would require faster network deployment, but this is difficult to handle financially. In terms of network developments, a larger amount of equipment with 5G SA (Standalone) technology is expected to be available in practice by 2021, but the replacement of core networks will be a longer process.

In the case of the 3.8-4.2 GHz band, it was suggested in several forums that it could be allocated to verticals. There has been an initiative to this effect in the CEPT, but no such study is underway. It should be taken into account that although there is currently no mobile service provision in this band in Hungary, it does occur in other countries. So far, there has been no demand from potential users in the national environment. In terms of verticals, there is currently no consensus among individual potential users (e.g. car factories) on the use of the band.

In addition to the primary (pioneering) bands, the roll-out of 5G is also ensured in the 2100 MHz band, as technology neutrality is ensured here according to the regulations. In the 900/1800 MHz band, there is a CEPT mandate to examine the introduction of technology neutrality (here, for the time being, it is determined which technologies can be used). Once the relevant regulations have been amended, the use of the band for 5G purposes may be realized within 3 years. Following the expiration of the current 900/1800 MHz entitlements to frequency use, the new entitlements will be granted to the prospective holders in the first quarter of 2021 for 15+5 years as a result of the auction procedure launched on 16 October 2020, as required by the Code.

An important achievement of 5G mobile telecommunications systems is their ability to provide a number of significantly different services on a single platform, including mobile broadband services, virtual reality, autonomous driving and IoT solutions. The recurring individual and social communication demands seem to go beyond these, and as 5G systems may no longer be able to meet them, the development of a new sixth generation (6G) mobile technology has already begun. That is why ITU-T set up the Focus Group on Technologies for Network 2030[36] in the summer of 2018 to define network requirements for the next decade, including 6G technology. The working group completed its work in June 2020 and defined the requirements for 6G networks. Artificial intelligence and new technologies such as near-terahertz (sub-THz) and visible light communication, as well as the development of actual 3D network coverage[37] will play a major role in providing the background for services.

The already formulated technical requirements for 6G[38] are described in Table Table 9.1, which also provides a comparison with the 5G features.

[35] Due to the pandemic situation, the rotation speed of the device stock decreased in 2020, so it may take more than 24 months for 5G devices to become more widespread.

[36] https://www.itu.int/en/ITU-T/focusgroups/net2030/Pages/default.aspx

[37] In a cloud-based infrastructure, the technology can handle a variety of aerial access points, which include HAPS and UAV devices, but also LEO satellites in addition to terrestrial network access points.

[38] https://www.itu.int/pub/T-FG-NET2030-2020-SUB.G1

Table 9.1 Expected technical parameters of 5G and 6G mobile networks

KPI[39]	5G	6G
Traffic capacity	10 Mbps/m^2	~1-10 Gbps/m^3
DL data rate	20 Gbps	1 Tbps
UL data rate	10 Gbps	1 Tbps
Unified user experience	50 Mbps 2D everywhere	10 Gbps 3D everywhere
Latency (on radio interface)	1 ms	0.1 ms
Latency fluctuation (jitter)	not required	1 μs
Reliability (frame error rate)	10^{-5}	10^{-9}
Energy/bit	not required	1 pJ/bit
Positioning accuracy	10 cm in 2D	1 cm in 3D

Similarly to the former mobile network generations, the 3GPP works on the standardization of the 6G technology. The first significant studies related to the standard can be expected from 2023.

9.1.2. Additional MFCN technologies

The use of the supplemental downlink band is described in TS 36.101. It should be noted that in the 5G systems, only Band 75 and Band 76 bands (1427-1517 MHz) are marked for SDL technology, Band 67 (738-758 MHz) and Band 69 (2570-2620 MHz) are not. In the national environment, currently, there is no immediate demand for SDL frequency bands in the range of 1400-1500 MHz. According to one of the service providers, the award of 5G frequency bands as well as the resale of 900/1800 MHz should be awaited, and thereafter, depending on the development of demand, the issue of the use of the SDL band will be relevant in 2022-2023.

The 2300 MHz TDD band should be considered after the future of the “main bands” is settled. The amount of available spectrum in the band is adequate, but there is no demand for it yet, it is worth returning to its examination in 2022.

The technology of the Supplementary Uplink (SUL) is a new feature in 5G systems, however, the technology is not yet fully completed, and there are still many innovative proposals from the members of the 3GPP working group. The frequency bands that can be used for SUL are defined in the uplink range of the 700, 800, 900, 1800, and 2100 MHz bands, which are summarized in 3GPP TS 38.101 document.

In small cellular systems in a broader sense, the radius of a cell provided by a base station or access point can range from 10 meters to a few kilometers, but typically does not exceed a few hundred meters. These solutions were already present in the 2G systems, where higher user densities have been handled by a microcell arrangement instead of large-area macrocells. In case of LTE and 5G systems microcell, picocell, and femtocell, etc. applications are handled together as small cell applications. With their use, the large data traffic demand in a small area (e.g. in a crowded downtown, shopping centers, etc.) can be handled for both outdoor and indoor use.

Many of the issues related to supplementary technologies and special services belong to the communication systems used in vehicles. For eCall (and other) systems, the SIM cards used in vehicles are installed by the vehicle manufacturer, so they are

[39] Key Performance Indicator

foreign resident cards, which also increase the number of cards using data roaming in Hungary.

The issue of data roaming also arises in the case of the international transport of railway vehicles, where there is a mobile station installed in railway cars with Wi-Fi router function connected to the 5G network, which solves the indoor supply of the railway car and provides roaming service. Questions arise in connection with the operation of base stations belonging to the mobile network installed in railway cars, regarding regulations. Currently this issue is not yet solved in Hungary, but such devices have already been installed in some international trains.

9.2. Development trends and system techniques of GSO and NGSO satellite broadband systems

GSO and NGSO[40] satellite systems are spreading at a rapid pace, which may be alternatives to mobile services in some service areas. In case of low-orbit satellites it should be noted that the connection delay is not significant either, so the voice service is also operational. An example is SpaceX's Starlink system, in which 904 of the 4400 satellites planned to be launched in the first phase[41] have already been launched and all satellites are planned to be launched in the next 2-3 years. In addition to Starlink, there are other systems operating or planned with a large number of satellites (Kepler, Telesat, Kupier, OneWeb) which will soon be installed by satellite operators, or they have already started their installation. Such spread of satellites also fundamentally affects the position of terrestrial systems.

In satellite communications, demand for LEO[42] satellites has increased internationally, although previous estimates have predicted a faster upswing. In Hungary, the use is quite marginal, it cannot satisfy the data traffic demands yet. Among the national service providers, Antenna Hungária Zrt. also provides broadcasting and Internet services via terrestrial and satellite connections, considers them as separate platforms, and does not prefer any of them in this respect. Satellite services can complement terrestrial services in places where there is a lack of coverage, e.g. rural areas. Satellite services have a greater importance in less developed regions, e.g. in Africa. The number of national satellite users that use the services of Hungaro DigiTel Kft., a subsidiary of Antenna Hungária Zrt., is not significant. These mostly have specific locations, such as hunting lodges. Antenna Hungária Zrt. claims that the spread of LEO satellites is unlikely in the next 5 years. Other operators do not consider low-orbit satellites to be a significant competition in terms of service, they see mostly see it as just another electronic communications platform.

A new development in the national market is CarpathiaSat Magyar Űrtávközlési Zrt. It was founded in August 2020 by the 4iG private company, Antenna Hungária Zrt. and a law firm. The company intends to have the right to operate the geostationary orbital slot coordinated and notified by Hungary, which would mean exploiting the orbital position above 4 degrees west longitude (4°W), at which a satellite of an Israeli-owned private company currently operates under a contract with the Hungarian state.

[40] Geostationary Orbit, Non-Geostationary Orbit
[41] according to the status of February 2020
[42] Low Earth Orbit (satellite)

9.3. Broadcasting

9.3.1. Technological trends of digital video broadcasting

Several organizations are engaged in standardization activities in digital video broadcasting (DVB). ETSI, CENELEC (Center for Electrotechnical Standards) and the EBU (European Broadcasting Union) have set up a Joint Technical Committee (JTC) to manage all parts of the DVB family of standards. The DVB family of standards consists of the following standards: DVB-AVC, DVB-I, DVB-T2, DVB-C2, DVB-S2, DVB-S2X, DVB-CI-Plus, DVB-IPTV, DVB-DASH and DVB-CSS.

Significant transformations can be observed in digital video broadcasting. DVB-T service has been discontinued in certain countries (Belgium, Switzerland), while in other countries the DVB-T – DVB-T2 transition has started or has already taken place (Netherlands, Italy). There are examples of mixed use of DVB-T and DVB-T2 as well, this type of use is typical in Hungary, among others.

In addition to classic broadcasting networks, broadcasting can also be achieved by using suitable terrestrial mobile networks. LTE systems support the enhanced Multimedia Broadcast Multicast Service (eMBMS) features for media transmission from the Rel-12 standard version (although the MBMS feature previously existed in UMTS Rel-6).

The television broadcasting service can also be properly implemented by using 5G networks (5G Broadcast), however, systems with this capability are still under standardization. According to broadcasters (Medientage München 2019), 5G Broadcast is an exciting topic for the future, but due to technical and regulatory barriers and lack of business models, it is likely to take several more years for this technology to be used effectively in linear terrestrial television service. The standardization activity for 5G Broadcast is in progress in 3GPP, and the related specifications will be published in Rel-17 of 2021-2022. In order for the equipment supporting 5G Broadcast to be put into production, it is absolutely necessary to finalize the standard. Once this is done, the devices are expected to be on the market within 1-2 years. **If the 5G Broadcast function is included in the Rel-17 standard, then devices with this capability are expected to appear on the market in 2022-2024**.

With the clearance of the DD2 band, the band of terrestrial television broadcasting continued to narrow in Hungary from 2020 onwards. The combination of 2 DVB-T and 3 DVB-T2 multiplexes developed for the current situation was necessary in order to keep the content available free of charge under the same technical conditions as the current ones. In the future, it can also be expected that the service will be reduced to an even smaller spectrum range, with some opinions making it likely that the 600 MHz band (possibly DD3) will be handed over to MFCN in the medium term future (10-15 years). The future of the 470-694 MHz broadcasting band is provided until 2032 in Hungary (the official contract and the frequency licenses issued will then expire accordingly). Union protection Pursuant to Article 4 of Decision (EU) 2017/899 of the European Parliament and of the Council, the availability of the 470-694 MHz band (”below the 700 MHz band”) should be ensured for the provision of terrestrial broadcasting services until 2030.

9.3.2. Technological trends of digital sound broadcasting

The digital sound broadcasting system is based on the **DAB (Digital Audio Broadcasting)** standards, namely EN 300 401 (basic standard) and TS 101 496

(guidelines for use and operation). This original DAB standard used MPEG-2 audio codec. An improved version of the standard, DAB+, was released in February 2007, already using the HE-AAC v2 (AAC+) audio codec. The DAB+ technology is approximately twice as effective as the DAB technology.

The DAB service is currently available in 40 countries around the world, which means 2270 services worldwide. The number of DAB receivers exceeds 70 million, of which 20 million are installed in vehicles. In Europe, DAB has a solid market in Germany, Switzerland, Italy, the Netherlands, Denmark, Norway and the United Kingdom. There is also a permanent service in France, Belgium, Slovenia, the Czech Republic, Poland, Greece, Austria, Spain, Sweden, and Ireland. Pilot systems are operating in Estonia, Slovakia, Croatia, Romania, Bulgaria, Serbia, and North Macedonia.

The **DRM (Digital Radio Mondiale)** is a set of digital sound broadcasting technologies designed to operate in the frequency bands in which analogue broadcasting is taking (or formerly has taken) place. These include the low frequency, medium frequency, high frequency, and very high frequency bands of radio broadcasts with AM and FM modulation. One advantage of DRM is that it is spectrally more efficient than the former AM and FM broadcasts, allows more stations to be set up, and can provide better sound quality at a given bandwidth. DRM audio encoding uses the MPEG-4 format. Instead of the previous MPEG-4 HE-AAC, MPEG-4 CELP and MPEG-4 HVXC encodings, the MPEG xHE-AAC codec must be used as required by the 2014 standard.

The national frequency set of VHF FM sound broadcasting is allocated in Hungary, an amount of frequency enough for another national network shall not be allocated (5 nationwide networks are in operation). The expansion of the already existing nationwide networks is very limited. This is a multi-factor process, the first step of which is international frequency coordination, during which the feasibility of a possible expansion can no longer be guaranteed due to the saturation of the frequency band. There seems to be a greater chance of installing new transmitter stations with local coverage (for about a few tens of thousands of people), as the coordination of frequency possibilities of this size is more likely to be successful. At the same time, it should be noted that the launch of new stations is not only a matter of technical demand, but also of media policy, user and business demands.

It would take about 2 years to build the nationwide DAB network, at a cost with possible return on investment. Calculations on this were made earlier, in the 2008 tender. An important fact, however, is that without a proper media policy, business is not attractive. **The role of the NMHH is to inform policy makers. Appropriate media content is required for the operation and sustainability of the service.** Nationwide digital commercial licenses could be attractive.

With regard to sound broadcasting, it is an open question whether the DAB system will be introduced nationwide in Hungary, especially after the official contract of Antenna Hungária Zrt. for the operation of the nationwideDAB+ network expired on 5 September 2020, the plan contained therein was not fulfilled, and the limited coverage system with only three transmitters was shut down in September 2020. Where justified by market and consumer demands and current technological trends, the authority will consider tendering for the operation of a digital sound broadcasting network.

9.4. Point-to-point and point-to-multipoint systems

In Hungary, there are thousands of radio licenses for fixed point-to-point and point-to-multipoint applications. Based on the data available in the NFFF, NMHH made a total of 73.7 GHz spectrum available for the establishment of point-to-point microwave connections in the frequency range between 1GHz and 100 GHz.

Of the authorization models applicable to fixed services (individual licensing /including light licensing as well/, block management, license exemption, licensed shared access[43]), three types are valid for the listed frequency bands in cases where authorization is granted:

- block management: in the 26 GHz band
- light licensing: in the 60GHz and 70/80 GHz band (E-band)
- individual licensing: all the remaining.

The use of the frequency bands available for fixed service applications above 1 GHz is becoming increasingly limited with the development of new generation mobile service applications and the increasing spectrum demand. The following frequency bands can be used for fixed point-to-point connections: 4 GHz, 6 GHz, 7 GHz, 8 GHz, 11 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 26 GHz, 31 GHz, 38 GHz, 49 GHz, 52 GHz, 56 GHz, 58 GHz (these last four bands are practically not used), 60 GHz, 71-76/81-86 GHz. In the following years, a key issue will be to regulate the use of the 26 GHz band (handover for MFCN purposes) and to open the 32 GHz band.

Of the frequency bands for fixed services point-to-multipoint systems may operate in the following bands:

- 1.3 GHz band (1350–1375 MHz, non-civil application)
- 1.5 GHz band (1492–1525 MHz, non-civil application)
- 5 GHz band (4400–5000 MHz, non-civil application)
- 26 GHz band (24.5–26.5 GHz, civil application)

Alternative wireless internet service providers (WISPs) serve a varying proportion of residential and business customers. WISP providers are the largest users of license-exempt frequency bands in the 5 GHz band. They also use the 60 GHz frequency band, in which they have indicated that they would need to enable PMP application outdoors, primarily in urban environments and industrial parks. They would also like to use the 24 GHz frequency band (24-24.25 GHz). WISPs are also interested in using the 5.9-6.4 GHz and 6.4-7.1 GHz bands, in case it becomes possible in Hungary.

9.5. Short Range Devices (SRD)

The conditions for the use of SRDs are regulated by Decision 2006/771/EC of the European Commission on the harmonization of the radio spectrum for use by short-range devices. For devices operating in the 900 MHz frequency band, Implementing Decision 2018/1538 of the European Commission on the harmonization of the radio spectrum for use by short-range devices in the 874–876 MHz and 915–921 MHz frequency bands shall apply. SRD devices are radio equipment that can be operated with a low risk of interference, usually because their radiated power is low, therefore their radio range is also small. The SRD definition includes various types of wireless

[43] Licensed Shared Access (LSA), this authorization model has not yet been introduced in Hungary. The LSA approach is basically designed for sharing between MFCN and PMSE, but it can even be applied to point-to-point connections.

devices, including access control systems (including door and gate openers), alarms and motion detectors, closed-circuit television (CCTV) systems, wireless audio devices (including wireless microphones), industrial control devices, wireless local area network (WLAN) equipment, medical implants, UWB sensors and radars (e.g. ground radars), remote control devices, radio frequency identification devices (RFID), road transport telematics systems, and telemetry as well. The use of short-range devices is mostly exempted from the obligation of individual licensing, with only a few cases requiring individual licensing. However, like all other radio equipment placed on the market in the EU, it must comply with the RED Directive (Directive 2014/53/EU) in accordance with European Union regulations. The method of authorization of the use of SRDs is up to the Member States.

One of the most important SRD applications is Intelligent Transport Systems (ITS), which include telematics solutions and communication between vehicles (V2V) and communication between vehicles and fixed infrastructure elements (V2I) (altogether V2X). In addition to ITS and other vehicle communication systems, the increasingly widespread data network SRD systems and individual medical applications (e.g. capsule endoscopy) are also important. With regard to short range devices, there has been significant interest in wireless power transmission (WPT) systems, which has also been examined by the ITU in the recent years (e.g. Rep. ITU-R SM.2303-2 (06/2017)), and the SRD applications below 9 kHz. The latter include, for example, robotic mowers (see ETSI EN 303 447), metal sensors (see ETSI EN 303 454), nuclear magnetic resonance (NMR) technology (see ETSI EN 303 658) and inductive gluing systems (see ETSI EN 303 734).

9.6. New technologies and solutions that increase frequency reuse and efficient spectrum use

In many cases, many of the new technologies that help efficient spectrum use first appear in radio local area networks (RLANs) and Wi-Fi devices (regarding civil use). After that, it is used in a more developed way in systems that require more reliability, such as mobile access networks or microwave point-to-point connections. In practice, it can be said to illustrate the capabilities of the Wi-Fi technology in the service that some devices with 4×4 MU-MIMO technology can provide data rates of 600 to 800 Mbps in 90° sectors. Of the current Wi-Fi systems operating below 6 GHz, 802.11ac (5 GHz) and, from 2019, 802.11ax (2.4 GHz/ 5GHz) devices are available on the market. These devices use 4x4 MU-MIMO and OFDM technology. In the 60 GHz range, 802.11ad (WiGig) devices are operating, 802.11ay standard is still under development. It should be noted that currently the best-performing devices used in microwave PP and PMP do not operate according to the Wi-Fi standard (although they are often referred to as such) but they operate according to custom manufacturer protocols. A modern microwave device is capable of beam forming and beam steering. Devices in the 24 GHz band available on the market currently have up to 1024QAM modulation, but the 4096QAM is expected soon. In addition, devices with a data rate of 2 Gbps using XPIC technology using cross-polarization separation is now available on the market.

Among the multi band technologies available on the market, (dual) solutions that complement E-band transmission with 23 or 26 GHz transmission are important, where the sustainability of the SLA is ensured by using the lower frequency link in case of higher rain attenuation.

Specifications for the use of active antenna systems (AAS) in MFCN (5G) systems have been published in European Commission Decisions of 2019 and 2020 (decisions (EU) 2019/235, (EU) 2019/784, (EU) 2020/667, and (EU) 2020/636). Modification of the regulation in the 1800 MHz band is required for the usability of active antenna systems. There are no plans to use active antenna systems in the 900 MHz frequency band.

9.7. Priority applications

9.7.1. Public Protection and Disaster Relief

3GPP is also continuing to standardize towards mission-critical applications, under the responsibility of the SA6 (mission-critical applications) working group. More than 600 functions have been collected for standardization, mostly adapted from the former TETRA, Tetrapol and P25 systems. Mission-critical LTE is based on the 3GPP Rel-12 standard, which defines group communication (GCSE) and direct mobile communication (D2D, ProSe). The latter has not yet been implemented by anyone in a standard way, and only Samsung has produced a non-standard solution. The mobile gateway function could work according to the standards, but the problem with this is that the maximum transmit power of the mobile device is too low, so the range is short. A number of mission-critical features have been identified in the 3GPP Rel-13 to Rel-16 standard versions:

- mission-critical audio service (MCPTT 1.0, 2.0, 3.0)
- mission-critical video broadcasting service (MCVideo 1.0, 2.0)
- mission-critical data transmission service (MCData1.0, 2.0)
- IOPS (retaining the functionality of an island-like (isolated) base station disconnected from the core network) function
- the multimedia broadcast and multicast (eMBMS) function.

The novelty of the 3GPP Rel-15 standard version is that it allows interaction with narrowband systems, although this can only be done through the standard radio interface (since the core network and transmission network of narrowband systems are not standardized). According to certain opinions it is necessary also because, despite the obsolescence of the technology, the TETRA system is still expected to be the basis of group communication for up to the next 10 years.

At the initiative of NMHH, it has been achieved within the CEPT to enable the application of 2x5 MHz LTE-based BB PPDR in the 410-430 MHz band. The 410-417/420-427 MHz band[44] in Hungary is currently allocated for non-civil application. Many questions arise in connection with the use of the band, but for the time being it is certain that the non-civil user side will seek to keep the band in non-civil use.

In the 700 MHz band, various sub-band combinations have been standardized so far, but 3GPP will standardize new combinations upon request. In the 700 MHz frequency band, the civil status of the lower 5 MHz part of the MFCN block in Hungary is currently planned, given that there is a clear Government demand, and this 2×5 MHz will be used for a dedicated BB PPDR purpose in the event of such a government decision. In the opinion of mobile service providers, it would be a better solution to designate the 5 MHz band in question for the public mobile service, and instead e.g. to implement

[44] It is often referred to only as the 410-430 MHz non-civil band; however, it should be noted that the 417-420/427-430 MHz band is for civil use.

the use of PPDR in the 410-430 MHz band. The usability condition of the frequency band was provided by NMHH, but at the same time, on the part of the governmental the process itself has not yet progressed. The government's dedicated spectrum demand known by NMHH in the 700 MHz band for broadband data transmission service is at least 2x10 MHz (currently the government is not open to other, e.g. hybrid solutions). In addition to the 400 MHz and 700 MHz frequency bands, dedicated spectrum in the 1500 MHz and 2300 MHz bands, as well as in the 26 GHz band, could be suitable for PPDR use, which could contribute to meeting ever-increasing emergency service needs in the future.

9.7.2. Situation of further non-civil applications

In the field of non-civil and military applications, there are several international efforts to enable the use of mobile network (MFCN) and Wi-Fi in the 6.425-7.125 GHz band ("upper 6 GHz"). Due to non-civil (military) applications operating in the national environment and covered by services other than the International Radio Regulations, Hungary did not support (nor did it oppose) these efforts at WRC-19. The Wi-Fi application is being studied primarily at the CEPT level. The national use of the band may be significant in the Zrínyi National Defence and Armed Forces Development Program. According to national regulations, currently non-civil applications of radio location and aeronautical radio navigation can operate in the band until 31 December 2023.

For non-civil use, the upper 1 GHz part of the 26 GHz band is currently still affected, as it is now dedicated for non-civil purposes. There are currently no such applications in the band, but the non-civil side does not want to give up the band altogether and is interested in having some access to its future systems based on new technologies in this band as well. It should be noted regarding the 26.5-27.5 GHz range that this part of the band is also harmonized according to the decision of the European Commission.

9.7.3. Unmanned aircraft systems (UAS)

The industry of unmanned aircraft systems, UAS[45] manufacturing, is a constantly and dynamically growing area with expanding applications (logistics, agriculture, etc.). It is estimated that by 2035 it will represent a market of around EUR 10 billion. Proper regulation of the area is very important, which in the case of fast developing areas often means follow-up regulation, but in many cases influential regulation must be sought to shape the use. The technical requirements and regulatory requirements for UAS are summarized in ECC Report 268. The change in the official regulation of the UAS is of particular importance, for which European Union legislation was established that originally entered into force on 1 July 2020, but the date was modified to 1 January 2021 regarding the pandemic situation. The EU regulation does not cover non-civil use, there is no harmonization obligation for non-civil use, but it is advisable to harmonize the rules of airspace use and to tackle the regulatory situation of non-civil use. In doing so, NATO's military standardization conventions and, in the case of other

[45] Due to its popularity, the name drone is often used, which was originally a collective name taken from American military jargon. Originally, a drone can be either a crawler or a wheeled device. The EASA and EU terminology refer to it as RPAS. EU regulations consistently use the term UAS for such aerial systems and UAV for aerial vehicles.

non-civil users (e.g. police, disaster relief, national security services), the relevant international standards and other specificities must be taken into account.

Under current regulations, UAVs can only be used in designated locations, and their use in other locations is prohibited. Under the regulation, which will take effect from 2021, this system will be reversed. The MyDroneSpace[46] mobile application, through which individual flights must be registered, will play a key role in regulating UAS usage. The use of UAVs also raises many other legal issues, which is why an Aviation Strategy Council has been set up at the Aviation Authority.

Cyber security is also highly important for UAS. Due to the large number of data generated in the field, the use of AI (artificial intelligence) will be absolutely necessary. In terms of market opportunities, there is still a plenty of potential in software development, but the hardware market is quite flat, with a company (DJI) market share of 70%. There is currently a shortage of validated data processing solutions in the market.

The most significant of the Hungarian UAS, UAV civil users are the following: electricity suppliers, waterworks, water directorates, MÁV Zrt., agricultural users.

9.7.4. LPWAN and IoT solutions

National electronic communications service providers also invest significant energy in the development of IoT systems implemented on mobile networks, and they also provide information on technological solutions and the general market situation on their own websites. Globally, according to service providers, some networks already have an annual traffic growth of 44%, and currently 86 million devices are already connected to the network of one of the service providers on this basis, of which 14.4 million are vehicle communication devices. The most significant IoT, M2M solution in the case of 2G/3G technology is the communication of cash registers, while in the case of 4G and 5G Industry 4.0 solutions are expected to spread mainly. LPWAN solutions of service providers were launched in Hungary in 2019 in urban public utility services, e.g. for smart parking, where about 1500 sensors are connected to the network.

In addition to mobile technologies, LoRA technology is widely used for M2M communication. According to European standards, the system is a narrowband technology operating in the 868 MHz SRD band with a channelspacing of 200 kHz as recommended by CEPT Rec. 70-03, but operation is also possible in the 433 MHz SRD band. There are also LPWAN systems in Hungary that use several license-exempt bands. The first Hungarian LoRa network was established in Budapest in December 2015, the expanded network is currently available in Budapest, Győr, Debrecen, Székesfehérvár, Lake Velence, Érd, the Danube Bend, and Kecskemét, and is also suitable for providing commercial services.

Another provider has also built a network with LoRaWAN technology on which it provides IoT services. The first stage of the investment took place in the area of Lake Balaton in the spring of 2017, after which the further development was aimed at fully covering Budapest, the county capitals and several large rural cities. Thanks to its continuous network development, it has outdoor coverage in Budapest and beyond its agglomeration in all county capitals. The area of Lake Balaton is given priority in terms of coverage. The LoRa service of a third service provider is operating in Budapest

[46] accessible: https://mydronespace.hu/

since February 2018. The company built the network in Debrecen, Győr, Miskolc, and Szeged in the same year. The deployment of the national network is in progress.

Like LoRa technology, SigFox operates in the SRD band (868 MHz). One of the main differences between the two technologies is the bandwidth used. While the bandwidth used by LoRa is 125 kHz or more, SigFox uses a narrower band, which is why it is also called ultra-narrowband technology. The technology already has nationwide coverage in 17 countries. In Hungary, although nationwide coverage is not yet provided, the technology is already available from one service provider.

9.8. Solutions for efficient frequency use

9.8.1. Secondary trade

In order to increase the security of investments, in the spirit of flexibility and efficiency, secondary trading of radio spectrum is normally possible in Hungary in the case of harmonized bands, that is, NFFF allows rightsholders to transfer their entitlements to radio spectrum use to a third party and to lease their rights to a third party. Besides compliance with the conditions attached to the rights in question and the competition rules, the approval of the NMHH is also required. The procedural rules in Hungary are laid down in NMHH Decree No. 7/2013 (IX. 19.) on the secondary trade of radio frequencies. During the implementation of the Code, NMHH created the rules for the examination of the observance of the competition rules based on international samples. NMHH also sees a growing need for smaller participants to benefit from the technical capabilities of 5G in addition to mobile operators. With efficient spectrum use in mind, it has not yet identified the spectrum dedicated to the NMHH verticals, but supports secondary trade agreements and has developed a simplified approval procedure.

Secondary spectrum trading is less common in the member states of the European Union except for the United Kingdom. There are still few examples in Hungary of secondary trade transactions (the agreement between Hungarian Telekom Nyrt. and Telenor Hungary Zrt. on 800 MHz frequencies, which is still being examined by the Hungarian Competition Authority (GVH) to determine whether the above conduct of Hungarian Telekom Nyrt. and Telenor Hungary Zrt. is in accordance with the provisions of the Competition Act and the Treaty on the Functioning of the European Union).

9.8.2. Shared or collective spectrum use

“Shared frequency use” is difficult to determine according to the RSPG terminology system, it could rather be circumscribed by the criteria defined by the RSPG in its various documents. In general, shared spectrum use involves regulatory and technological or combined solutions that do not favour exclusive frequency use, thereby improving spectrum utilization. The specified shared frequency use covers a broader concept than Collective Use of Spectrum (CUS – see section 4.5.2), it also covers “situations in which a known number of independent users access the same range of frequencies on the basis of an agreed sharing *arrangement*”[47].

There are many solutions to shared use, of course, the regulatory-level solutions are not the only ones known since new technological solutions that make shared use feasible (e.g. cognitive technologies) also play an important role. The table below

[47] https://rspg-spectrum.eu/wp-content/uploads/2013/05/rspg11_392_report_CUS_other_approaches_final.pdf

compares the spectrum sharing at the static, dynamic, and technological levels. In the interpretation of the table, static methods refer to conventional frequency management. At the technological level, there are listed methods that, when built into devices, share spectrum in a way that is transparent to the user (and on the use of which dynamic methods are often based). The dynamic methods column lists properties that are specific to dynamic methods, not separated by sharing method, because they often take advantage of all sharing options.

Classification of spectrum sharing between users			
	Resource sharing based on their temporal variability		
	Static	**Technological level**	**Dynamic**
Temporal sharing	Frequency use can be shared in time in the case of licenses establishing exclusive rights for a given frequency and area as well. **Shared use frequency** according to NFFF.	E.g. time slot based communication, Low Duty Cycle, TDMA, TDD.	Utilization of the multidimensional nature of the spectrum resource is typical, so these methods often cannot be classified based on the application of temporal-frequency and territorial separation. They are typically based on the use of a central frequency management database that allows short-term or immediate resource (frequency) reservation. They may also require the use of cognitive technologies for their application. The use of geo-location databases is the basis of most of these methods. TV White Space and LSA solutions are included. Different types of applications may be authorized within a band. They are based on innovations at both technological and regulatory levels.
Frequency sharing	In a traditional authorization procedure, the management authority determines whether a given frequency can be received by a requesting user within a given band for a given area without causing interference to existing applications. This is how **users share frequencies within the bands**. On a larger scale, the assignment of different services to bands is also a similar kind of resource sharing, if we look at the services as users and at the whole radio spectrum as the resource in question.	E.g. FDMA, OFDMA, FDD, Wi-Fi,	
Territorial sharing	As the geographical distance increases, the interaction of two frequency uses decreases proportionally, so **even the same frequency can be assigned for use at a distance deemed appropriate** by the management authority. (frequency reuse concept)	Adaptive Transmit Power Control (ATPC) or cognitive technologies can be used to reduce the required degree of territorial isolation.	
Code sharing	There is no example of static management with orthogonal codes, **it is only possible in theory**.	Assigning (orthogonal) codes to each user that "addresses" the location of messages sent to them within channels	The application of these technologies among common dynamic sharing methods is not yet known. It is a kind of spectrum pooling.

Based on the experience and opinion of national service providers, due to spectrum sharing, collective use of spectrum (and network sharing), the business value of each frequency band, the required amount, etc. will significantly change in the event that spectrum sharing (and network sharing) activities work properly. Service providers believe that this business activity should be promoted. It is absolutely necessary to change the current regulatory situation, as they believe that the sharing activity is

working properly, but it is very difficult for the authorities to make a decision. As part of the implementation of the Code, we will introduce a system of simplified approval in connection with lease agreements. In such cases, it will not be necessary to conduct tender tests. Reducing the cost burden on service providers through spectrum sharing (and network sharing) will play a very important role in the deployment of 5G, which is why service providers consider it important that these transactions can be carried out smoothly. The approval system based on simplified notification could mean a solution for this.

9.9. Challenges due to harmful interference

Some of the current issues related to harmful interference are of a spectrum policy nature, but others are specifically spectrum management issues. The expected major interferences are detailed in the following subsections. Some new problem areas can be already noticed in the tasks of the measurement service, e.g. interference caused to cable TV systems by 5G systems is expected. For now, what seems to be a significant problem regarding measurement, is when a system has a large number of stations communicating with another large number of stations in both directions. Thus, for the measurement service, the difficult problem is not when 2-3 base stations cause interference, but when it is caused by many small devices, e.g. interference caused by mobile service and cordless phones, car alarms.

After the switch-off of broadcasting and further examining the 700 MHz frequency band that can be used by 5G systems, it can be concluded that in addition to cable TV systems, there is also interference from other devices. In this band, in addition to 5G systems, wireless microphones and other SRD devices are likely to continue to operate in a large number (now irregularly), which was not a problem for previous broadcast systems, but for 5G devices, the interference could be significant.

Further unexpected interference appears in 433 MHz SRD devices that occur near MVM NET 450 MHz base stations. Experience has shown that the receivers of these 433 MHz SRD devices have such poor selectivity or inadequate bandpass filters, and thus a signal that is not actually an interfering signal is interfering with their operation. Such situations could be prevented if NMHH investigated the potential problem well in advance and communicated it properly to users.

A new phenomenon is the significant increase in the number of low-orbit satellites, which will also increase the amount of interference. In this case too, the task of the measurement service will be to eliminate the interference, but the specific tasks are not known yet. In the case of nationally operated systems, NMHH can take action against interference. In case during measurement a foreign satellite system can be identified, and its registering administration is known, then a procedure in accordance with the International Radio Regulations may be initiated to eliminate the interference.

9.9.1. 5G/LTE cable television systems

The expected interference problem between the MFCN and the cable television systems was indicated by one of the national cable television operators. Surveys show that more than 80% of cable operators use the 700 MHz band, so the involvement is high. In general, it can be said that in case of interference bigger problems mainly occur in the case of the older cable TV technology (for them, interference caused by mobile network can be critical in the cable network), as newer technologies are now prepared for interference situations. With DOCSIS 3.1 technology, there are already solutions to

deal with interference (the system also uses OFDM), so if all cable networks used this, they would have to face significantly fewer problems. However, DOCSIS 3.1 technology is typically used only by major operators, and for smaller operators, interference will be a problem due to obsolete technologies. A new technology, DOCSIS 4.0, will be used by the major operators within two years.

9.9.2. GSM-R and SRD (RFID) systems

An earlier report on the Radio Spectrum Inventory has already indicated that SRD applications play an important role in providing spectrum for smart grids, smart meters and the Internet of Things (IoT). These SRD devices include the Radio Frequency Identification (RFID), M2M communication and the mesh networks as well. For GSM-R systems, the RFID systems' maximum radiated power of 4 W and the interference they cause have been the problem so far. In addition to this known interference effect, another interference will appear caused by the spreading data networks (M2M, mesh), but their exact effect is not yet known.

However, regarding SRD systems, additional uses in addition to GSM-R in the 870–876 MHz and 915–921 MHz bands (e.g. existing allied and planned military systems) should be taken into account. In order to allow military, railway and SRD applications to coexist properly, Decision 2006/771/EC on the harmonization of the radio spectrum for use by short-range devices in the relevant bands has also been amended by the European Commission.

9.9.3. GSM-R and MFCN systems

GSM-R systems use the commercial GSM system as a backup system, which might cause a problem[48]. For the coexistence of the GSM-R and other MFCN systems, the ECC prepared a guidance, and further proposals for the definition of RMR[49] LRTC[50] conditions are under development. Similarly, the LTE-based railway mobile communication and the coexistence of GSM-R/LTE in the railway band are examined.

9.9.4. Wi-Fi and meteorological radars

National Meteorological Service (OMSZ) operates four 5 GHz band radars in the country, well distributed geographically, these are: Budapest Gilice Square, Sármellék-Pogányvár, Szentes, Nyíregyháza-Napkor. For the radars, the point-to-point Wi-Fi connections are the main cause of interference (which, mostly, in fact, no longer use the classic Wi-Fi technology, but the frequency band is the same). Additional interference is caused by the radio connections of wireless camera systems in this band. The interference in the meteorological radars caused by WLAN devices can be traced back to the improper implementation of the DSF function (the function is available but does not operate in line with the standard) or to incorrect setting (intentional or unintentional shutdown). Delimiting the disturbance is difficult because, widespread Wi-Fi routers and other devices in the SRD band operating nearby mask the actual interference signal during a given measurement. For the meteorological radars, the RLAN systems have caused interference in the 5600-5650 frequency band,

[48] Devices used in locomotives can be interfered by mobile devices in the commercial GSM network due to the filters used there.
[49] Railway Mobile Radio
[50] Least Restrictive Technical Conditions

but recently this problem seems to have been solved as there are no complaints. This is also due to the measurement service work of NMHH. NMHH's measurement service did a lot to investigate the proper use, and the problem was largely solved.

9.9.5. 5G and meteorological-satellite measurements

The interference of the 23.8 GHz frequency band used by meteorology for satellite measurements caused by 5G (26 GHz band) is currently an assumption (based on calculations) because in many cases the 5G mobile service is currently only in a test system. There is a debate between meteorologists and 5G operators about the performance on which 5G stations can operate (which is also related to the installation density of base stations). Meteorological services claim that the performance limits set for 5G under the regulations are not strict enough. Because of the possible consequences (false measurements modify the initial values of meteorological models and thus significantly worsen the predicted weather fields which may endanger life and property safety), finding an appropriate regulatory solution at international level is a priority. Based on the assumptions, microwave satellite measurements and 5G interference may cause problems. The most important input data of the weather forecast models are the satellite measurements. For the measurement of atmospheric water vapour, for example, the 23.8 GHz frequency proved to be the most suitable, with which the water vapour content of the atmosphere can be measured excellently day and night, even in cloudy weather. At WRC-19, they eased the maximum of interfering signals emitted by 5G devices, which will be stricter from the earliest of September 2027, but still not to the extent deemed necessary by the meteorological services. EU harmonization rules allow for additional measures to be taken at national level to ensure coexistence with other services and applications, where necessary. [51]

9.10. Issues of national satellite regulation, trends in official tasks

Regulations for launching satellites into orbit around the Earth (or other celestial body) have been established in the framework of the International Telecommunication Union (ITU). Pursuant to Article 1 (2)(a) and (b) of the ITU Constitution (promulgated by Act XLV of 2011), in addition to the allocation and assignment of radio frequencies, the ITU also allots and registers geostationary and other satellite lots, and coordinates the use of them. The ITU is also responsible for ensuring that satellites do not interfere with each other. In the Hungarian environment, NMHH performs many tasks related to satellite systems, which are the following:

a) regulation,
b) frequency-based licensing (frequency assignment, licensing) for satellite systems registered by Hungary and for Earth stations of satellites registered by other countries and operating in Hungary,
c) frequency coordination tasks (ITU, co-administrations)
d) construction authorization of Earth stations operating in Hungary,

[51] Stakeholders' organizations also make recommendations on the subject. According to the recommendation of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), such measures could be to favor technologies that can meet stricter conditions or, initially, to sell bands as far away as possible from 24 GHz.

e) registration of services
f) communications monitoring tasks.

The electronic communications regulation for satellites enables and regulates that the satellite system, available in the plans for the Hungarian administration or successfully coordinated during an international procedure, could be put into operation and an electronic communications service could be provided on it internationally, not only in Hungary. In connection with the performance of satellite frequency coordination tasks, the Hungarian administration has already gained experience in two types of procedures in connection with CERES-1 coordination and pico-satellites implemented within Budapest University of Technology and Economics (BME) (MASAT-1, SMOG-1, SMOGP and ATL-1), for which NMHH acted as a notifying administration to the ITU-BR, coordinated with the administrations of the countries concerned. Coordination of RADCUBE is currently underway at NMHH.

At present, the use of satellite frequencies is subject to individual authorization as a general rule, with the sole exception of the frequency band used for the 2 GHz MSS service allocated by the European Union to the European Aviation Network in a comparative selection procedure. Changing it is not intended. In radio licensing practice, the above means that the administration registering the satellite system issues a license to the satellite service provider. Operating Earth stations in the EU are largely exempted from the obligation of individual licensing, those which are not, are licensed and coordinated by the authority of the place of installation.

An agreement was reached between Hungary and China on new satellite positions in addition to the existing geostationary satellite positions (“21st century silk road”).

The planned satellite system consists of 7-8 satellites. Hungary will have a small role in the operation, its tasks will be mostly licensing and coordination. There will definitely be a gateway Earth station in Hungary, the technical plans are not known yet. It is proposed to create forward-looking regulation in the next 3-4 years, by which time the first satellite is expected to be launched into orbit.

In addition to the above, at the Space19+ Conference organized by the European Space Agency (ESA) in November 2019, the Hungarian government made a number of announcements about governmental plans. Hungary wants to train and send a Hungarian astronaut to the International Space Station in cooperation with the Russian Roscosmos by 2024. Other goals include that in 2024 Hungary launches an independent satellite into orbit around the Earth. Additionally, in cooperation with Russia, it will bring Hungarian scientific and measurement tools to the International Space Station by 2024. Furthermore, a space-weather mission is in the preparatory phase, in the framework of which Hungary will build a microsatellite fleet.

Exploitation of the existing Hungarian national orbit positions (common BSS and one FSS) For the time being, a single coordinated and notified satellite position is used by an Israeli satellite, but with the expiration of the related contract, the Hungarian satellite position is expected to cease in the absence of a new satellite launch or contract extension. In the position in question (4°W) there were a mixture of Hungarian, Israeli and Papuan New Guinean registrations, it is likely that with the cease of Hungarian notifications, the position would be completely taken over by Israel. There are currently no other available geostationary satellite positions, the geostationary orbits over Europe are saturated, so Hungary cannot get another position. Overall, the value of geostationary orbits is declining. GEO satellites are designed for a time interval of 15-20 years, while the new LEO, MEO satellites can be produced in large quantities cheaply and have a shorter operating time. Although the importance of the GEO orbital

position seems to be diminishing, it should not be underestimated. The issue to be resolved in the 2021-25 period is the fate of the 4°W position, as the relevant contract expires in 2024. The issue is not resolved by the establishment of CarpathiaSat Magyar Űrtávközlési Zrt. (see Chapter 9.2).

10. The three strategic pillars of spectrum management

One of the most important tasks of strategy-making is to define the pillars and the analytical aspects assigned to the pillars, on the basis of which the structure of the strategy can be built, from the visions to the overall objectives to the strategic target system. In defining the pillars, we took into account the experience so far, the previous spectrum strategies and the most important topics of research and strategies in international and national professional workshops. In accordance with the government's strategy development guidelines, as part of the radio spectrum strategy, the key areas of the highest level along which the most important characteristics, processes and contexts of the radio spectrum regulation period up to 2025 can be described should be identified. These pillars provide a framework and a higher-level structure for the individual steps of strategy preparation, the analysis of the current situation and the effects, and the actual strategy can be developed along these bases and contexts. The pillars stem from the vision for the area and the overall strategic goal.

In the determination of the content of the pillars and in the development of the priorities, special emphasis was placed on getting to know the professional opinions and positions as a result of discussions with the industrial participants and the experts of the authority. The following were identified as reasonable pillars of the radio spectrum strategy (see Figure 1).

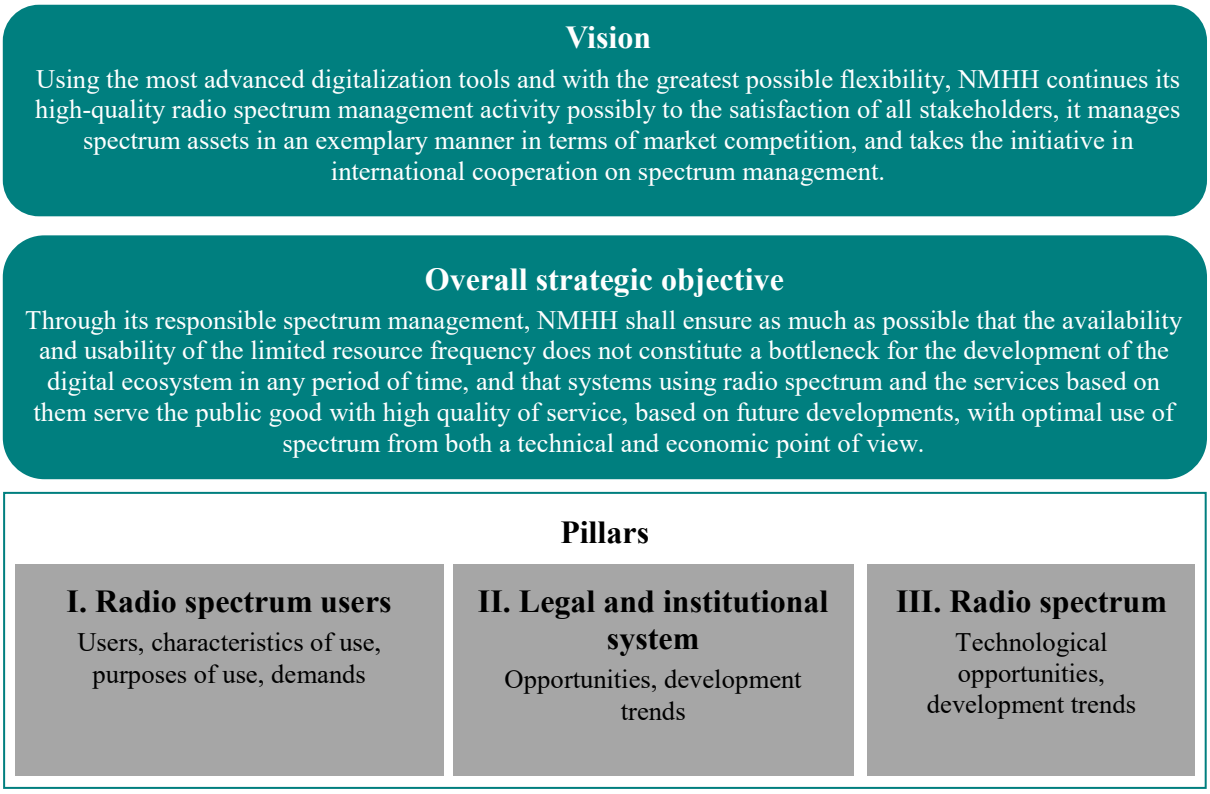

Figure 1 The place of the vision and the overall strategic objective in the target system

1. **Radio spectrum users** who use or intend to use (require) a limited resource. The first defining pillar is the number of users of radio spectrum who, by using limited resources, create socio-economic value for themselves or for part or all of society. The first factor in the pillar is the market environment. This includes the state of infrastructure and services, as well as market processes related to radio spectrum and the operations performed by their participants. The other factor is the social and economic environment that summarizes the radio spectrum aspects of the digital ecosystem.
2. **Legal and institutional system** that determines the manners, possibilities, and practices of disposing of limited resources.
   The first determining factor of the legal and institutional system pillar summarizes the possibilities of radio spectrum technology, the institutional elements of the legal and institutional environment and conditions directly influencing and determining its use, and the legal, regulatory and normative environment behind them at the international level. The second factor, similarly to the previous one, condenses the relevant legal and institutional elements of the European Union. The third factor describes the Hungarian legal and institutional (official, ministerial) environment.
3. **Radio spectrum** as a limited resource with its dynamic value and specific properties.
   The first determining factor of the radio spectrum pillar summarizes the characteristics of spectrum use. The second factor summarizes the totality of the technologies and their development trends together with all the current and future technical-technological peculiarities, characteristics and properties. The third factor includes the technical and other characteristics of certain bands and radio services, their potential opportunities, limitations and the expected future usage demands based on them. The fourth factor contains promising regulatory solutions for the future.

11. Vision of the radio spectrum strategy until 2025

The aim of NMHH is to ensure as much as possible, through its responsible spectrum management, that the availability and usability of the limited resource frequency

- is not a bottleneck for the development of the digital ecosystem in any period of time,
- the systems based on its use and the services based on them are based on future developments,
- its use is technically and economically optimal, free of harmful interference, serves the public good with a high quality of service, keeping in mind the principle of technological neutrality and ensuring the protection of investments.

As a vision of spectrum strategy, NMHH defines that

- by applying the most advanced IT systems and technical solutions, the efficiency of national radio spectrum management will be continuously improved,
- its activities shall be guided by the promotion of efficient, professional and consumer-friendly use of radio spectrum and the promotion of technological development,

- it shall support innovation and through this the development of digital economy to strengthen Hungary's competitiveness,
- taking into account the efficiency of market competition in its measures and considering the opinions and needs of all interested parties, it strives to conduct competitive procedures to the satisfaction of all,
- as a responsible spectrum manager, it ensures the enforcement of public health aspects with the means at its disposal,
- it participates in the fight against climate change through spectrum management tools, and
- follows international standards for spectrum management in an exemplary manner and fulfils its obligations to cooperate with the authorities of neighbouring countries and international organizations, while promoting national interests.

The aim of the spectrum manager is to reduce the effects of spectrum limitations and at the same time achieve the greatest social benefits during spectrum use. For all this:

- it must be ensured that the distribution of radio spectrum for electronic communication networks and services, the issuance of general authorizations for them and the granting of individual rights of use are based on objective, transparent, pro-competitive, non-discriminatory and proportionate criteria;
- it must be ensured that unused spectrum reaches users who are able to create the greatest social value with it, whether it is a market or non-market type of spectrum use;
- economical use of spectrum should be encouraged, which
    - results in cost savings for the user due to lower frequency usage fees
    - can meet new usage needs due to redistributability
    - reduces the effects of spectrum limitations by expanding spectrum supply.

12. Specific objectives and indicators of the radio spectrum strategy until 2025

The overall objectives of the radio spectrum strategy have been broken down into more detailed, specific objectives. Table

Table 12.1 details the specific objectives for the overall objectives, as well as the indicators for monitoring the achievement of the specific objectives.

Table 12.1 Objectives and indicators of the spectrum strategy

Pillars	Overall objectives	Specific objectives	Indicators
1. Radio spectrum users	1.1. Flexible provision of the availability and use of radio spectrum necessary for the continuous development of mobile services, promotion of efficient use	1.1.1. Providing harmonized frequency bands in the European Union for mobile data traffic according to market demand • providing frequency bands with maximum time and volume flexibility • identification of MFCN needs in the 26 GHz band and development of conditions for award • carrying out the reaward of bands before the entitlements to frequency use of mobile network operators (900/1800 MHz) expiry in 2022, with a preference for multiband award • making preparations for the reaward of frequency bands (2100 MHz) with entitlements expiring in 2026 • getting acquainted with the frequency band demands suitable for both SDL and SUL purposes and developing the conditions of award • identifying the needs for the 2600–2615 MHz band that remained from the 2020 competitive procedure for the 2.6 GHz frequency band and establishing the conditions for award again • identifying the demands for the 2.3 GHz frequency band and depending on those establishing the conditions for award • continuous provision of conditions for the sharing of resources for all frequency bands within the possibilities of responsible spectrum management • pursuing responsible spectrum management that allows verticals to access 5G-based service without restricting the opportunities of mobile network operators • making preparations for the assessment of 6G resource- and spectrum demands	The bandwidth made available to the public mobile service during the implementation period in MHz is divided into three ranges: Below 1 GHz, between 1 GHz and the upper limit of the “6 GHz band”, and above 24 GHz. Public consultation, assessing demands and launching awards for bands marked for competitive procedures. Bandwidth of the MFCN (5G) band in MHz made available primarily and/or indirectly to the verticals. 6G preparatory study. Development of a document on the practical application of the principles governing the approval of transactions in the field of secondary spectrum trading (in particular joint and shared spectrum agreements), taking into account international practices
		1.1.2. Maintaining the high standard of international activities • continuing proactive participation in international spectrum management activities • maintaining the high level of international coordination activity necessary for the introduction of the latest broadband technologies, concluding agreements as soon as possible	Initiating the conclusion of necessary coordination agreements. Number of coordination requests examined. Based on the review of ITU coordination notifications, the number of examinations of cases affecting Hungary.

Pillars	Overall objectives	Specific objectives	Indicators
		• notifications to the ITU as required continuously to protect operating services • active participation in the development of international regulations and coordination	
	1.2. Ensuring the availability of radio spectrum required for audio-visual and sound broadcasting, the continuous development and digitalization of broadcasting in line with the demands expected.	1.2.1. Review and, if necessary, amend the long-term (at least until 2030) concept and national roadmap for public and commercial terrestrial television broadcasting: • prepare alternative scenarios for the possible development of national television focusing on spectrum use issues (e.g. terrestrial, satellite, mobile technology)	Preparation of a document analyzing the long-term future of television broadcasting.
		1.2.2. Prepare a long-term concept for terrestrial sound broadcasting (public service, commercial) up to at least 2030, covering the following: • international frequency coordination and theoretical networks using the existing frequency use plan for digital terrestrial sound broadcasting (Geneva Plan) • prepare a concept plan analyzing the development plans of VHF, HF and MF radios and the possible way and schedule of the widespread deployment of the digital technology (e.g. DAB+, DRM30/DRM+, etc.) • prepare a plan for the national utilization of the frequencies planned for the DAB+ system, including the schedule for the introduction and the date of the planned implementation depending on the media policy decision • preparations for the study on the phasing-out of analogue FM broadcasting technology depending on the spread of digital radio in Hungary • a survey on the adaptation of digital receivers in Hungary should be carried out annually	Preparation of a document analyzing the long-term future of sound broadcasting. Preparation of the frequency plan for the nationwide DAB+ system. Preparation of the MF, HF and VHF sound broadcasting concept. Digital receiver adoption survey.
		1.2.3. Carrying out an analysis of future alternative options for the implementation of broadcasting (in particular based on mobile networks, but also on other radio frequency services), taking into account the principles of responsible spectrum management	Expert analysis material.
	1.3. Continuous satisfaction of frequency demands of priority terrestrial applications	1.3.1. Assessment of the frequency needs necessary for the operation of PMSE systems and the analysis of the possibilities of spectrum provision following technological trends • preparation of a regulation concept for the PMSE systems • preparation of an informative on the frequency bands available for PMSE services, taking into account the shared band usage possibilities of PMSE and aviation • serving PMSE measurement needs	A regulatory concept for serving PMSE needs. Recommendation for frequency bands available for PMSE services.
		1.3.2. Developing the necessary conditions for the coordinated operation of SRD (IoT, RFID) devices in the 874.4-880/919.4-925 MHz band	Analysis of the need and possibility of amending the relevant regulations.

Pillars	Overall objectives	Specific objectives	Indicators
		and railway communication systems (GSM-R, FRMCS) • serving the SRD and GSM-R measurement demands	
		1.3.3. Development of the spectrum usage conditions necessary to satisfy the communication needs of UAS devices (data transmission, control, identification, tracking)	Expert analysis and decision-making document. Ensuring proper regulations.
		1.3.4. Ensuring the interference-free band usage for intelligent transport systems (ITS) in the 5.9 GHz band including Urban Rail systems, as well as for Wi-Fi equipment designed in the lower 6 GHz frequency band, subject to relevant international documents	Preparation of an expert preparatory document for licensing procedure, and rates, if necessary.
	1.4. Meeting the frequency demands of satellite services/applications in line with the National Space Strategy	1.4.1. Assessment of the spectrum needs of geostationary satellite systems	Starting to coordinate international frequency and orbital positions in case of a justified and legitimate demand. Ratio of demands and number of coordination started.
		1.4.2. Assessment of the spectrum need of low-orbit satellites and satellite fleets	Starting international frequency coordination in case of a justified and legitimate demand. Ratio of the number of the demands and the coordination started.
		1.4.3. Modification of the regulation on the national frequency allocations assigned to satellite services on the basis of demand assessment	NFFF amendment.
	1.5. For primarily governmental and PPDR applications, facilitating the efficient use of spectrum and meeting the frequency demands for its operation and development	1.5.1. Development of a concept for reuse of the 450 MHz frequency band (450-457.38/460-467.38 MHz) in the light of a government decision for the continuous use of the band • measurements for the 450 MHz band	Decision-making document on frequency reuse. Market demands assessment through public hearings.
		1.5.2. Monitoring the spectrum demands of PPDR applications (also at an international level) providing frequencies according to the emerging demands, with due regard to the aspects of efficient frequency management, taking into account all available frequency bands • on-demand provision of parts of the spectrum available for PPDR in the 700 MHz frequency band, with due regard to the aspects of efficient frequency management • meeting additional broadband PPDR spectrum needs (AGA, ad hoc systems, DMO) with due regard to the aspects of efficient frequency management • monitoring and supporting European efforts for regional frequency harmonization of emergency response and disaster relief radio applications for the realization of BB-PPDR • on-demand provision of Band 87 (410-415/420-425 MHz) and Band 88 (412-417/422-427 MHz)	Expert decision-making document(s). Initiation of government decision.

Pillars	Overall objectives	Specific objectives	Indicators
		bands for PPDR in the 410-430 MHz frequency band, with due regard to the aspects of efficient frequency management • serving measurement needs for PPDR systems operating in the 410-430 MHz and 700 MHz bands • the military utilization of the frequency set (380-385/390-395 MHz) after the phasing-out of the narrowband PPDR system	
	1.6. Meeting the frequency demands for the development of non-civil radio communications	1.6.1. Provision of the necessary amount of spectrum for national non-civil use, with special regard to national military and NATO demands • on-demand provision of spectrum for non-civil, military systems in the 27 GHz (26.5-27.5 GHz) band, with regard to the conditions of coexistence with civil IMT systems • national support of NATO's operations through the development of a federal spectrum, including the spectrum released by the termination of TETRA technology (in the 380-385/390-395 MHz band) • ensuring the operating conditions of non-civil radio location and air navigation services in the band 6.425-7.125 GHz, taking into account their life cycle, depending on the results of WRC-23 • measurement of non-civil applications in the 380-385/390-395 MHz, 6.425-7.125 GHz and 26.5-27.5 GHz bands	Related radio licenses. International representation of frequency provision at NATO and CEPT/ECC forums.
		1.6.2. Meeting individual national non-civil demands and the use of non-regulated technologies in the framework of NATO and the Zrínyi National Defence and Armed Forces Development Program in times of peace and special legal order	Related individual licenses.
	1.7. Supporting the early introduction of modern, innovative technologies, facilitating the phasing-out of obsolete technologies	1.7.1. Ensuring the frequency needs of national experiments enabling the development, testing and early adoption of the latest technologies (e.g. 6G technology) • strengthening the participation in the related standardization tasks	Expert analysis and decision-making document. Pilot licenses on justified requests.
		1.7.2. Preparing for the phase-out of obsolete or non-frequency efficient technologies and providing the necessary conditions for the implementation. • frequency management measures supporting the modernization of analogue railway systems (160 MHz) • supporting the phase-out of 3G mobile technology • prepare a concept plan analyzing the further application or possibility of phasing-out 2G mobile systems	Regulatory measures (deadlines, consumer protection measures). Raising consumer awareness through communication. Data collection on existing usage. Shutdown of 3G systems. Analysis of the possibility of further application or phase-out of 2G mobile systems.

Pillars	Overall objectives	Specific objectives	Indicators
2. Legal and institutional system	2.1. Supporting the early introduction of modern, innovative technologies, facilitating the phasing-out of obsolete technologies	2.1.1. Revision of the frequency trading system, if necessary • introducing the most innovative frequency trading models available as early as possible in order to further increase spectrum efficiency • making new legislation to support the efficient operation of activities regarding the forced trading of spectrum	Expert material related to the frequency trading and use evaluation model, draft legislation, if necessary.
		2.1.2. Revision of the system of radio spectrum fees, if necessary • for the promotion of the spectrum use efficiency, assess the value of frequency use in non-civil frequency management fields with regard to the economic and social values of the frequency bands • ensure the policy and legal background of radio spectrum fees based on actual frequency use (consumption) in order to facilitate the introduction of future-proof technologies • the fees regulation should be renewed in such a way that its spirit and pricing solutions reflect the application principles of modern telecommunication systems, and the fees reflect the scarcity of spectrum	Completion of the renewed fees regulation. Completion of the study assessing the value of non-civil frequency use.
		2.1.3. Ensuring the active enforcement of regulatory elements that enable efficient spectrum use • review and, if necessary, amend the rules on secondary frequency trading by incorporating new, innovative elements and simplifying them where necessary • promoting shared use of spectrum in light of market acceptance and related influencing factors	Completion of demands assessment, expert analysis material(s). Launching the simplified lease agreement approval system.
	2.2. Drafting and maintaining the legislative framework and conditions pertaining to spectrum management to a high standard	2.2.1. High quality legislation in accordance with the guidelines of Hungary's Electronic Infocommunications Policy, in accordance with the provisions of the Code	Number of legal provisions defining spectrum management during the implementation period.
		2.2.2. Possible and necessary extension of the regulatory limits of the radio spectrum and participation in the development of international regulations	Supporting the preparation of an international expert study.
		2.2.3. Leading contribution to the development of the national legal background of the radio frequency countermeasure necessary for the performance of the tasks arising from the basic purpose of non-civil frequency users, development of the necessary regulations.	Amendment of relevant legislation.

Pillars	Overall objectives	Specific objectives	Indicators
	2.3. Ensuring high quality harmonization tasks in the field of spectrum management	2.3.1. Ensuring legislative conditions for the regulatory environment promoting the harmonization of the use of radio spectrum for electronic communications networks and electronic communications services • examining the observance of the clear and transparent rules for the granting, transfer, renewal, amendment and revocation of radio spectrum licenses in order to ensure the security, consistency, and predictability of the regulatory environment, gathering experience in law enforcement • taking into account the stability of long-term investments in the granting, renewal, modification, restriction, and revocation of radio spectrum licenses • for the flexible and efficient spectrum use, expanding the range of frequency bands and applications in the simplified authorization system that are the most appropriate and least burdensome for the parties	Completion of the related national legislation. Starting procurement to expand the light-licensing system.
		2.3.2. Ensuring technical legal provisions promoting the harmonization of the use of radio spectrum by electronic communications networks and services, implementing harmonized technical conditions • facilitating the rapid development of new wireless communication technologies and applications through a multi-sectoral approach • ensuring access to high-quality, high-speed, wireless broadband coverage for the entire population through service providers • encouraging the shared use of radio spectrum among the different uses of radio spectrum (e.g. LSA, joint spectrum use) in accordance with competition law and in the light of national demands • preventing harmful interference with neighbouring state(s) and, to that end, taking appropriate preventive and interference mitigation measures;	Completion of the national legislation.
		2.3.3. In the course of the amendment of the NFFF, in view of the increased demand for space telecommunications services and the use of radio astronomy, the revision of national frequency allocation in accordance with the International Radio Regulations and the reduction of deviations as far as possible.	NFFF amendment.
	2.4. Ensuring high quality communication tasks in the field of spectrum management	2.4.1. Maintaining external-internal communication at a constant high level, strengthening it as needed: • ensuring the functioning of communication procedures in line with the international and EU institutional system • forwarding important issues in the professional field of spectrum management to the relevant decision-makers and decision-analysts with the help of appropriate contact systems and communication procedures • ensuring the possibility of interdependent communication processes and regular dialogues	Updates and developments of the STIR system to adapt to NFFF changes. Making a new version of STIR available. Number of meetings organized by Hungary in support of the work of international working groups.

Pillars	Overall objectives	Specific objectives	Indicators
		between civil and non-civil users of spectrum and between industry and spectrum management authorities, and experts and also towards co-regulators • continuously providing information for stakeholders, organization of personal meetings, forums, conferences, as well as establishing a customer service point • continuous development of the extensive access surfaces of the registers, data, and knowledge supporting the operative functioning of frequency management and use • applying new communication tools (communication campaigns) in priority areas such as 3G termination, health effects (e.g. electrosmog), CE marking • making the NFFF available at an electronically searchable, user-friendly interface and continuously improving the interface	Number of NMHH employees involved in leading the work of international working groups. Number of consultations, professional events held with market participants and other stakeholders. Extent of use of publicly available databases. Number of communication campaigns held.
		2.4.2. Presentation of the measurement results of public interest of the measurement service and the calculation results based on an information database to the stakeholders • high-quality operation of measurement data publication systems (e.g. SZÉP, e-Szmog), updating them in parallel with the development of technology, and further developing them, if possible	Ensuring the online accessibility of public measurement data. Number showing the use of the publication system.
	2.5. Keeping abreast of technological development with measurement activities facilitating spectrum management	2.5.1. Harmonization of the current measurement system strategy to the current spectrum strategy • annual controlling of measurement system strategy • preparing measurement plan	Harmonized annual measurement plan.
		2.5.2. Continuous provision of measurement capabilities that are able to control the radio spectrum use without being subjected to or causing interference • extension of measurement service activities with new areas, including the performance of tasks related to radio frequency countermeasures • ensuring that measurements are carried out in accordance with the Measurement Service Strategy, the Metrology Plan and current demands • fulfilment of the Metrology Procurement Plan.	The handover of the new metrology laboratory. Number of new bands and technologies in the expansion of spectrum monitoring activity. Establishment of the competence required for the extended tasks.
		2.5.3. Ensuring that the measurement service is prepared to perform tasks related to radio frequency countermeasures	Conducting trainings. Timely availability of necessary technical equipment.

Pillars	Overall objectives	Specific objectives	Indicators
	2.6. The institutional framework of spectrum management must be made more flexible, stronger, more open to users, consumers, and the industry, and its national and international recognition and high standard must be preserved.	2.6.1. Continuous maintenance of high standards of national and international spectrum management work: • continuous support for youth education among employees and managers, including the non-civil (national defense, home affairs) side, which is a slow, time-consuming and costly process, in line with the NMHH Strategy • maintaining and developing a resource planning system that takes into account the expected tasks of spectrum management in the coming years • continuous strengthening of the organization's change management • strengthening process automation with the tools of digitalization	Continuation of the scholarship and internship program. Number of interns. Keeping migration on a minimal level. Strengthening the process culture with workshops, the number of workshops, maintaining the periodic rotation system within the organization to the extent deemed necessary. Position changes within the organization.
		2.6.2. Ensuring the efficient use of processes and records in individual cases • ensuring efficient spectrum management through the continuous use of the latest supporting tools • maintaining a high level of contact with service providers and continuously simplifying and improving the efficiency of service provider data provision	Annually assembling FMS (and eKFGH) development goals according to the planning deadline and incorporating them into financial plans. Annually assembling STIR development goals according to the planning deadline and incorporating them into financial plans.
		2.6.3. Preserving the autonomy of spectrum management at the national level and enforcing our interests in cross-border agreements • reviewing the requirements of cross-border agreements • performing monitoring and mobile measurements	Expanding the capabilities of the spectrum monitoring system. Taking the necessary measures on request.
		2.6.4. Taking health-related measures in connection with the use of radio spectrum and spectrum management • public information on the health aspects of spectrum use • continuing existing consistent and predictable practices during the authorization of the use of radio spectrum in order to protect public health	Initiating communication programs. Expanding measurement capacity, developing an application that helps determining the exposure to electromagnetic radiation.
3. Radio spectrum	3.1. Continuous and precise service of spectrum use and meeting the current spectrum demand at the highest level	3.1.1. Provision of bands for the operation of complementary ground components (CGCs) of the mobile satellite service and Earth stations in motion (ESIMs) and for current and future services and service providers	Available spectrum bandwidth. Number of radio licences issued to CGC stations.
		3.1.2. Radio spectrum provision for governmental use • providing the spectrum needed for government networks	Available spectrum bandwidth used for governmental purposes. Expert study on governmental spectrum demands or individual governmental demands.
		3.1.3. On-demand provision of bandwidth for BB-PPDR	The bandwidth of the spectrum used for BB-PPDR purposes.

Pillars	Overall objectives	Specific objectives	Indicators
		3.1.4. Providing the radio spectrum required for the operation of PMSE applications	The amount of spectrum available for PMSE. Number of dedicated PMSE requests actually served. Changes in the annual PMSE usage intensity measured by the monitoring department.
		3.1.5. Providing sufficient spectrum for fixed civil point-to-point and point-to-multipoint applications • providing sufficient spectrum for mobile backhaul applications in view of the expected significant growth of 5G network traffic	Amount of spectrum available for fixed microwave PP and PMP applications. Preparing and launching a competitive procedure for the 32 GHz band.
		3.1.6. Promoting efficient use and preventing unjustified spectrum accumulation • developing and implementing a framework for examining the efficiency of spectrum use for individual civil and non-civil uses in accordance with ITU recommendations • developing and implementing a policy framework for the event of inefficient use of spectrum	Examination of the determination of spectrum usage efficiency indicators based on the ITU recommendation in Hungarian environment for the evaluation of different types of systems. Determining the maximum spectrum that can be obtained in each competitive procedure.
	3.2. Making available ample spectrum to meet the continuously changing social and economic spectrum demands	3.2.1. Encouraging the introduction of emerging new technologies for efficient radio spectrum management • ensuring the usability of applications that can take advantage of 5G's advanced capabilities • Ensuring the usability of IoT/M2M applications with the technological reorganization in mind • providing the necessary regulatory conditions to meet the spectrum demands of the verticals	Number of studies and events aimed at learning about new technologies. Number of application types undergoing technological change. Determining the amount of spectrum dedicated to use by verticals adapted to the demands.
		3.2.2. Participation in international studies on the 470-960 MHz spectrum band, taking into account national interests • preparing the WRC-23 member state position on the UHF band	Completion of supporting materials.
		3.2.3. Providing sufficient spectrum for satellite applications based on national satellite frequency demands in accordance with international regulations.	Proportion of radio licenses requested and issued under the International Radio Regulations.
		3.2.4. Providing continuously coordination of frequencies used by state-owned satellites and satellite services planned with national participation	Number of coordination procedures initiated.
		3.2.5. Maintaining and expanding the frequency bands that can be used for unlicensed internet services in accordance with harmonized international regulations	The growth of available spectrum amount.
		3.2.6. Meeting the spectrum demands regarding the use of non-regulated technologies in the Hungarian Government's Zrínyi National	Identification of the spectrum and, if necessary, a proposal to amend the regulation.

Pillars	Overall objectives	Specific objectives	Indicators
		Defence and Armed Forces Development Program, on the basis of a survey and evaluation	
	3.3. Ensuring quality radio spectrum use without being subjected to or causing harmful interference, and performing the tasks related to radio frequency countermeasures from non-civil users to a high standard	3.3.1. Continuous provision of the interference-free coexistence of railway communication systems and MFCN systems	Regulatory steps needed to achieve this goal for future networks.
		3.3.2. Ensuring the smooth operation between short-range devices (SRD) and mobile network applications	On-demand provision of measurements, interference tests for SRD and mobile network applications.
		3.3.3. Ensuring the mutual interference-free use of mobile and other services (wired and wireless) in the 700 MHz band in view of the expected intensive use of MFCN • ensuring that there is no interference between the operation of the MFCN and the cable television networks • ensuring that the soon to be phased-out PMSE devices remaining in the band do not cause interference • ensuring the smooth coexistence of broadcasting systems operating in the adjacent frequency bands and other applications operating in the 700 MHz band	Technical tests performed by application type based on EMC measurements. Number of promoting measures and information to ensure interference-free operation. Implementation of modernization support programs. Providing on-demand measurements and interference tests for mobile network- and other applications operating in the 700 MHz band. Providing continuous support and communication between mobile- and cable network operators.
		3.3.4. Ensuring interference-free operation of WAS/RLAN devices and meteorological radars operating in the 5 GHz frequency band	Number of measures taken to ensure interference-free use
		3.3.5. Ensuring the smooth operation of passive Earth exploration-satellite applications operating in the 23.6-24 GHz band (also used for meteorological purposes)	Number of measures taken to ensure interference-free use
		3.3.6. Supporting the harmonization objectives of the European Union, enabling the harmonized spectrum to be made available as soon as possible • extension of the use of the 5 GHz license-exempt band for RLANs in the range 5925-6425 MHz, in particular for point-to-point microwave connections and interference-free operation • on-demand provision of conditions for shared access between different possible technologies • enabling the widespread use of active antenna systems	NFFF amendment. Examining the need for a regulatory and control methodology.
		3.3.7. Ensuring the availability of amateur radio bands, expanding them as necessary in accordance with international regulations	NFFF amendment.

Pillars	Overall objectives	Specific objectives	Indicators
		3.3.8. Ensuring the necessary spectrum usage conditions for the pilot operation of new services and networks (e.g. BB-PPDR, 6G, etc.) when the demand arises, in particular: • providing test and measurement conditions for BB-PPDR systems in the 410-430 MHz and 700 MHz spectrum bands on demand • ensuring the operating conditions of 6G pilot systems according to the 3GPP schedule, but from no later than 2025 • creating test conditions for additional expected interference (e.g. GSM-R-SRD interference)	Ratio of radio licenses and reported requests by radio application type. Number of measurements done.
	3.4. Improving the operating conditions of the solutions promoting the efficient use of the radio spectrum, ensuring its continuous operation	3.4.1. Review of the secondary trade regulatory system to facilitate the usage, taking into account practical experience and efficiency of use	Revision of the rules of procedure. Development of a document on the practical application of the principles governing the approval of transactions in the field of secondary spectrum trading (in particular joint and shared spectrum agreements), taking into account international practices
		3.4.2. Investigation of innovative tools to increase the intensity of shared spectrum use, taking into account national demands	Expert review material.

13. Tools for the implementation of the strategy

13.1. Public policy tools

Public policy includes political decisions affecting the community as a whole and the strategy for the implementation of public goals, as well as the government's response to a problem or issue, the action process. During the public policy process, the government embeds the political visions into specific programs and measures in order to achieve the results set among the goals.

Applicable public policy tools for NMHH's spectrum management activities and radio spectrum strategy can be identified primarily in the following areas:

- developing a general policy framework for all analogue-to-digital and digital-to-digital transitions;
- publishing the draft for the frequency awards roadmap;
- involving professional organizations, creating and maintaining joint professional workshops for the preparation and implementation of activities related to international spectrum management processes (e.g. preparation for WRC meetings and other professionally important international tasks, and activities between meetings);
- creating a bilateral and multilateral institutional dialogue between the authority, experts, co-regulators and other stakeholders, organizing effective public hearings, and creating and maintaining permanent and temporary forums;

- the involvement of Hungarian professional organizations and experts in the utilization of the resources and expertise of institutional experts; ensuring active participation for them, under the guarantee conditions of the enforcement of national interests over institutional interests, in the development of Hungarian interests and in their international standardization;
- making relevant measurement results and calculation results based on a database (e.g. exposure studies) of the measurement service available to both the public and stakeholders;
- strengthening national and international relations and adopting best regulatory practices;
- launching promotional programs for the introduction of new technologies, such as intelligent transport systems, drone-based and other mobility applications, and new digital technologies supporting the education, health and social care systems, with technological reorganization in mind (spread of 5G technology, phase-out of 3G and then 2G, emergence of 6G technology).

13.2. Regulatory tools

Perhaps the most influential elements of the strategic tools are the regulatory tools, the application of which can achieve effective results even in such cases where public policy tools are no longer sufficient and support (development policy) tools are not available (e.g. due to lack of resources). At the same time, it is important to point out that regulation and compliance with regulatory requirements entail costs for the state, the authority and the regulated market. The legislator and the law enforcer, which in this case is NMHH, must consider these costs.

13.2.1. System of radio spectrum fees

One of the most important NMHH regulation is the NMHH Decree No. 1/2011 (III. 31.) on frequency reservation and usage fees, effective from 2011 and amended[52] several times since. Revenue from radio spectrum fees, also referred to as “annual” fees collected under the decree, is the main source of revenue for the regulatory authority, which finances the activities of the spectrum manager.

Among the long-term requirements of the radio spectrum fees system, the need to ensure long-term, predictable and stable funding for the operation of the independent authority and for spectrum management activities is a key issue. The design and development of a proper pricing system is a very complex task and many of the circumstances are constantly changing, which requires constant monitoring.

The pricing system of national spectrum management must be in line with the requirements set out in the Code. The Code requires that, for the optimal use of resources, fees should reflect the economic and technical situation of the relevant market and other relevant factors determining the value of the market (according to paragraph (15) of the Preamble). At the same time, fees should be set in such a way as to ensure the efficient assignment and use of radio spectrum.

The objectives of the radio spectrum strategy include the determination of the value of non-civil frequency use, taking into account the value of the frequency bands, and the performance of related studies. In line with the general objectives, the aim of this study

[52] The latest amendment was issued by the NMHH Decree No. 2/2019 (III. 22.) of the President of the National Media and Infocommunications Authority.

is to identify the possibilities of increasing efficiency. Previous studies on a similar topic can be used as a starting point for the research.

13.2.2. Spectrum access procedures

Section 55 of the Electronic Communications Act, effective from 21 December 2020, states that rights of radio spectrum use may be obtained - under the circumstances prescribed in the relevant legislation - by decision of the Authority (spectrum assignment and radio licence). In specific cases provided for by law radio licences may be requested exclusively on the basis of entitlements to radio spectrum use obtained through a competitive procedure (auction or tender)[53].

Acquisition of entitlements to or rights of radio spectrum use is possible according to the authorization models described in ECC Report 132[54], and presented in Table Table 13.1 in case of direct spectrum access.

Table 13.1 Spectrum access models

Individual authorization		General authorization (no individual rights of use)	
Individual license	Light-licensing		Exempted from the obligation of individual licensing
Individual frequency planning, coordination Traditional authorization process	Individual frequency planning, coordination Simplified process compared to the traditional process The number of users is limited	No individual frequency planning, coordination Registration and/or notification Unlimited number of users, no coordination required	No individual frequency planning, coordination No registration nor notification

Spectrum access through secondary trade is considered to be indirect (i.e. secondary) spectrum access. In the case of indirect acquisition of entitlement to and/or rights of spectrum use (indirect spectrum access), the Party wishing to use a frequency acquires the entitlement or rights in whole or in part from the person who previously acquired the entitlement and/or rights through direct spectrum access (original holder).

The rules of spectrum access are currently defined by the Code in the European Union, thus in Hungary as well, and at the same time, the Code provides **the means of regulating spectrum access** in the manner detailed in this chapter. With regard to national legislation, the Electronic Communications Act is decisive, which, as of 21 December 2020, already contains the new provisions prescribed by the Code, thus complying with the implementation obligation.

Article 5 of the Code includes in the tasks to be performed by national regulatory authorities, among several other tasks, the following: "*carrying out radio spectrum management and decisions or, where those tasks are assigned to other competent authorities, providing advice regarding the market-shaping and competition elements*

[53] The Electronic Communications Act distinguishes between the concepts of right of radio spectrum use and entitlement to radio spectrum use.

[54] https://docdb.cept.org/download/87ccb237-fa9a/ECCREP132.PDF

of national processes related to the rights of use for radio spectrum for electronic communications networks and services". **With this provision, the Code provides national regulatory authorities, including NMHH, with the means to regulate spectrum access.**

13.2.3. Spectrum trading

The main requirements for spectrum trading can be summarized as follows:

- seeking to achieve the most beneficial and efficient use of spectrum for society by developing conditions of trading;
- increasing flexibility in spectrum management and access to spectrum;
- facilitating market entry for new participants and access to spectrum for smaller service providers in order to stimulate market competition;
- complying with the European Union and Hungarian legislative frameworks, such as the Code, the Electronic Communications Act, the Media Act and other relevant legal acts;
- continuously evaluating and taking into account the experience and practices from previous competitive procedures in accordance with the principles set out in the Code;
- having effective, sufficiently deterrent legal consequences of breaches of the rules of awards;
- striving for value-based pricing;
- it should always be clear which other participants the rightsholders have a legal relationship with and which participants has rights and obligations to which participants;
- ensure that the auction or tender is properly announced and thoroughly prepared during the primary trade, so that the users can prepare for the awards in time by preparing appropriate business plans;
- prepare and make available a roadmap of which bands you intend to award (auction or tender), when, mostly by what type of method, and deviate only in particularly justified cases so that awards can be predictable for the market in the long term;
- review and, where appropriate, clarify the rules for secondary trading as required by the Code.

The essential directions and principles of spectrum trading are set out in the Code. It is essential that the transfer of radio spectrum and the leasing of it ensure the effective use of radio spectrum by the original rightsholder (according to paragraph (122) of the Preamble). The conditions for the transfer or lease of individual rights to use radio spectrum are detailed in Article 51 of the Code. This requires the transferability and leasing of individual rights to use radio spectrum between companies. In Hungary, the basic governing legislation for spectrum trading is the Electronic Communications Act, Section 10 (1)(10) of which defines NMHH's activities related to radio spectrum, according to which *"it exercises state ownership rights over radio frequencies and identifiers in accordance with government policy, manages radio frequencies and identifiers, decides on the announcement of the auction and tender for the acquisition of the entitlements to frequency use and conducts the auction and tender procedures for the acquisition of the entitlements to frequency use, and implements European Union acts on spectrum management addressed to the spectrum management authority".*

Further rules on secondary trading are laid down in NMHH Decree No. 7/2015 (XI. 13.) on the national frequency allocation and the rules of using frequency bands (NFFF). The provisions of this Decree on the use of frequencies related to transfer and lease are contained in the paragraphs of Section 11. As part of the implementation of the Code, the revision of the rules is underway during the strategy development period. Regulation related to competition impact assessment has been developed. In the annex to the NFFF, it provides separate names for the frequency bands in which secondary spectrum trading is possible.

13.2.4. Ensuring technology neutrality

In the case of harmonized radio spectrum used for service purposes, the principles of technology- and service-neutral regulation, which are mandatory under the EU regulations, must be observed. Technology neutrality is an important principle laid down in the Code, which should be defined in the case of radio spectrum in such a way as to contain as few restrictions as possible, while ensuring interference-free use. In order to avoid harmful interference, restrictions are sometimes needed which are easier to meet in practice by certain technologies. According to the principle of service neutrality, the holder of the entitlement to or right of radio spectrum use determines for which service they intends to use the given frequency band. In terms of spectrum management, a restriction on a service using a given frequency band, usually, cannot be technically justified. Technology- and service-neutral regulation does not contradict regulation from favouring the use of more advanced technologies over the use of obsolete technologies. By replacing obsolete technologies, in addition to the efficiency of spectrum use, the quality of radio services can also significantly improve, so the preference for modern technology also promotes the spectrum efficiency of specific radio services and the services provided on them. In order to achieve this goal, accessibility must be ensured for as many radio services as possible in all spectrum ranges where this is technically possible and does not cause unacceptable interference (service neutrality). With the provision of the conditions for the use of spectrum, the technology used to provide the service is irrelevant (technology neutrality). Due to the continuous emergence of new technologies in wireless electronic communications, it is necessary to regularly review the rules of spectrum access and the extensibility of the principle of technology and service neutrality.

In line with the provisions of the Code, the most important legislation and regulatory tool relevant to the principle of technology neutrality among Hungarian legislation is the Electronic Communications Act and the provisions contained therein. The version of the Electronic Communications Act effective from 21 December 2020 complies in all respects with the provisions of the Code, and its intention to do so is already stated in the introductory part:

The requirement of neutrality may in some cases make it impossible to successfully apply certain technologies and services across Europe, to exploit the benefits of size- and selection-efficiency, to reduce market segmentation, to take advantage of the benefits of the single internal market, which would contradict the Code’s aspirations. Therefore, the introduction of technology and service neutrality should be pursued in bands where its application does not result in unacceptable interference. A compatibility test is required to demonstrate this. The increase in the proportion of harmonized technology and service-neutral spectrum bands will increase the efficiency of national spectrum management, as no compatibility tests need to be performed for bands classified as technology neutral at social level.

On basis of this, the Authority is tasked with maintaining the necessary balance between counter-effective EU harmonization and flexible spectrum use efforts. On the other hand, it is necessary to ensure enough necessarily technical and administrative regulation for the interference-free use of these bands and for the undisturbed coexistence of the various services and technologies.

13.2.5. National distribution methods for frequency bands

In many cases, due to the significantly different needs and durations of use of radio spectrum users, different authorization approaches are required for the use of radio spectrum. If the number of users requesting the use of the radio spectrum exceeds the number of users that can be served in the available spectrum, simple "first come, first served" service is not an appropriate solution. Distribution mechanisms such as tendering, comparative bidding, auctioning and lottery are then needed. A summary of possible spectrum distribution methods, based largely on the ITU Spectrum Management Manual, is summarized in the following subsections. Some of these methods are no longer used and others are not yet used in national practice. Regarding the spectrum distribution methods used in Hungary, NMHH Decree No. 7/2012 (I. 26.) on certain administrative procedures of civil spectrum management is applicable.

The main spectrum distribution procedures can be summarized as follows:

- Distribution in order of arrival[55]
- Administrative distribution process[56]
- Administrative distribution based on a bid (auction procedure, including incentive auction), comparative bidding[57] (Tender),
- Lottery[58]
- Light-licensing
- LSA[59]
- Geographic spectrum sharing with devices connected to geolocation databases
- Renewal
- other

Compared to the previous regulation, the renewal is a new solution in the Code that can be used to distribute entitlement(s) to radio spectrum use. An important rule is that "*the conditions attached to the renewal of the rights to use radio spectrum must not confer undue advantages on the holders of those rights*".

The distribution procedures of non-civil spectrum use are not motivated by market principles and competition rules, but they are rather based on the principle of social utility. Its procedure rules are regulated by NMHH Decree No. 11/2011 (XII. 16.) on certain administrative procedures of non-civil spectrum management; Pursuant to Section 5 (1) of this decree, frequency assignment is required for the installation of radio equipment and radio systems. An exception to this is the radio systems included in Section 4 of the decree.

Pursuant to Section 7, the period of validity of a frequency assignment is a maximum of three years, which, if the legal conditions are provided, can be extended once, upon

[55] First-Come-First-Served
[56] Administrative Process, referred to in the ITU Spectrum Management Manual as the "Beauty Contest"
[57] So called "Beauty contests with a financial bid"
[58] Lottery
[59] Licensed Shared Access

request, by a maximum of one year. According to Section 10, a radio system may be operated on the basis of a radio license, which may be issued if the radio equipment used meets the requirements set out in the legislation on its placing on the market. In the application for a radio license, the applicant shall provide the relevant information by referring to or repeating the relevant provisions of the frequency assignment. Pursuant to Section 12, the period of validity of a radio license is a maximum of ten years, which may be extended upon request if the legal conditions are provided.

13.3. Incentive tools

13.3.1. Fee discounts

The most common form of discounts is radio spectrum reservation fee, radio spectrum usage fee or band fee discounts related to strategically important radio service operators and radio services. The fees, also referred to as the annual fee to be paid for the use of spectrum for civil purposes, are set out in NMHH Decree No. 1/2011 (III. 31.) on radio spectrum reservation and usage fees. This Decree was last amended by Decree 2/2019 No (III. 22.) of the President of NMHH. The fees regulation lists the fee discounts that can be granted, such as the total fee exemption and the percentage of discounts for the various fees (radio spectrum reservation, radio spectrum usage and band fees).

13.3.2. Incentive fees

As radio spectrum is a limited but reusable resource, it must be used efficiently and effectively to avoid unwanted interference, to maximize the benefits of its use and to ensure equal access to spectrum for existing and potential users. Cost-based pricing policies and spectrum allocation mechanisms based on non-market mechanisms may not be the best solution for managing access to spectrum, as they usually do not encourage the achievement of certain management objectives. Incentive fees are specifically designed to influence the behaviour of spectrum users. Using these solutions well:

- they provide a transparent mechanism to promote efficient use of spectrum;
- prevent users from accumulating spectrum they do not actually need;
- encourage the switch to alternative spectrum bands, if desired;
- provide a method for the rapid allocation of limited spectrum when there is high demand and competition between spectrum applicants.

The overall aim of incentive fees is to encourage more efficient use of spectrum, with the aim of balancing spectrum demand with supply by encouraging users to use more spectral-efficient devices, return unnecessary spectrum and use less saturated parts of spectrum.

13.3.3. Tenders, auctions

In addition to discounts on radio spectrum reservation, radio spectrum usage and band fees, indirect discounts may appear for bands sold through competitive procedure. The relevant regulations must comply with the provisions of the Code (for example, it is possible to give preference to the use of more innovative technologies in case of a tender). The main aspect of giving discounts is to support the objectives set by the radio spectrum strategy and do not cause contradictory effects, so as not to lead to

unjustified band reservation, band accumulation, waste of spectrum, and reduction of competition. Providing them should facilitate the most efficient use of radio spectrum by society, in line with the objective set out in Section 45 (1) of the Code that, which is given that radio spectrum is a public good of important social, cultural and economic value, Member States shall ensure the efficient management of radio spectrum for electronic communications networks and services in their territory.

13.3.4. Areas to be supported

In connection with spectrum management, it is also necessary to strengthen the social role of NMHH related the spectrum strategy in the field of radio telecommunications. Long-term involvement has been and will continue to be of paramount importance in achieving the Authority's spectrum policy objectives, communicating the information society, media and communications values and interests of the public administration, exploiting the opportunities and knowledge provided by innovation and technological development, to raise awareness of a more livable environment.

This engagement is also in line with the Code's expectation that "*National regulatory and other competent authorities should have a harmonised set of objectives and principles to underpin their work, and should, where necessary, coordinate their actions with the authorities of other Member States and with BEREC in carrying out their tasks under this regulatory framework"* and "*The tasks assigned to competent authorities by this Directive contribute to the fulfilment of broader policies in the areas of culture, employment, the environment, social cohesion and town and country planning."* (according to paragraphs (21) and (22) of the Preamble). The role of NMHH is not only to promote and inform about technologies for the provision of electronic communications services, but also to stimulate demand for these services.

In order to achieve the overall objectives of the strategy, a number of specific goals can be achieved through the use of supporting tools. One of the most basic objectives of the authority is to ensure the radio spectrum use without being subjected to or causing interference, for which the metrology and measurement service capabilities must be maintained at all times. In connection with this, the task is, among other things, to organize the service necessary for the measurement of interference elimination in civil and non-civil systems, and to organize the appropriate on-call system. Due to technological development, continuous competence development (staff training, exams, etc.) is essential for interference elimination (including tasks related to radio frequency countermeasures), which has significant financial and support implications.

Similarly, NMHH's task and purpose is to ensure the efficient use of the various registers, which requires real-time, public availability of these registers and the continuous expansion of the amount of data (as a tool). This requires the continuous development of the IT background and, as a part of it, the integration of design systems and design data with the factual data of the measurement system. Keeping the existing systems up to date, further developing the FMS system, ensuring transparency and compatibility with other NMHH systems requires significant supporting tools again and again. This includes extending the online light-licensing to additional frequency bands, also advocated by telecommunications service providers which will require additional funding.

It is important to facilitate the phasing-out of obsolete or non-frequency efficient technologies and to support them within the legal framework provided to the Authority. An example of this is supporting the phasing-out of 3G mobile technology.

From the point of view of the communication of the Authority, it is important to continuously inform the population and those involved in spectrum management, to organize personal meetings, forums and conferences, and to provide their appropriate funding. It is also necessary to ensure the continuous further development of the extensive access surfaces of the registers, data and knowledge that facilitate information. Communication campaigns are mainly used in priority areas, such as information on the phase-out of 3G mobile systems, information on mobile network technologies (e.g. 5G systems, use of 26 GHz) and other health effects (e.g. electrosmog). These campaigns also require the use of significant supporting tools.

14. Monitoring and institutional system of the strategy implementation

An important objective of radio spectrum strategy development is to ensure that its implementation is easy to monitor, that its monitoring and institutional system is uncomplicated, resilient and straightforward, aligned to the Authority's processes. Monitoring the fulfilment of the spectrum strategy does not require a separate institutional system.

Radio spectrum strategy monitoring and monitoring according to the work plan are interrelated as follows:

1. The prorated elements of each task set out in the adopted radio spectrum strategy should be reflected in the Authority's and within that in each organizational units' annual Work Plan, broken down, with the purpose to ensure that the objectives are met outside the work plan monitoring system.
2. The Work Plan includes the timely implementation of the tasks of the radio spectrum strategy for the given year, while the field operates its own monitoring system for measuring the indicators of professional objectives.
3. A prorated status report on the implementation of the approved radio spectrum strategy is prepared by 31 May each year;
4. The annual status report contains:
    a. an evaluation of tasks relating to strategic objectives set out in the Work Plan for the given year;
    b. the actual values of indicators defined for strategic objectives;
    c. strategic priorities derived from the NMHH's strategy and the radio spectrum strategy, as well as related tasks from the Work Plan must be featured in the work plan drafted for the upcoming year;
    d. the experiences of implementation and, based on changes in environment, the tasks not specified among strategic objectives but related to the strategy that have been suggested for the upcoming year's work plan.
5. Deviations from tasks specified in the approved radio spectrum strategy may be permitted by the party having approved the strategy.

15. Financial impacts

The purpose of the development of the Radio Spectrum Strategy is supporting and setting the guidelines of a radio spectrum management that, in accordance with the aspirations of the Code (see Section 45), provides radio spectrum as one of the public goods of important social, cultural and economic value efficient management related to the electronic communications networks and services. Accordingly, the objective is to maximize social and economic utility by achieving set objectives and using the tools assigned for implementation.

When determining social utility, besides revenue that can be used to finance activities that are important for society, we must also take into account improvements in citizens' quality of life and well-being, guaranteeing their access to information, their relations with public administration, the conditions of equal opportunity and the security of the country, and improving the competitiveness and resilience of businesses. Acting on behalf of the state in matters of spectrum management, the Authority is the exercising the ownership rights of frequency assets and engages in the award of entitlements to or rights of frequency use. Taking the approach of 'good stewardship', the Authority strives to put these assets to work to the possible greatest benefit of society. Such benefits are not limited to monetary amounts but also include social utility, or results that are tangible to the population at large. One of the main financial impacts of the strategy is, with the award scheduled of frequency assets, the assessment of the value of radio spectrum, state property and better planning (of expenses). Parallel to this, expenses related to spectrum use become more predictable, with users and interested parties – that is, market players – also becoming better equipped to prepare sound business plans.

Spectrum revenues are published by National Media and Infocommunications Authority on its website as part of the budgets planned for the given years and their budget reports[60].

[60] Accessible: http://nmhh.hu/tart/index/232/Koltsegvetes_koltsegvetesi_beszamolo

16. Acronyms and abbreviations

Acronym	Definition	Hungarian translation
BEREC	Body of European Regulators for Electronic Communications	Európai Elektronikus Hírközlési Szabályozó Hatóságok Testülete
BSS	Business Subsystem	Üzleti (megvalósítást támogató) alrendszer
CEPT	European Conference of Postal and Telecommunications Administrations	Postai és Távközlési Igazgatások Európai Értekezlete
DJP	Digital Welfare Program	Digitális Jólét Program
ECC	Electronic Communications Committee	Elektronikus Hírközlési Bizottság (a CEPT szervezete)
FMC	Fixed-mobile Convergence	Fix-mobil konvergencia
IEEE	Institute of Electrical and Electronics Engineers	Villamosmérnökök Intézete (nemzetközi szervezet)
ITS	Intelligent Transport Systems	Intelligens szállítási rendszer
ITU	International Telecommunication Union	Nemzetközi Távközlési Egyesület
LPWAN	Low-Power Wide-Area Network	Alacsony energiaigényű, nagyhatótávú vezeték nélküli hálózat
LSA	Licensed Shared Access	Engedélyezett megosztott spektrumhozzáférés
LTE	Long-term Evolution	4G mobile network technology
MFCN	Mobile/Fixed Communications Networks	Mobil és fix távközlési hálózatok
MIMO	Multiple Input Multiple Output	Több bemenetű több kimenetű (rendszer)
MNO	Mobile Network Operator	Mobilszolgáltató
NMHH	Digital Welfare Program	National Media and Infocommunications Authority
PMR	Professional Mobile Radio	Professzionális rádiórendszer (PPDR célú)
PPDR	Public Protection and Disaster Relief	Közrendvédelem és katasztrófavédelem
RLAN	Radio Local Area Network	Rádiós technológiájú helyi hálózat
RSPG	Radio Spectrum Policy Group	Rádiófrekvencia-politikával foglalkozó csoport (Európai Bizottság)
SIM	Subscriber Identity Module	Előfizetői azonosító modul (mobilkészülékben)
SLA	Service Level Agreement	Szerződéses szolgáltatásszint
UMTS	Universal Mobile Telecommunications System	Univerzális mobiltávközlési rendszer (3G)
URLLC	Ultra Reliable Low Latency Communications	Nagy megbízhatóságú, kis késleltetésű rádiós átvitel (5G)
WRC	World Radiocommunication Conference	Rádiótávközlési Világértekezlet