National Media and Infocommunications Authority

# National Media and Infocommunications Authority

# Spectrum Strategy 2016-2020

SUMMARY

Prepared by: NMHH

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# Contents

# 1. The Spectrum Strategy – Reason and Purpose

This document contains the spectrum management strategy of the National Media and Infocommunications Authority for the 2016-2020 period. It has been prepared in order to define the strategic tasks of spectrum management for the period at hand, adhering to Hungary's infocommunications policy objectives and taking heed of obligations at international level.

According to the European Commission's report COM(2014) 228: *"Radio spectrum is the basis for wireless communications such as Wi-Fi and mobile phones, and a key resource to other sectors including broadcasting, manufacturing and transport, and non-commercial essential services such as defence, emergency services, and environmental protection. Radio spectrum is a finite natural and reusable resource in high demand, and the devices that use it can easily cross borders. Using spectrum as efficiently as possible throughout the internal market, including spectrum sharing between different applications and users, requires coordination at international level and at European level, taking into account its impact on EU policies."* [p. 1 (3)]

In view of the significance of an efficient, interference-free use of the radio spectrum and its social and economic impact, the constantly changing economic, social and regulatory environment, and the rapid advancement of technology, radio services and providers, a thorough and reasoned preparation is required – with spectrum strategy being one of the key tools thereof. The Authority must be able to respond to the challenges and changes taking place on a broader and narrower basis alike, reconsider its previous practices in spectrum management, take into account the pertaining legislative framework, review its current processes and tasks, adapt whatever third-party processes and tasks can be utilised, and possibly establish new processes as well.

Under the Electronic Communications Act, spectrum management falls within the competence of the NMHH. Harmonised with civilian spectrum management, the use of frequencies for non-civilian purposes, which was brought under the Authority's control in 2010, allow for an efficient use of Hungary's frequency assets.

Based on the domestic regulatory environment effective from 2016, this strategy applies to the 2016-2020 period, covering Hungary's entire radio spectrum and radio applications, civilian and non-civilian alike. During the drafting of the strategy the objectives, directions, tasks, tools and financial impacts were determined based on a thorough review and analysis of economic, social policy, technological and regulatory trends as well as the changing local and international environments that affect spectrum management.

As one of its key objectives, the strategy intends to specify for stakeholders what frequencies the NMHH seeks to provide to users throughout the period ending in 2020, in what schedule and for what purpose, as well as the key directions of regulation for spectrum management. Taking into account the economic and policy environment, the strategy sets out the NMHH's main objectives and tasks for the period at hand, in order to ensure the efficient and interference-free use of the radio spectrum and to allow for secure planning.

With the strategy, the NMHH is capable of meeting the requirement of efficiently managing the scarce national resource it has been assigned with – one that possesses a marked social, cultural and economic value – in both civilian and non-civilian applications.

For analyses, reviews and details supporting the spectrum strategy, refer to the underlying background materials.

## 2. Key considerations for spectrum management through 2020

The following is a list of key strategic target areas and indicators applicable to the 2016-2020 period, to be detailed in Sections 8-10.

## Key target ares

1. **Meeting the increasing demands in mobile broadband**
   For mobile services and to ensure the continuing advancement of mobile broadband, spectrum must be provided and assigned as needed.
2. **Meeting the demands of terrestrial audiovisual broadcasting and digitisation**
   Spectrum required for terrestrial audiovisual broadcasting, the continuing advancement of broadcasting, the digitisation of radio broadcasting must be ensured in line with demands expected at national, regional and local levels alike.
3. **Meeting the demands of narrow and broadband PPDR applications**
   Demands for spectrum necessary for the operation and development of PPDR applications must be met and narrow band spectra must be kept available for future applications for at least another 10 years, while preparing for surges in demand for broadband and taking into account the possible frequencies both currently available and newly released (sale of the 700 MHz band, future regulations of the 410-430 and 450-470 MHz bands).
4. **Preserving the value of non-civilian radiocommunications and meeting relevant demands:**
   Demands for spectrum for the development of non-civilian radiocommunications must be met.
5. **Shared or collective spectrum use**
   A possible expansion of shared or collective radio spectrum use must be evaluated.
6. **Supporting the early adaptation of innovative and advanced technologies**
   It is important to support the early adaptation of innovative and advanced technologies.
7. **Ensuring an efficient and quality spectrum management**
   The legislative framework and conditions pertaining to spectrum management must be drafted and maintained to a high standard. Harmonisation tasks relating to spectrum management must be performed to a high standard.
8. **Establishing a flexible and open institutional structure, attending to communication tasks at a high standard**
9. **Meeting demand for spectrum**
   Ample spectrum must be made available to meet the continuously changing social and economic demands for frequencies.
10. **Ensuring the smooth and interference-free use of spectrum and carrying out measurements related to spectrum management**
11. **The legislative framework for spectrum management must be drafted and maintained to a high standard, with a focus on continuous advancement in regulations and efficiently representing national interests**

## Indicators for key strategic goals

- During the strategy's implementation period, another 160 MHz must be made available to mobile services.
- As an indirect result of implementing the spectrum strategy, by 2020 a minimum indoor service coverage of 99% must be achieved for wireless Internet.
- In bands designated for auction/tender, utilisation procedures must commence during the strategy's implementation period.

- Until 2020 the 470-790 MHz band must be kept available for terrestrial television broadcasting.
- In 2016, preparations must commence for the sale of licences in the 694-790 MHz (DD2) band for wireless broadband.
- By 2020, tendering for broadcasting services in the 470-694 MHz band must be launched.
- In order to effectively prepare for the digital-digital switchover of terrestrial television broadcasting following the date stipulated in EU legislation, possible technological scenarios and their likely impacts must be assessed during 2016, and new broadcasting network plans must be prepared.
- By 2019, the long-term concept for nationwide terrestrial (public service and commercial) and local broadcasting must be completed.
- Preparations are also necessary for the post-2020 launch of broadband public protection and disaster relief (BB-PPDR) systems, which calls for a road map being prepared and a government decree issued by the end of 2017.
- The early adaptation of 5G technologies must be facilitated by, inter alia, meeting early demands for frequencies above 20 GHz for experimental purposes.
- With a view to update the scheme of frequency usage fees, a comprehensive overview and analysis of the entire spectrum (incl. civilian, non-civilian and shared bands) must be completed by 31 December 2019.
- Following its announcement of the EU's telecommunications framework regulation, expected in 2017-2018, the more flexible regulations of spectrum management must be implemented.
- Annual measurement plans must be prepared based on a harmonised measurement strategy and taking heed of the spectrum strategy's considerations.
- Reports containing the measurement results in the 5 GHz band must be prepared by 31 December each year.

The following figure presents the specific dates in the road map of planned frequency sales.

## Roadmap of planned frequency sales during the strategy's implementation period

This table summarises the sales of frequency bands planned during the implementation period, together with relevant scheduling data.

| Radio spectrum sales roadmap | 3400-3800 MHz band | 1452-1492 MHz band | 2300-2400 MHz band | 700 MHz band | 2100 MHz band | 2600 MHz band | 26 GHz band |
|---|---|---|---|---|---|---|---|
| **The (current/planned) provisions of the Decree on the national frequency allocation and the rules of the use of frequency bands (hereinafter: NFFF)** | **Annex 3 Section 4.6** | **Annex 3 Section 4.3.a** | | | **Annex 3 Section 4.4** | **Annex 3 Section 4.4** | **Annex 3 Section 2.10** |
| **The sale procedure** | Auction | Tender | Tender | Tender | Tender | Tender | Tender |
| **Available bands** | 3410-3590 MHZ; 3600-3800 MHz | 1452-1492 MHz | ? | 703-733/758-788 MHz; and max. 4x5 MHz (738-758 MHz) | 1965-1980/2155-2170 MHz or 1920-1980/2110-2170 MHz | 2600-2615 MHz | 24549-24605/25557-25613 MHz; 25249-25445/26257-25453 MHz |
| **Possible band use (applications)** | MFCN (3410-3590 MHz FDD, 3600-3800 MHz TDD) | MFCN-SDL | LSA MFCN/PMSE | MFCN+SDL | MFCN | MFCN | Digital point-to-point, point-to-multipoint |
| **Band availability (reserved bands)** | At the auction closed in June 2001, five 14 MHz duplex frequency blocks were sold in the 3400-3600 MHz band. | | | DVB-T | 1920-1965/2110-2155 MHz | | |
| **EU obligations** | | | | | | | |
| **Referenced EU obligations** | Decision 243/2012/EU of the European Parliament and of the Council, and Commission Implementing Decision 2014/276/EU | Commission Implementing Decision (EU) 2015/750 | Alignment with the acquis in progress | Alignment with the acquis in progress | Commission Implementing Decision 2012/688/EU | Commission Implementing Decision 2008/477/EC | |

| Radio spectrum sales roadmap | 3400-3800 MHz band | 1452-1492 MHz band | 2300-2400 MHz band | 700 MHz band | 2100 MHz band | 2600 MHz band | 26 GHz band |
|---|---|---|---|---|---|---|---|
| Preconditions / notes | | | EU Commission Implementing Decision<br><br>Introduction of LSA in national law | EU Commission Implementing Decision<br><br>Decision of the European Parliament and of the Council on the deadline | Decision on the extension of existing licences in Q3-Q4 2018 | | Decision on the extension of existing licences (25,249-25,445 / 26,257-25,453 MHz) in Q3-Q4 2018 |
| Available technologies | Technology neutral regulation | Technology neutral regulation | Technology neutral regulation | Technology neutral regulation | Technology neutral regulation | Technology neutral regulation | Technology neutral regulation |
| Equipment availability assessed | | | | | | | |
| | **4 December 2014** | | | | | | |
| Date vacated | | | | **5 September 2020** | | | **30 April 2019** |
| Date released | | | | **5 September 2020** | | | **30 April 2019** |
| Date of sale | **Q1-Q2 2016** | **Q1-Q2 2018–2019** | **Q1-Q2 2018–2019** | **Q1-Q2 2018–2019** | **Q1-Q2 2018–2019** | **Q1-Q2 2018–2019** | **Q1-Q2 2018–2019** |

**Table 1: Spectrum sales roadmap, summary**

# 3. The purpose of spectrum management

Radio spectrum, or simply spectrum or frequency management plays an important role in the functioning and development of infocommunications and a host of other sectors (e.g. transport, healthcare, energy) as well. Under the Electronic Communications Act, and in line with Government policy, all management activities pertaining to frequencies are to be carried out by the NMHH from legislation to ensuring the conditions of interference-free operation. This also entails management activities related to electromagnetic waves (radio waves) of up to 3000 GHz at both national and international level. Matters of spectrum policy fall within the Government's competence.

In addition to the provision of spectra 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, civilian and non-civilian radio applications, radiocommunications, radio astronomy and other non-radiocommunications applications (traffic safety, medical diagnostics, medical implants etc.) must also be ensured.

As part of its management activity, the Authority guarantees the conditions of operation to over 40 radio services while handling approximately 1,000 applications and more than 1,000 civilian and non-civilian radio licences. It continuously strives to perform its tasks to a high standard of professionalism and is represented at many international organisations and committees. The Authority is keeping abreast of new technologies, international standards, recommendations, resolutions, decisions, and agreements, and evaluates their applicability in Hungary. It drafts the technical and legal conditions and engages in compatibility assessment and abstract spectrum planning. It 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. It performs continuous radio spectrum monitoring, and works toward monitoring and eliminating interference. It provides the conditions for use of governmental and other non-civilian band requests. It engages in radio licencing and registration. It maintains planning records and meets reporting obligations. It is tasked with dividing and rearranging bands and preparing the conditions of band use, as well as with drafting and continuously updating all other legislation and decrees pertaining to frequency usage fees and spectrum management. It prepares the conclusion of coordination contracts and border zone agreements at both domestic and international levels. It engages in the operative frequency coordination for radio stations and consults on satellite systems. It carries out spectrum auctions and tender procedures.

**The primary objective of the NMHH's spectrum management is to ensure, amidst a continuously changing professional, international legal and technological environment, in line with international and local conditions and with a view to leveraging the possible highest value for society, that the radio spectrum – a scarce state-owned resource with a notable social, cultural and economic value – it has been entrusted with is utilised in the most efficient manner and free of interference, generating the possible highest value for society at large.**

# 4. Challenges for spectrum management through 2020

In the period up to 2020, the NMHH's technological, economic and legal departments, which engage in spectrum management for both civilian and non-civilian purposes, face the following key challenges and questions:

**In accordance with EU regulations and resolutions passed at the WRC-15[1], spectrum demand for mobile services must be aligned with those of terrestrial broadcasting.**

- For mobile services and to ensure the continuing advancement of mobile broadband, spectrum must be provided and assigned as appropriate.
- Spectrum required for terrestrial audiovisual and radio broadcasting and the continuing advancement of broadcasting must be ensured in line with demands expected at national, regional and local levels alike.
- Preparations must commence in due course and relevant tasks must be executed to ensure the suitability of the 700 MHz band for mobile services.
- Steps allowing for a smooth digital-digital switchover must be taken.

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

- The implementation of the spectrum strategy must facilitate the country's rapid and steady development in infocommunications.
- As an indirect result, we must achieve quality, coverage and price indices in wireless broadband infrastructure similar to those of wired NGA developments being rolled out as part of the Superfast Internet Project (SZIP).
- Complex sales models and mechanisms must be deployed to facilitate the early adaptation of the latest technologies. Multi-brand sales and spectrum return facilities must be used to promote an efficient frequency use.
- The gradual phase-out of outdated and inefficient wireless technologies must be encouraged.
- Fair market competition must be strengthened with the use of publicly accessible databases and enhanced transparency.
- By focusing on measurements and enhancing transparency, tangible improvements in service quality must be facilitated.

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

- Demand for spectra 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 of modern spectrum management must be in place**

- Regulations facilitating an efficient spectrum use must be continuously updated, the conditions of operation improved and efficient operations ensured.
- The legislative framework and conditions pertaining to spectrum management must be drafted and maintained to a high standard.
- Harmonisation tasks relating to spectrum management must be performed to a high standard.

[1] World Radiocommunication Conference 2015, Geneva, 2-27 November 2015.

- The early adoption of advanced innovative technologies must be encouraged and the utilisation of their outcomes facilitated, while keeping a constant eye on benefits and striving to recognise and leverage new possibilities.

**Spectrum use free of interference must be ensured**

- As the primary objective, use of the radio spectrum must be available without being subjected to or causing harmful interference.
- Constant technological development of measurements facilitating spectrum management.
- Measurements must be carried out with careful planning and adequate regulations in place, also focusing on the continued development of measurement capacities and keeping abreast of technological advancements.
- The use of modern, interference-proof technologies, devices and radio services must be facilitated.
- Efficient regulatory tools must be in place.
- Spectrum-related management must be ensured with ever-increasing efficiency.
- The institutional framework of spectrum management must be strengthened and made more resilient and more open towards users, consumers and the sector 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 made to simplify and rationalise management processes.
- Management must be made more open by involving market participants and other entities, keeping them informed, and engaging in dialogue and active work relations.
- Ample spectrum must be made available to meet the continuously changing social and economic demands for frequencies.
- Available unused spectra must be assigned to market or non-market users who are capable of creating the greatest value for society.
- A sparing use of frequencies must be encouraged.
- Unused and unallocated bands must be assigned according to a timetable, the sales roadmap of frequency assets must be prepared and kept updated on an ongoing basis.
- Unused but allocated band use must be strengthened on the secondary spectrum market by sanctions (or ultimately, by coercion).
- We must assess the possibilities of new and innovative avenues of sales.
- Various forms of collective spectrum use must be facilitated.
- Demand for frequencies on the medium and long term must be recognised in time.
- International agreements promoting national interests and facilitating national use must be advocated, drafted and concluded.

# 5. The legal and institutional environment

As regards international institutions, the ITU, NATO and a host of national and international organisations involved in standardisation (such as IEC, ISO, ETSI, NIST, ANSI, IETF, 3GPP etc.) play important roles.

ITU[2] committees issue recommendations for governments to enact telecommunications-related legislation. Of the ITU's four major organisational units, the ITU-R focuses its activities on spectrum and radiocommunications at large. It typically convenes every four years at the following two conventions: Radiocommunication Assembly (RA)[3] and World Radiocommunication Conference (WRC)[4]. Usually held every four years, the World Radiocommunication Conference (WRC) is the global venue for discussing and when necessary, revising radio spectrum regulation and management, and the international radio regulations (RR[5]) that governs global use of the radio frequency spectrum and satellite orbit resources. Resolutions and recommendations of the WRC-15 that was held in Geneva between 2-27 November 2015, as well as its agenda items for the upcoming WRC-19 all have a clear and specific impact on the strategy.

At the international level, NATO is a rather significant organisation that regulates radio spectrum use at treaty level. NATO's specialised body for managing spectrum is the Civil/Military Spectrum Capability Panel (CaP3). It is the NATO's sole competent advisory and decision-making unit in frequency management, supporting the Military Committee (MC) and the Consultation, Command and Control Board (C3) in times of peace and war, as well as during periods of tension and crisis in meeting the radio spectrum demands of NATO operations.

Spectrum management may at times be also impacted by additional international organisations (e.g. the World Health Organisation, the International Union of Railways, the WorldDAB Forum for digital radio broadcasting, etc.).

Of European institutions, the CEPT, the European Commission, Parliament and Council, the Spectrum Unit B4 of the Directorate General for Communication Networks, Content and Technology, as well as BEREC, RSC and RSPG are the most prominent. Various European workgroups tasked with planning and operational coordination, such as SEDDIF that is in charge of mitigating the impacts of the digital switchover, also have a notable impact.

Hungary's spectrum management efforts are greatly influenced by the immediate international environment and the fact that, in matters involving border-zone and other spectrum management, bi- or multilateral coordination treaties and border-zone treaties must be reached with up to 10 neighbouring countries, some of which are outside the Community.

Following the paradigm shift of 2010-2011 in Hungarian spectrum management, regulatory affairs, as well as activities related to the media and civilian and non-civilian applications, are expected to continue in a cultivated and consolidated form during the 2016-2020 period.

The National Media and Infocommunications Authority (NMHH or the Authority) is the independent regulatory body over the media, electronic communications and postal sectors. Its nationwide competence is assigned by Parliament, with the President of the Authority being appointed, upon the Prime Minister's recommendation, by the President of the Republic. Bodies of the Authority with autonomous power: 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 NMHH is tasked with the preparation and, subject to

[2] International Telecommunication Union.
[3] Radiocommunication Assembly.
[4] World Radiocommunication Conference.
[5] Radio Regulations.

government approval, implementation of the radio spectrum policy, as well as with spectrum management.

**In the international legal and institutional environments, an effective and successful participation in international organisations is becoming an ever greater challenge. The WRC-15 is a perfect example of the substantial changes the Authority must be prepared to handle. Participation in international organisations must be stepped up to higher-than-before levels. Bi- and multilateral coordination agreements and border zone treaties concluded with neighbouring countries – some of which are outside the European Community – have become utterly significant.**

**In recent years, Hungary's legislative and institutional frameworks have undergone major overhauls, providing greater transparency to market participants as well. Furthermore, the new processes and pending decisions, the constant enhancement of the regulatory environment, and the organisational developments and principles that must be updated on a regular basis all represent new opportunities and new challenges to spectrum management.**

# 6. The user environment

Users of the radio spectrum and their expected demands have been grouped according to key application areas.

## Civilian use

### *Regulatory aspects of mobile applications*

The NMHH's radio spectrum strategy must be in line with the Government's spectrum and communications policies that are yet to be announced. The three major mobile operators find the currently available spectrum assets to be more or less sufficient for a few years ahead. The fourth operator having just been awarded frequencies is interested in acquiring additional bands. Should new bands become available, they intend to commence preparations 12-18 months before the tender or other announcement is published. Recent spectrum tenders have been highly successful in the assignment of frequencies. By taking advantage of regulatory tools available for certain frequency bands (e.g. the 800 MHz band), certain operators have been able to benefit from band aggregation and thus achieve notable savings on investment, while also providing subscribers with better service quality. In the coming years, the frequency demands of mobile operators are expected to increase, thereby justifying the use of the 700 MHz band that is set to be released following the WRC-15 and the related EU decision. It is important that, in the case of expiring frequency licences – such as those related to the 3.5 GHz band – where operators continue to provide services, appropriate transition mechanisms be put in place to migrate subscribers to prospective new technologies. Some argue that civilian TETRA and digital PMR technology ought to be adapted, but the former is not likely to gain a foothold at this time. There are market participants claiming that TETRA technologies should be made available to strategic users in the 410-430 MHz band. The Authority's publication of road maps is a good practice that should be maintained. As a common requirement of all frequency users, the Authority must closely monitor band usage on a continuous basis, interferences and impacts on cable television must be managed from an EMC standpoint, pirates and the use of illegal devices (e.g. jammers) must be eliminated, compliance with power ratings of the ISM band must be enforced – that is, use of bands must be guaranteed to be free of interference.

### *Use of the 800 MHz DD1 band and the 2.6 GHz band*

These bands are used for LTE technology, with affected operators likely to welcome an additional 5-10 MHz. Expectations are also high regarding the release of the 700 MHz band.

### *Use of the 700 MHz band*

The sale of the 694-790 MHz band is poised to be the most important challenge in the upcoming period, both from a regulatory and operator aspect.

Whenever the 700 MHz band is handed over to operators, a total bandwidth of 2x30 MHz will probably be allocated for MFCN purposes. Therefore, this new frequency range will be available in the post-2020 period. This band will likely be used for LTE technology, in conjunction with the neighbouring 800 MHz and later on the 900 MHz bands (LTE-A). Coverage of urban settings with the 700 MHz band can be exploited by also complementing the 1500 and 2300 MHz bands. Antenna Hungária's exclusive nationwide licence for the 700 MHz band expires in 2020, therefore further uses of the band must be conceptualised and the related sales procedure prepared during the current strategy's implementation period. After the release of the 700 MHz band for mobile purposes, carrier aggregation in the 700, 800 and 900 MHz bands can yield significant bandwidths in rural areas as well.

### *Sale of the 3400-3800 MHz band*

The sale procedure of the 3400-3800 MHz band commenced on 11 April 2016. Its use for mobile broadband could be particularly significant in densely populated urban areas. Several possible scenarios can be developed to ensure cooperation between incumbent operators and new entrants.

### *Use of microwave bands*

Based on experiences in the 26 GHz band, additional demand is likely for the 32 and 70 GHz bands as well, from incumbent mobile operators and alternative service providers alike. Microwave backhaul is slowly reaching its limits and will likely be replaced by optical transmission. Around the end of the strategy term, the band thus released can be put to use with 5G technology.

### *Terrestrial broadcasting*

Once decision is made at EU level based on results of the WRC-15, the period through 2020 will be marked by another round of the digital switchover due to the clearance of the 700 MHz band. Given that nationwide digital TV and radio licences for the 470-790 MHz and VHF bands that expire on 5 September 2020, multiplex tenders must commence during the current strategy term. The tender documentation must be drafted and the tender announced within the shortest possible time frame so as to have everything in place at the next switchover. At the time the 700 MHz clearance becomes due, DVB-T2 must be taken into consideration, which can, to some extent, offset the loss of the two DVB-T multiplexes. In case decision is also made for DVB-T2, appropriate preparations must be made in due course, similarly to the analogue-digital switchover. As a result of Hungary's obligations as a member of the EU, the number of networks that can be deployed using today's DVB-T technologies will be below 3 across a significant part of the country, resulting in a notable decrease in the number of channels that are currently available. Maintaining or increasing current channel offerings calls for a shift to new technologies. DVB-T2 makes it possible to attain more extensive coverage using SFN[6] networks. Having two DVB-T and two or three DVB-T2 multiplexes in operation is possible, as is the premise of DVB-T multiplexes being phased out by DVB-T2 at a later stage. An increasing amount of content is now available in HD, with UHD also gaining foothold – SD programming is being slowly replaced by better quality broadcasts. Combined with HEVC, DVB-T2 is capable of transmitting the same amount of channels within the same bandwidth but in better quality.

DAB+ (Digital Audio Broadcast Plus) will only become a viable alternative once broadcasting commences with nationwide coverage. Since there is limited content, demand for DAB+ is lacking. Making public service broadcasting available would make the most sense as the first step, and only after its prolification could commercial stations be migrated to DAB+. An FM shutdown during the strategy term would be ill-advised.

### *Satellite broadcasting*

From a technological aspect, the situation of satellite broadcasting in Hungary has remained mostly unchanged over the past few years, with the market being dominated by four major operators. Programming content is on the rise, and HD channels are now available. Satellite services are currently used by more than 900,000 subscribers.

### *Frequency sales*

There is a distinct demand for having all reporting and communication activities related to frequency sales take place electronically, as well as for having sales procedures being announced at the possible earliest date, with pertaining documentation being available well before the actual announcement. The minimum requirements of frequency use should be included in the sales

[6] Single Frequency Network.

procedure, the non-compliance of which could serve as grounds for the revocation of frequencies. As regards the sale of new frequencies, operators find tendering to be more suitable than auction.

### *Secondary spectrum trading*

Some market participants argue that the collective use of spectra awarded to operators has to do with market surveillance and can influence the market. At the same time, collective spectrum use can boost competition, provided that a new entrant intends to take part in the tender. If a frequency band is shared and used collectively, subscribers in an unsaturated network can access services at higher speeds, whereas a saturated network can cater to more subscribers than two bands with half the bandwidth each – an important consideration of service quality.

### *Other applications*

Needs and expectations can be summarised as follows:

| | |
|---|---|
| WiMAX | Manufacturers and service providers agree that the WiMAX technology will not proliferate in Europe, and this applies to Hungary as well. |
| Cognitive radio | Service providers and manufacturers are on the opinion that the technology is unlikely to take off in Hungary over the next 5 years. |
| Civilian TETRA | Unlikely to be introduced in Hungary. |
| PMR | From a user perspective, a clearance of the 160 MHz PMR band is possible, as is the need for acquiring the 450 MHz PMR band. |
| Whitespace | Unlike previously, mobile operators no longer demonstrated any demand for using “whitespace” radio applications in the 470-790 MHz band. |
| VSAT | In satellite data communication, there is operator demand for the Ka and S bands to operate VSAT systems. |
| IoT/M2M/ITS | The proliferation of IoT/M2M/ITS applications is expected, with a growing number of endpoints. |
| Wi-Fi, femtocells | Femtocell and Wi-Fi solutions could gain significant momentum, as they can divert traffic to users’ fixed-line Internet connections, thereby relieving operators’ bands. |
| MCA[7] | Demand for public services in aviation is increasing. |
| SRD, RFID | The growth of ISM-band applications (SRD, RFID etc.) will continue in the next 5 years. |
| UAS[8] | The use of unmanned aircraft (and drones) is expected to skyrocket among civilian frequency users as well. |
| Mobile Internet | Parallel to the growth of mobile Internet services, the proliferation of smartphones will continue, with demand for social media access via mobile also on a steep rise. Demand for downlink traffic is dominated by video content. |
| Mobile video | The ever-increasing demand for mobile video applications is a precursor to demand for frequencies beyond what will be available in 2020. |
| AeroCGC | Already in demand. |

## Non-civilian use

Currently there is no sign that demand for non-civilian frequency use would emerge over the next 5 years, with implications on the spectrum strategy. Despite recent overhauls of radio equipment by the

[7] Mobile Communications on (board) Aircraft.
[8] Unmanned Aircraft System.

Hungarian military, some outdated devices that are not fully compliant with the International Radio Regulation remain in use due a to lack of funding. Once these are replaced, demand for NJFA applications will be likely. Aside the operating requirements in line with the NJFA, these are not expected to constitute separate targets in the spectrum strategy. It will have to be assesed separately for each band as to whether the Hungarian Defence Forces or other non-civilian users are willing to make any compromises.

### *Unmanned aerial vehicle systems (non-civilian)*

Unmanned aerial vehicle systems (UAS) represent the focal point of the 2016-2020 period. As regards UAV regulation, spectrum management in this field is behind its market-specific counterpart. Decision can be expected after impact studies prepared for WRC-19 have been assessed, most likely during WRC-23.

### *Gap filler radars*

Gap filler radars currently used by Hungary are obsolete, and staffing is difficult. However, their replacement with advanced radars is a financial matter that falls outside the scope of the radio spectrum strategy. Should replacement become possible, the new radars can and must be deployed in line with the NJFA[9].

### *Government communications*

Government communications are governed by Government Decree 346/2010 (XII. 28.). With NISZ Zrt. as the governmental operator, the network in the fixed-line segment is being provided by MVM NET Zrt. Mobile voice services for emergency response agencies are provided by Pro-M Zrt., whose capabilities for data traffic are rather limited, given the technology used. As regards spectrum use by government agencies, a recently completed expansion of PMR (EDR) systems also meant that underlying technologies were to remain for the long term; however, the increased data bandwidth of proposed PPDR systems do call for a shift in, or the coexistence of, technologies.

### *Demands of emergency response agencies and BB-PPDR*

BB-PPDR demands will likely be met with LTE technology. In the 400 MHz range, according to the CEPT/ECC, the 450-470 MHz band is preferred over the 410-430 MHz band. The 450-457.38/460-467.38 MHz range, which is otherwise assigned for civilian purposes, is in part reserved for use by government agencies. For broadband PPDR a minimum bandwidth of 2x10 MHz must be provided using LTE technology. This demand, specified by the CEPT, seems sufficient for Hungary as a start. At the same time, however, according to ITU-R report M.2377-0, demand for spectrum may sometimes vary between 45 and 175 MHz in certain larger cities. In the vicinity of the 400 MHz band, a single future LTE release can be expected to provide required technologies, in the 400-470 MHz range. Until that time, demands can be met using temporary solutions (e.g. carrier aggregation) and other frequencies (e.g. combined TETRA-LTE450 terminal equipment etc.). BB-PPDR demands could also be met using the applicable part of the 700 MHz band, but that would require the band to be released before 2020. Considering the situation in Hungary, the LTE 400 could also be an important supplement to the 700 MHz band. Should international regulatory efforts supported by Hungary and a number of other countries succeed and the 410-430 MHz band is included, in addition to the existing 450-470 MHz band, in the CEPT resolution on broadband PPDR harmonisation, the range of available options could be expanded even further. A list of business models must be explored before BB-PPDR demands can be met. Hungarian users favour the solution of dedicated service provider models (with dedicated spectra); however, commercial and hybrid solutions must also be assessed from both spectrum and cost efficiency. One of Hungary's earlier PPDR applications is the MoLaRi (Monitoring and Public Alarm System), which was deployed using spread spectrum technology.

[9] NATO Joint Civil/Military Frequency Agreement.

# Spectrum requirements of broadband applications

## *The future of the remaining 470-694 MHz broadcast band*

There is currently a lot of debate on whether additional spectrum should be released for broadband mobile – and to the detriment of terrestrial television broadcasting – in the sub-1 GHz range. In many places worldwide, terrestrial broadcasting has been shut down or is being phased out. At the WRC-15, a decision in line with the EU's stance was made for ITU Region 1 regarding the 470-694 MHz range, which is to remain available for broadcasting purposes. Consequently, amendments to the Radio Regulation concerning said band is not expected before WRC-23; therefore, broadcasting will remain the band's primary purpose. Once broadcasting services are cleared from the 700 MHz band (DD2), due foresight must be exercised in Hungary in order to prevent investments by DD2 broadcasters from becoming obsolete in the wake of yet another change in band use following the switchover.

## *Spectrum demand for 5G*

While the approximately 100 MHz of total bandwidth that is currently owned by incumbent mobile operators is sufficient for LTE/LTE-A services, 5G requires even more band with. The evolutionary 5G approach is based on the continuing advancement of LTE, although the emergence of a new 5G technology completely different than LTE (beamforming and beam tracking in bands above 60 GHz) cannot be ruled out either (as indicated by successful tests). As a requirement for true 5G, services must be capable of providing users with 10 Gbps peak throughput and handover delays of less than 1 second. In order to reach 10 Gbps data rates, a minimum bandwidth of 500 to 1000 MHz is required, and that is only feasible in much higher frequency ranges. This just might be possible in the 32 and the 66-71 GHz bands. Although the 32 GHz band is technology neutral and harmonised, it is unused in Hungary and can thus be considered whether to be made available for mobile technologies. No decision on its utilisation is scheduled before WRC-19, thus falling outside the scope of the spectrum strategy. In theory, the band can be used for wireless backhaul traffic until 2020; however, given that preparations are likely to take two years, it is worth considering whether that would already be too close to the expected launch of 5G systems. A number of bands have been proposed for 5G use, one of which is likely to be the 66-71 GHz band, and a sub-10 GHz band will most likely have to be assigned as well. Decisions on 5G bands (24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz) are expected at the WRC-19. Hungary's NMHH could also play an active role in band assignment, in particular with regards to the 32 GHz band that could be put to use later.

**On the mobile market a fourth MNO and a fifth provider planning to launch governmental and commercial services have both been awarded a spectrum licence. The three major mobile operators consider their existing spectra sufficient. In the wake of the WRC-15, the release of the 700 MHz band will be mandatory EU-wide, possibly by 2020. The prospects of this band, set to become available in a few years' time, could give mobile data services another boost. Terrestrial broadcasting is facing tremendous challenges, and the upcoming digital-digital switchover (DD2) will require a series of media and spectrum policy considerations. Users intend to deploy new technologies (incl. 5G) that will require additional bands to be released.**

# 7. Technological environment

## Key trends in technology and regulation

Technological trends that affect all radio technologies:

- Network Functions Virtualisation (NFV) allowing for functionalities and capacities to always match current traffic demands;
- Software Defined Network/Radio (SDN/SDR) allowing for a more efficient spectrum use and a dynamic allocation of radio capacities;
- convergence and increased technological transparency (horizontal aspect) of access technologies (wired and wireless) and applications (broadcasting, broadband Internet).

New regulatory efforts resulting from advances in technology and thus affecting the future of several radioservices:

- technology independent spectrum use,
- global and harmonised frequency assignment (to facilitate roaming),
- further increasing demand for spectra (the rate at which spectrum efficiency is increasing is not enough to keep up with rising demands for throughput).

The convergence of technologies is another trend that can be observed:

- the technological transparency of different transmission and content services is also expected in Hungary (before the continent-wide launch of certain new technologies, Hungary often serves as the test market),
- on average, domestic mobile operators have been implementing major technology investments every two years in order to provide broadband applications and improve efficiency, meanwhile non-linear content services using ever broader bands are on a steady rise.

At an international level – and shortly thereafter in Hungary as well – demand for licenced shared access (LSA) or collective spectrum use will increase, and secondary trading is expected to grow further. Demand for mobile applications aboard aircraft is also on the rise.

Wireless communication of devices (IoT, M2M, road vehicles, aircraft, smart meters, wearables) will show a marked increase, with Hungary set to become host to approximately 70 million endponts over the long run.

Electronic communication means falling outside the currently regulated electromagnetic spectrum have emerged and are gaining ground. In line with international practices, Hungarian regulations apply to frequencies up to 3 THz. As the technology continues to proliferate, in order to ensure competition neutrality it should be assessed as to whether said limit should and could be raised. On a similar note, evaluating the reduction of the lower limit could also be justified.

Cost-effective applications in lawful interception could delay the introduction of various new technologies, especially if local demands are not fully in line with technological possibilities. From a regulatory standpoint – and to ensure, among others, competitive neutrality – it could be necessary to review applicable regulations and facilitate legislation.

## Mobile and fixed service, broadband wireless transmission

### *2G-5G*

In the years ahead, data traffic could rise by orders of magnitude: some envision a thousandfold increase for the 2020s.

Forecasted responses to the challenges of upcoming years:

- small cell deployment,
- proliferation of LTE and LTE-A,
- growth of efficiency-improving technologies, such as carrier aggregation,
- specification, testing and launch of 5G technology,
- introduction of a uniform RAN concept (all mobile technology defined by 3GPP, such as 2G/GSM, 3G/HSPA, LTE, LTE-A, will be supported within a module,
- emergence of software controlled radio devices,
- GSM networks will likely remain in operation as a separate system offering higher-level cooperation towards 4G networks and basic cooperation with 5G networks.

### *Auxiliary MFCN technologies*

Auxiliary MFCN technologies are likely to continue losing significance, eventually disappearing from both the European Union and Hungary. While WiMAX networks could in theory be operated over multiple bands, instead of WiMAX 2 the use of TD-LTE (LTE band 38) – for instance, for roaming – and LTE-A is more conceivable.

### *Wi-Fi*

In addition to the licence-free 2.4 GHz band, use of the 5 GHz band, which provides greater bandwidth, is also gaining momentum. As terminal equipment and network devices are being replaced, Hungary can also register increases in 5 GHz band usage. By 2020, in addition to a more widespread use, the 5 GHz band could also feature LTE. The next stage of development was brought on by Pass Point and Hotspot 2.0, already offering professional (carrier grade) Wi-Fi devices and QoS capability.

Free-of-charge RLAN use primarily via Wi-Fi technologies in community and public spaces, as well as on fixed-access personal and corporate network endpoints is expected to increase, possibly resulting in an extreme saturation of available bands. From a technological standpoint, the use of Wi-Fi technologies could also be made more difficult by services offered by mobile operators in the coming years. At present, the entire bandwidth awarded to MFCN operators (without guard bands) is 564.36 MHz, whereas the amount of spectrum available free-of-charge within the 5 GHz Wi-Fi band comprises 455 MHz. There option of licence-free frequency use in the 5 GHz band also applies to 5G technology.

### *Heterogeneous networks*

The term ‘heterogeneous network’ refers to the facts that mobile networks utilise various radio technology (2G/3G/4G), and even within the same technology the network is composed of various types of cells (macro/micro/pico/femto). Different radio technologies are expected to coexist for a long time, with several smaller cell types – micro, pico and femtocells – having already been emerged, in addition to macro cells.

Dense heterogeneous networks resulting from the large number of mixed base stations present new challenges, with an intelligent and uniform, heterogeneous network being the possible answer.

## Terrestrial broadcasting

Terrestrial broadcasting plays an important role (media policy, mass media) in a number of countries and particularly in Europe, but is no longer assigned the same level of significance in different countries.

### *Digital-digital switchover in terrestrial television broadcasting*

Terrestrial television broadcasting has lately been on a steady decline as far as available frequencies are concerned. After the analogue shutdown and the DD1 clearance, broadcasting must be terminated in further frequency ranges due to the dual function (broadcasting and MFCN) of the 694-

790 MHz (DD2) band. As a result of this obligation, the number of national networks (multiplexes) that could be carried using terrestrial broadcasting would drop to 3, unless a shift to different technologies is implemented. If the current number of channels is to be retained or increased, a migration to another technology must be evaluated.

### *LTE Broadcast*

The European Union had previously introduced the DVB-H standard as a means to facilitate mobile television, but to limited success[10]. The Multimedia Broadcast Multicast Service (MBMS) and its LTE-counterpart eMBMS (standardised by the 3GPP as a part of LTE release 9 and informally called LTE Broadcast) are both promising mobile television specifications that have yet to be deployed outside experimental settings. However, replacing conventional terrestrial broadcasting with LTE Broadcast – or any other – technology is not only a matter of spectrum strategy, it also raises telecommunications policy, economic and sociological concerns[11].

### *Digital radio*

With regards to digital switchover in Hungarian radio, no demand-side information is available, and the lack of receiving devices is also prevalent. To ensure a gradual introduction and proliferation of receivers, an unequivocal commitment on the supply side is required towards the digital platform. Although DAB+ compatible radio units are already available in Hungarian retail outlets, their coverage for the population at large remains minimal. Digital radio units in new automobiles are usually offered as options. Seeing that the average life of cars in Hungary is 12.5 years, we cannot expect large numbers of built-in digital receivers to show up on roads any time soon. However, the situation might change if attractive exclusive digital content were available or broadcasts that can be received with analogue devices were discontinued. This has to do with media policy and as such is outside the scope of the spectrum strategy. Parties involved in frequency management must inform affected decision-makers about pending issues. The technical results of responses given by decision-makers can then be incorporated when the spectrum strategy is updated.

The regional radio market is gaining momentum and likely to improve further; however, the chances of digital terrestrial radio truly taking up and gathering widespread use are rather slim unless the state makes a solid commitment and intervenes.

A breakthrough in Hungarian DAB+ would require the launch of public service broadcasting: with the four state-owned radio stations being in a single DAB+ MUX, an extra 20% in costs would allow additional programming to be included, creating broadcasts that are only available on the digital platform and thereby expanding its appeal.

DRM[12] could operate in bands currently used for analogue radio (long, medium and short-wave), even parallel to existing analogue broadcasts.

### *VHF broadcasts*

Based on data currently available, it is almost certain that FM radio broadcasting in the VHF II band (87.5-108 MHz) is to remain unchanged for the next 10 years. This frequency range is not particularly valuable for other, e.g. mobile, uses, and the digital technology that could be used instead (DRM+) has yet to obtain a foothold.

[10] Its failure was largely due to the absence of a viable business model: apparently, very few people would be willing to subscribe for a reduced-value service that is adapted to small screens, and even free-of-charge programmes failed to keep people before screens for more than a couple minutes a day. The platform also lacked support from content producers, and quality was not up to par.
[11] Distinctions betwen the ‘lean back’ and ‘lean forward’ attitudes in media consumption can already be made in Hungary as well. While the supply of streaming services remains limited, it is indeed growing. However, the lack of demand by affluent users will most likely be a hindrance to ts large-scale deployment.
[12] Digital Radio Mondiale.

## Avenues of development for point-to-point and point-to-multipoint systems

When used below 6 GHz, point-to-point[13] and point-to-multipoint[14] systems do not require line of sight (LoS): inexpensive terminal equipment can be used to serve these connections en masse. Line of sight is usually required for broadband traffic above 6 GHz[15].

Features of the latest microwave point-to-point systems:

- in widespread use: 2048 QAM
- commenced: 4096 QAM
- bandwidth is 112 MHz, up from 56 MHz.

## PMR/PAMR systems

Analogue PMR systems intended for civilian use have disappeared from the 80 MHz band and can be replaced by non-civilian systems. Meanwhile, new civilian systems, primarily using digital PMR, have appeared in the 160 MHz band. Analogue systems will be phased out from the 450 MHz band without intervention as devices reach their useful life, unless other incentives are applied. Throughout the current strategy's term, the civilian TETRA is not expected to take off due to a lack of demand.

## Broadband wireless transmission systems and radio applications in aviation

Demand for omnipresent Internet access will continue to grow in both private and business segments, and is needed by aviation stakeholders also. The solutions:

- mobile communications services on board aircraft (MCA) systems,
- connection via satellite technology,
- direct connection to terrestrial networks (e.g. DA2GC[16] )
- hybrid technology of integrated satellite and complimentary terrestrial network components (e.g. the CGC[17] using MSS and auxiliary terrestrial components, or the Aero CGC in the S band).

## Unmanned Aerial Systems

Unmanned aerial systems (UAS[18]) represent a special field of aviation. Unmanned aircraft are either controlled remotely or perform autonomous flight missions, but the combination of these two is also rather common. Such aircraft can be flown for military, government/law enforcement, commercial or recreational purposes. That said, additional future uses may also be possible. Thanks to mass production, prices have dropped so low that recreational devices are now available at retail level. These typically operate on licence-free – mostly SRD – bands (such as the 2.4 and 5 GHz and the 433 MHz ISM bands). In addition to hobby devices, more robust commercial applications have also been launched. CEPT and EU workgroups are working toward assessing the suitability of the band assigned by the WRC.

[13] a radiocommunication system operating as part of a fixed service and consisting of two stations linked exclusively with each other via radio [4].
[14] a radiocommunication system operating as part of a fixed service, in which all user stations connect to the central station directly or via a repeater, without user stations being directly connected via radio[4].
[15] In case of NearLine of Sight, available data rates drop significantly when the frequency is increased.
[16] Direct Air-to-Ground Communications, and Broadband Direct Air-to-Ground Communications (BDA2GC).
[17] Complementary Ground Components.
[18] Unmanned Aircraft System.

From a spectrum management standpoint, unmanned aircraft are to be sorted into categories according to the ITU-R M.2171. Based on a 2009 ITU review, the assumed total demand for spectrum is 34 MHz for terrestrial and 54 for satellite communication links. Ground communication in the 5030-5091 MHz range and satellite links in the 5000-5150 MHz range were discussed at the WRC-12. Partial agreement on band sharing that ensures the remote control, monitoring and aeronautical guidance of, and the connections providing sensory functions for, unmanned aircraft systems (UAS) was reached on the last day of WRC-15: use of the satellite band for this purposes is subject to approval of the impact studies prepared for WRC-19.

## Programme making and special events (PMSE)

PMSE applications are intended to meet the specific frequency needs that may arise in programme production (e.g. live reporting) and the coverage of special events such as concerts, athletic events or any other major (e.g. religious) outdoor event. PMSE applications can be classified into 3 categories: audio transmission, video transmission (with or without audio), and the transmission of other (control) signals. For PMSE applications the use of limited shared access (LSA) could be recommended, as it increases the available bandwidth while also improving spectrum utilisation rates. Products/solutions using alternative technologies (3G and 4G) cannot fully substitute devices operating on dedicated frequency bands; therefore, frequency allocation for PMSE applications must continue in line with European regulations. Devices may be subject to testing, particularly in the 5 GHz Wi-Fi band, where some devices may not comply with emission power requirements.

## Short range devices (SRD)

Under ITU regulation SRDs do not constitute a radio service. According to ITU-R SM.2153-4, SRDs may feature integrated or external antennae and all types of modulation and channel pattern can be permitted, and may be regulated at national level. Short range devices have in recent years become accessible to an ever greater number of users, with a host of new areas of application added. SRDs can operate in various frequency bands and are generally exempt from individual licencing. The management and elimination of device interference is a particularly important task. In the near future, as technologies and applications advance, wireless SRDs are expected to continue growing at a massive rate. RFID devices used for identification or data storage and transmission, capable of operating on various frequency bands and providing enhanced protection of privacy are gaining importance. As a result of widespread use, rising device numbers will likely cause growth in demand for SRD spectra, thus calling for the allocation of additional SRD bands or the extension of existing ones.

Ultra-wideband devices (UWB) represent an important subcategory of SRDs, with new areas of use being continuously added. There can be a host of different home automation functions, and demand for spectrum can be increased also by metering devices such as water or heat meters. For body-mounted and medical alarms, wireless access is of essential importance. A steep increase in demand is expected in this field. For vehicle-borne SRDs, harmonisation is particularly important, as vehicles are free to move between countries and the devices installed in them can therefore appear and operate anywhere. As regards hearing aids, systems operating on FM and licence-free bands, in the infrared range and analogue audio frequency induction loops (AFIL) as per IEC 60118-4 have gained the most momentum. The recommended replacement system (Telecoil Replacement System, TRS) could indeed replace single-channel induction loosp with radio, thereby opening up a broader area of usage. These devices are recommended in the 915-921 MHz range with emission powers not exceeding 10 mW.

# IoT/M2M applications

## *IoT and M2M*

M2M[19] and the broader "Internet of Things"[20] both refer to communication between machines, the global number of endpoints of which is expected to rise to above 50 billion by 2020, with around 70 million in Hungary. Most devices will connect to the Internet wirelessly – the narrow band is sufficient for communication. As devices will also result in the collection and processing of data at quantities significantly greater than today, data protection and security in this field will pose yet another challenge. Device communication is undergoing spectacular development in the automobile industry, with the deployment of autonomous road and aerial vehicles (drones) becoming ever more widespread. As the prolification of remote sensors and radars built into vehicles is expected to grow at never-before seen rates, driving an automobile will soon require multiple radars operating in various bands (5 GHz Ultra Wide Band Radar, 24 GHz Narrow Band Radar, 77 GHz Multi Mode Radar, 79 GHz). Since 2014 a number of manufacturers have been shipping their vehicles with 3G SIM cards on board to be used with their online security, information and entertainment systems. In the European Union, the eCall regulation on emergency calls will take effect in April 2018.

## *Satellite positioning (Galileo, GPS, Glonass, Compass)*

Galileo is a positioning system intended to free Europe from dependence on America's GPS. With a proposed launch in 2016, it could result in the gradual rise of dedicated end user devices, in addition to the GPS positioning devices that already enjoy massive popularity in Hungary as well. With two new satellites recently added, the entire network will require a total of 30 units for normal operation, all planned to be put into orbit by 2020.

## *Public protection and disaster relief (PPDR)*

Recent natural disasters and the necessity of being able to handle various phenomena of society call for the rapid development of response networks. The CEPT/ECC treat PPDR systems and pertaining radiocommunications as matters falling into the competence of sovereign nations. European countries have vastly different requirements for PPRD. At concept level, broadband PPDR systems are composed of two parts: wide area (WAN[21]) BB-PPDR networks and ad-hoc BB-PPDR networks providing additional temporary capacities. The future of the 450 MHz band has yet to be clarified at pan-European level. As for applications, there are chances for an LTE-based, supplementary PPDR service in the 410-430 MHz band (which could be used for broadband transmission, perhaps in addition to the existing narrow-band TETRA). Hungarian response agencies using TETRA technologies have already indicated their demand for faster data rates (BB-PPDR). However, the advanced Tetra Release 2, the TETRA-TEDS[22] solution that features improved data transmission can only become reailty after a major overhaul on the current TETRA system, requiring several years at least.

Bands are likely to be assigned for PPDR applications in the 700 MHz band. Relevant regulations will be drafted during the spectrum strategy's term. A total bandwidth of 2x30 MHz is likely to be allocated to MFCN networks, but talks are currently underway on whether to include PPDR in said 2x30 MHz band or in remaining bands, also considering the possible use of the 400 MHz range as a complementary band. By the time the 700 MHz band is put up for sale, these questions must be clarified. In the 400 MHz band, ongoing CEPT negotiations indicate that the 450-470 MHz range can be better utilised for PPDR purposes than the 410-430 MHz range.

[19] Machine to Machine.
[20] Internet of Things.
[21] Wide Area Network.
[22] TETRA Enhanced Data Service (TEDS).

At present, Hungary plans to use the 410-430 MHz band for dedicated broadband (BB) PPDR networks (2x5 MHz, 410-415/420-425 MHz, with an option for 2x2 MHz directly above).

## New technologies and solutions facilitating an efficient spectrum use

Key technologies and systems both recently introduced and expected in the future, with a direct impact on development and spectrum efficiency:

- active antenna systems, MIMO, carrier aggregation,
- intelligent self-organising networks (SON/ISON),
- self-interference cancellation (SIC),
- pattern division multiple access (PDMA),
- low power, high range networks.

In view of the spread of these technologies, future distinctions between TDD and FDD are likely to become redundant.

## Regulatory tools facilitating an efficient frequency use

Spectrum use is defined along the dimensions of frequency, space and time. At one extreme of licence regulation, the use of certain devices in specific bands (e.g. Wi-Fi) is not subject to any licences. At the other, the frequency licence specifies the eligible organisation (non-transferable licence), the frequencies at hand, and possibly the underlying technologies or other technical parameters (emission power, encoding, channel pattern, guard bands etc.). Broadcasting is a good example. In between the two extremes there are a number of novel alternatives, all of which are primarily intended to ensure a more efficient and flexible use of spectrum. ASA[23] is a method centred on taking advantage of dynamic changes in spectrum use, and is based upon the LSA[24] concept. According to this, the frequencies unused by an incumbent application at any given time and place can be utilised in a shared, interference-free manner, subject to individual licence.

### *LSA*

Radio spectrum as a multi-dimensional resource can be shared by various types of frequency use in the following three categories (fig. 1):

- {0}, {1,2,3}: of the three dimensions, only one is shared at most,
- shared access {4,5,6}: only one dimension of spectrum use is different,
- collective use{7}: users share all three resource dimensions.

Of these categories of resource sharing, collective frequency use – i.e. when the same frequency block is shared by mutliple users at the same time and space – is most relevant from a spectrum strategy standpoint[25].

| Shared dimensions of various types of frequency use | |
|---|---|
| Space | Time |

[23] Authorised Shared Access.
[24] Licensed Shared Access.
[25] In theory, shared frequency use can be spatial (when the same frequency range is being accessed by users from non-overlapping geographic areas), temporal (when the same spectrum is being accessed by users at different periods, such as the various seasons during the year), or collective, where each user only accesses a separate segment of the given frequency band.

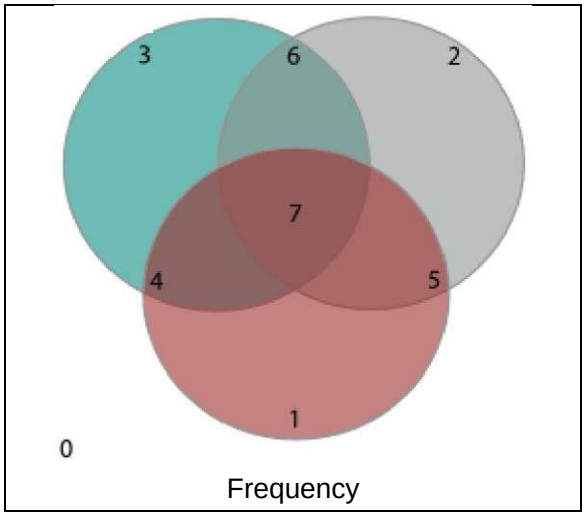
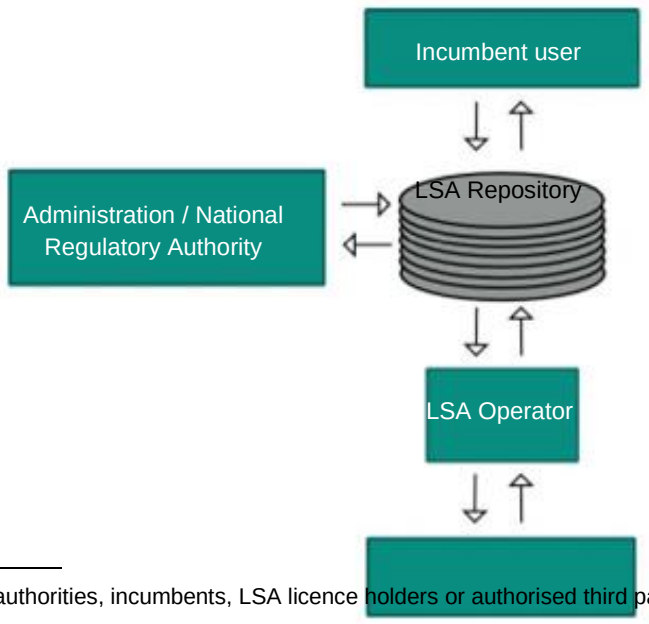



**Figure 1: Possible shared dimensions of frequency use**

Due to continuously increasing demands, frequency use based on licenced shared access is recognised as an EU objective. Figure 2 represents the possible schematic operation of LSA: In the model:

- LSA data repository refers to a registry ensuring acess to information on spectrum availability and relevant conditions;
- LSA operator[26]: handles access to spectrum subject to LSA licence based on the following data:
  a. files of incumbent frequency users stored in the repository,
  b. rules of the sharing framework,
  c. the band made available to the LSA licence holder;
- incumbents are band users who had already been functioning, or recognised, as such even before the LSA was introduced;
- regulations are made and maintained by the Administration/National Regulatory Authority, which serve as the basis for the system;
- by definition, LSA licence holders are band users who operate applications different than those run by incumbents.




[26] In theory, national regulatory authorities, incumbents, LSA licence holders or authorised third parties can all function as the pertaining IT system's operator.

**Figure 2: Possible block diagram for LSA**

The LSA model is only expected to really take off once we start experiencing severe shortages of spectrum. Over the strategy's term, this is not likely to take place, particularly among mobile operators.

### *Secondary trading*

An efficient use of spectrum is also facilitated by secondary trading. As a prerequisite, primary trading – and the licencing procedure as part thereof, allowing for resale – must have already been completed. Secondary trading has yet to gain widespread acceptance. In the currently effective framework, besides the importance of interference protection, secondary trading is subject to approval by the Authority. Some operators hold that the introduction of secondary spectrum trading is, or will be, necessary primarily in the point-to-multipoint bands (e.g. 3.5 GHz and 26 GHz).

At present, there is an agreement between Telenor Magyarország and Magyar Telekom on collective frequency use for the deployment of LTE800 (which, from a regulatory aspect, based on the rules of secondary trading).

## Challenges posed by harmful interference

Ensuring protection from interference is one of the key arguments for radio spectrum regulation. Interference may occur due to the specifications of a given technology or because of the characteristics of wave propagation. With the emergence of new technologies, new spectrum strategy implications may also arise: interference can now occur with not only other radio services but also with technologies used in frequency ranges typically reserved for fixed-access.

Interference issues between LTE and cable television has been covered by several news articles. LTE technology uses OFDM modulation on the downlink, with potentially greater signal density as opposed to previously used MFCN technologies. The presence of even relatively low-power LTE signals could interfere with cable modems. Furthermore, LTE terminal equipment can cause significant interference in set top boxes (STBs) resulting in reduced picture quality and loss of data transmission, even at a distance of several metres. Such interference may occur not only in the presence of LTE terminal equipment but can also be generated by nearby LTE base stations. With the use of indoor femtocells on the rise, these could further intensify. Interference elimination will have the Authority involved as a mediator.

## Cloud services, virtualisation, and network function virtualisation

The cloud computing model provides access to a shared set of configurable IT resources from any given location at any given time. The system is based on the idea of having large consecutive capacities (which, at times of high utilisation can improve economies of scale) dynamically shared between users, similarly to the services (e.g. electricity) of utility providers. After their recent migration of their IT infrastructures into cloud-based services, some telecommunications providers are already assessing the option of making the various functions of telecommunications equipment available via the cloud (virtualisation), which could bring about a paradigm shift in the industry.

Cloud computing in telecommunications has the following four dimensions:

- network function virtualisation (NFV;
- use of software-defined networks (SDN);
- cloud-enhanced radio networks (e.g. centralised RAN);

- complete automation and cloud management of radio, transmission and connection elements of the network.

**With terrestrial GSM mobile technology remaining in use, mobile broadband will be based on LTE technology and its more advanced versions (LTE-A). The surge in M2M communication over mobile access networks will call for new types of shared access (LSA). The impending shutdown of nationwide terrestrial television broadcasting in the 700 MHz band and its subsequent handover for MFCN purposes will pose challenges for spectrum management and media policy alike. In digital radio, T-DAB (DAB+) and DRM technologies are already available. Wireless short-range (SRD) technologies, such as RFID and software-determined radio (SDR) are playing an ever more important role. Cloud technologies are likely to be embraced by mobile networks, as is the case with RAN. The growing number of novel technologies and devices, as well as related interference issues will pose additional challenges to spectrum management.**

# 8. The three strategic pillars of spectrum management

The spectrum management model is composed of **direct and indirect elements** (pillars and horizontal aspects) **determining spectrum management and thus the strategy** as well:

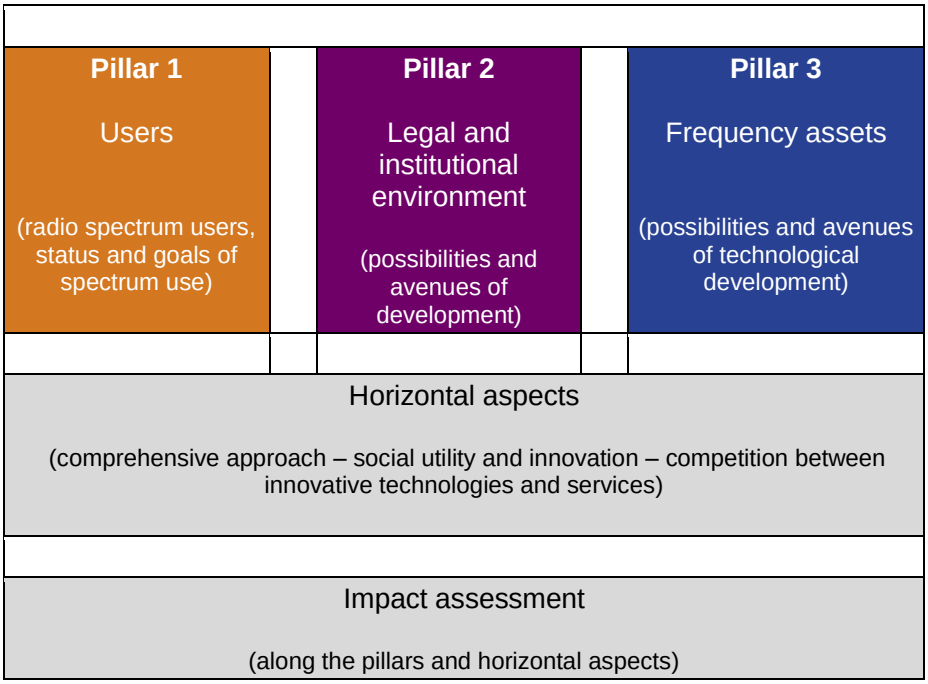



**Figure 3: The pillars of the spectrum strategy**

The three factors, or pillars, with a direct influence on spectrum management are:

*users – legal and institutional environment – radio spectrum*

The available frequency assets, or radio spectrum – together with its technological characteristics, possibilities and limitations – represent the single most crucial element of spectrum management. The local and international legal and institutional environment is a collection of factors directly impacting and determining spectrum use, as well as the possibilities and conditions thereof. Users of the radio spectrum can be natural or legal persons, or organisations without legal personality utilising or requesting scarce resources, thereby creating economic, social or cultural value for themselves or for society, whether in part or as a whole.

When preparing the strategy, our analyses were based on the following horizontal aspects:

1. comprehensive approach – social utility and innovation;
2. competition between innovative technologies and services;

As the first horizontal aspect, the comprehensive approach takes the significance and interpretation of pillars based on value chains and with a narrower focus on radio spectrum, and extrapolates them to society at large. The second aspect, the competition between innovative technologies and services, is of great importance in this area. That competition between innovative technologies and services is perhaps most disruptive in the field of infocommunication – and mobile technologies and services therein – is no mere coincidence. Thanks to its role in ensuring sustainable growth, this competition is recognised as a priority in the European Community's policy making as well. In the continuum of spectrum management activities, openness is indispensable. The task entails more than the Authority merely handling the accounts of the scarce state-owned resource – the radio spectrum – it has been assigned with. The manager is also responsible to engage in a more complex

management of assets, one that also takes higher level social-cultural aspects and interests into consideration. This requires a shift from the Authority's previous stances. In spectrum management, this shift will be reflected by new elements focussed on social utility and a spectrum-centred comprehensive approach that 'expands' direct factors based on value chains.

Technological advancement relating to spectrum use is unrelenting. This is driven by innovation, the emergence of novel technologies and services, as well as their competition for users and consumers, which could serve as the basis for sustainable consolidated growth. Beyond the day-to-day responsibilities, this continuous development and competition pose a constant challenge to the Authority, which must keep a particularly close eye on the competition of innovative technologies and services if it were to secure sustainability of spectrum management for the long run.

The strategic situation review was prepared in line with the Government's strategic planning methodology and taking horizontal aspects into account. Key elements:

- impact assessment of characteristics and processes identified along strategic pillars;
- value-based (quantitative) prospects;
- target value-based (qualitative) prospects;
- identifying strategic targets and alternatives;
- elaborating a set of strategic conditions;
- assessing the consistency and coherence of the strategy.

Based on the above assessment and evaluation of environmental impacts and strategic pillars, the following chapter contains a summary of the National Media and Infocommunications Authority's overall goals in spectrum management for the 2016-2020 period.

# 9. Overall goals of the radio spectrum strategy through 2020


**Figure 4: Overall goals of the NMHH's radio spectrum strategy through 2020**

# 10. Specific objectives and indicators of the radio spectrum strategy through 2020

The overall goals of the radio spectrum strategy have been broken down into specific objectives. These are presented in the following table under each overall goal, also detailing the indicators of implementation.

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| 1. Users | 1.1. For mobile services and to ensure the continuing dynamic advancement of mobile broadband, spectrum must be provided and assigned as appropriate. | 1.1.1. Ensuring the availability of frequency bands for mobile data according to market demand:<br>• preparing a bandwidth of 160 MHz for new applications;<br>• the 700 MHz DD2 band (694-790 MHz): preparing the conditions of mobile band use and announcing the tender already before the band is cleared by the date specified in EU legislation;<br>• preparing the 1452-1492 MHz band for SDL applications;<br>• decision on the utilisation of the 2100 MHz band;<br>• sale of the 2300-2400 MHz band;<br>• sale of the 3400-3800 MHz band;<br>• 5G spectra above 20 GHz: in the 2017-2020 period, Hungary must start preparing for the release of 5G bands; results of the WRC-19 should be adopted in a short time frame so as to allow for the earliest possible deployment of domestic experimental networks;<br>• decision on the utilisation of the 26 MHz band;<br>• preparing for the expiry and subsequent renewal of mobile operator licences, preference to multband sales. | During the strategy's implementation period, another 160 MHz bandwidth must be made available to mobile services.<br>By 2020 a minimum indoor service coverage of 99% must be achieved for wireless Internet.<br>Start of tendering in bands designated for sale.<br>Preparation of an internal schedule derived from the sales roadmap, to be included into the NMHH's tasks. |
| | | 1.1.2. International engagements<br>• Conclusion of international coordination agreements at the possible earliest time to facilitate deployment of broadband technologies.<br>• Strengthening of notification activities toward the ITU to ensure the protection of services already in operation. | Initiating the conclusion of necessary coordination agreements.<br>Identifying the services to be notified and clarifying the notification procedure with the ITU. |
| | | 1.1.3 The possibility of further extending shared band use must be assessed. | Compiling pre-decision materials for experts. |

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| | 1.2. Spectrum required for terrestrial audiovisual and radio broadcasting and the continuing advancement of broadcasting must be ensured in line with demands expected at national, regional and local levels alike. | 1.2.1 Preparation for the digital-digital switchover due to DD2 clearance:<br>• In order to effectively prepare for the digital-digital switchover following the date stipulated in EU legislation, possible technological scenarios and their likely impacts must be assessed during 2016<br>• Preparations must be made for all (likely three) possible scenarios<br>and related activities.<br>• Actual risks as well as real demands (e.g. for transmission) must be assessed, negotiations must be held as necessary.<br>• To the extent permitted by spectrum management, television programming content intended for terrestrial broadcasting and the number of channels must be evaluated and the conditions of ongoing operation of multiplexes containing public service programming must be ensured, while maximising the coverage area.<br>• The penetration of appropriate receiving devices must be facilitated, also taking whatever action is necessary to ensure their accessibility.<br>• The Authority must carry out awareness campaigns to educate the population about the DD2 switchover.<br>• Applicable international coordination activities must be continued and stepped up, taking all possible scenarios into account. | Analytical and pre-decision report by experts.<br>Until 2020 the 470-790 MHz band must be kept available for terrestrial television broadcasting.<br>By 2020, tendering for broadcasting services in the 470-694 MHz band must be launched.<br>Implementation of spectrum management-related elements of the subsequent decision.<br>Preparation of new broadcasting network plans.<br>Initiating an international coordination of the plans. |
| | | 1.2.2. To ensure the growth of digital radio, sales of multiband devices must be promoted. | Preparations. |
| | | 1.2.3. By 2019, the long-term concept for nationwide terrestrial (public service and commercial) and local broadcasting must be completed, encompassing<br>• an analysis of possible scenarios in television (trends, demand side analyses, consumer behaviour, media policy and demand-side requirements, scenarios of growth, decline, phase-out and migration, all in line with European plans and practices);<br>• revisiting the network of public service UHF stations, the long-term plans of MW and SW radio, as well as the possible means of and schedule for ensuring a broader use of digital technologies (e.g. DAB+, DRM30/DRM+ etc.). | Report detailing the concept. |
| | 1.3. Demand for spectra required for the operation and development of PPDR applications must be met. | 1.3.1. Ensuring the availability of spectrum required for maintaining narrow band PPDR applications. | Applicable radio licences.<br>International representation of spectrum management at NATO and CEPT/ECC level. |
| | | 1.3.2 Preparations for the post-2020 launch of broadband public protection and disaster relief (BB-PPDR) systems.<br>• Scenarios must be drafted for possible, or recommended, solutions of introduction and alignment, taking into account the peculiarities of the domestic market.<br>• To ensure BB-PPDR implementation, pan-European efforts concerning the regional frequency harmonisation of response and | Pre-decision materials.<br>Scheduling through end of 2017.<br>Calling for the enactment of a Government Decree. |

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| | | disaster relief radio applications must be supported with adaptable participation.<br>• The exact demand for spectrum use by BB-PPDR applications must be assessed and relevant usage scenario prepared, taking current local conditions and spectrum use into account. | |
| | 1.4. Demand for spectra for the development of non-civilian radiocommunications must be met. | 1.4.1 Making unregulated technologies resulting from non-civilian domestic demand and from Hungary's membership in NATO available for temporary periods. | Applicable radio licences. |
| | 1.5. Supporting the early adaptation of innovative and advanced technologies | 1.5.1 Assisting the early adaptation of 5G technology. Meeting early demands for frequencies above 20 GHz for experimental purposes. | Applicable radio licences. |
| | | 1.5.2. Meeting demands resulting from IoT, PMSE, satellite and other technologies, as needed. | Applicable radio licences. |
| 2. The legal and institutional environment | 2.1. Supporting the early adaptation of innovative and advanced technologies | 2.1.1 Updating the system of frequency fees:<br>• establishing and reviewing the system of charges pertinent to radio applications available for new modes of use (e.g. AeroCGC);<br>• with the economic and social value of frequency bands taken into account, assigning a monetary value to frequency use in non-civilian spectrum management, in order to improve the efficiency of spectrum use;<br>• policy and legal preparations must be made for consumption-based frequency charges, in order to facilitate the introduction of future-proof technologies. | A comprehensive overview of the entire spectrum (incl. civilian, non-civilian and shared bands) must be completed by 31 December 2019. |
| | | 2.1.2. The possibilities of introducing frequency sales mechanisms (e.g. incentive auction) that are more innovative than what is currently in use must be evaluated, as these might further enhance spectrum use efficiency. It must be examined as to whether new legislation on spectrum buy-back programmes and forced sale is indeed necessary. | Report on spectrum buy-backs and forced sale, draft legislation where necessary. |
| | | 2.1.3. If necessary, use of LTE-LAA must be ensured by changes in legislation. | Demand assessment, report, study. |
| | 2.2. The legislative framework and conditions pertaining to spectrum management must be drafted and maintained to a high standard. | 2.2.1. Setting the groundwork for legislation: Under Gov. Decree 2012/2015, the draft for the (communications policy) strategy as per Article 4(1) a) of the Electronic Communications Act is to be prepared by 30 June 2016. | Alignment of the spectrum strategy with communications policy. |
| | | 2.2.2. It must be examined whether the lower and upper edges of the spectrum can and should be regulated for wireless electronic communications. | Expert report. |
| | 2.3. Harmonisation tasks relating to spectrum management must be performed to a high standard. | 2.3.1 Implementation of the more flexible regulations on spectrum management in the EU's telecommunications framework regulation, set to be published in 2017-2018, must be ensured. | Compliance with amendment obligations while taking national interests into account and optimising the implementaiton period |
| | | 2.3.2 A possible expansion of shared (LSA) or | Expert report. Consultation on |

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| | | collective radio spectrum use must be evaluated. | demands. |
| | 2.4. Communication tasks relating to spectrum management must be performed to a high standard. | 2.4.1. Stepping up both internal and external communications:<br>• communications procedures in line with international and EU institutions must be in place;<br>• questions and observations arising in spectrum management must be forwarded, via appropriate relations and communications processes (interfaces), to affected decision makers and pre-decision personnel;<br>mutually supportive communications must be engaged by, and regular dialogue maintained between, civilian and non-civilian users of the spectrum and the Authority's industry and spectrum management departments and other experts. Organisation of regular workshops, hearings and public consultations;<br>• continuous enhancement of access interfaces to records, data and information assisting the operative functions of frequency management and use.<br>2.4.2. Making measurement results available to both the public and stakeholders. | Publication of the national frequency allocation plan.<br>Number of meetings held in Hungary as part of supporting the activities of international workgroups.<br>Maintaining dialogue with market participants and other stakeholders (number of consultations, meetings and industry events).<br>Utilisation rate of publicly available databases.<br>Number of public service communications on the Internet.<br>Number of measurement data types provided to stakeholders. |
| | 2.5. Constant technological development of measurements facilitating spectrum management. | 2.5.1. The measurement strategy must be aligned to the considerations of the spectrum strategy.<br>2.5.2 3.2. Ensuring the permanent availability of measurement capacities suitable for monitoring the quality and interference-free use of the radio spectrum. | Harmonised annual measurement plan.<br>Increasing the number of equipment inspections for market surveillance, radio and EMC.<br>Participation in EU-wide campaigns (e.g. ADCO for R&TTE)[27].<br>Stepping up spectrum monitoring activities.<br>Reducing the average lead time of cases, that is, the time required for eliminating reported interferences. |
| | 2.6. The institutional framework of spectrum management must be strengthened and made more resilient and more open towards users, consumers and the sector as a whole, while the reputation and high quality of spectrum management must be retained both in and outside Hungary. | 2.6.1. The high standards of spectrum management activities both in Hungary and on an international level must be maintained, while enhancing networking relations and assessing the possible adaptation of regulatory best practices:<br>• resource planning must take the functions set to undergo transformations over the next few years into account (this particularly applies to enhancing IT preparedness);<br>• the organisation's change management capacities must be reinforced; | Training participation rates.<br>Enhancing process culture through workshops, number of workshops, introduction of temporary internal job rotation. |
| | | 2.6.2. Processes and records must be simplified and made more transparent, and the volume of publicly available real-time records and data must be increased: | FMS development goals must be compiled by 31 August each year and incorporated in financial plans. |

[27] ADCO = Administrative Cooperation (in this context: for R&TTE implementation) between authorities.

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| | | • the efficiency of spectrum management must be ensured with continuous IT developments, whereby the planning system and planning data must be integrated with factual data from the measurement system. Existing systems must be kept up-to-date;<br>• the database of the Spectrum Management Information System (STIR) must be made available to the public;<br>• following the successful completion of the FMS4 project, decision must be made as to whether additional data should and can be made available;<br>• it must be examined what additional bands could be brought under simplified online licencing, which then should be put into effect on the broadest scale possible. | Meeting the targeted launch date for the public segments of STIR.<br>Review summary made on the FMS4 project.<br>Number of bands affected by simplified online licencing. |
| | | 2.6.3 The national autonomy of spectrum management must be retained and Hungary's interests protected also in border-zone agreements. | Stepping up spectrum monitoring activities.<br>Taking measures as necessary. |
| 3 Frequency assets | 3.1. Ample spectrum must be made available to meet the continuously changing social and economic demands for frequencies. | 3.1.1. For purposes of efficient spectrum management, we must keep abreast of emerging new technologies and encourage their deployment, with particular regard to<br>• new digital technologies supporting the healthcare and social system.<br>• IoT/M2M applications,<br>• ITS applications,<br>• unmanned aerial systems. | Number of studies introducing new technologies or solutions and serving as the basis for regulation, and of related organised events. |
| | | 3.1.2. Assessing demand for spectrum for IoT/M2M/ITS applications. | Expert report. |
| | | 3.1.3. For satellite mobile services, studying the feasibility of AeroCGC in the 2 GHz band under the CGC specified in EU regulation. | Expert report. |
| | | 3.1.4. Government agencies' spectrum use must be reveiwed as part of the consolidation efforts aimed at the Government's communication infrastructure. | Expert report. |
| | | 3.1.5. The possibilities and impacts of changes affecting terrestrial digital broadcasting in the 470-694 MHz band must be determined from a technological, economic, social and communications policy standpoint, and a uniform Central-Eastern-European solution must be advocated. | Expert report. |
| | | 3.1.6. In 2016, preparations must commence for the sale of licences in the 694-790 MHz (DD2) band for wireless broadband. | Sales roadmap |
| | | 3.1.7. Technical inspection of possible technologies suitable for digital radio must be conducted.<br>• The technical conditions of broadcasting in the MW band using DRM30 technology must be met by 2017.<br>• The technical conditions of broadcasting in the FM band using DRM+ technology must be met. | Technical inspections and measurements with affected companies.<br>New radio licence upon request. |
| | | 3.1.8. Radio spectrum required for PMSE applications must be ensured. | Regulation must be drafted accordingly. |
| | | 3.1.9. The bandwidth necessary for BB-PPDR must be ensured and taken into account in the planning stage. | Regulation must be drafted accordingly. |

| Areas of intervention | Overall goals | Specific objectives | Indicators |
|---|---|---|---|
| | | 3.1.10. Bands reserved for amateur radio must be expanded in line with international regulations. Endorsing requests for new experiments. | Amending the Decree on the national frequency allocation and the rules of the use of frequency bands. |
| | | 3.1.11 Unwarranted spectrum hoarding must be prevented, while promoting efficient use. | The maximum spectrum to be acquired must be determined whenever a new band is put up for tender.<br>Assessing, as part of tender procedures, compliance with specific, tailored obligations that encourage efficient spectrum use.<br>Use of other incentives. |
| | 3.2. As the primary objective, use of the radio spectrum must be available without being subjected to or causing harmful interference. | 3.2.1 Given the expected intense use of MFCN and rising spectral densities in the 700 MHz band, it must be ensured that mobile and broadcast distribution networks and other affected radio services operate without mutual interference. | Technical inspections based on EMC expert measurements.<br>Number of incentives (e.g. publicity) aimed at ensuring interference-free operation.<br>Number of the Authority's mediation efforts, where required. |
| | | 3.2.2. For the 5 GHz band, we must examine<br>• whether regulatory intervention is required in order to align the use of licence-free bands with those subject to licencing,<br>• the conditions of 'fair' access between the various possible technologies (Wi-Fi, LTE-LAA, LTE-H etc.). | Reports based on measurement results for the 5 GHz band must be prepared by 31 December each year. |
| | | 3.2.3. Conditions for experimental 5G operation must be met whenever needs arise. | Rate of radio licences versus submitted applications. |
| | | 3.2.4. Given the tertiary nature of PMSE use of the 870-876/915-921 MHz bands, we must prepare for an increase in interference-related complaints and handle them in an efficient manner. | Rate of resolved versus reported interferences. |
| | | 3.2.5. If necessary, cooperation between public mobile and GSM-R networks must be supported in order to ensure that relevant bands are not subjected to or cause harmful interference. | Rate of resolved versus reported interferences. |
| | 3.3. Regulations facilitating an efficient spectrum use must be continuously updated, the conditions of operation improved and efficient operations ensured. | 3.3.1. By promoting additional options in shared frequency use (e.g. LSA), an efficient spectrum use must be facilitated. | Regulatory activities where required. |
| | | 3.3.2. Reviewing the regulations of secondary trading based on field experiences. | Expert report. |

# 11. The monitoring and institutional framework of strategy implementation

It is important that the monitoring and institutional framework of strategy implementation be uncomplicated, resilient and straightforward, aligned to the Authority's processes. Monitoring the implementation process requires no separate institutions.

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

- Certain tasks specified in the spectrum strategy are incorporated into the Authority's Work Plan for a given year, whereas affected organisational units maintain their own monitoring system for measuring respective target indicators;
- A prorated status report on the implementation of the approved strategy is prepared by 31 May;
- the annual status report contains:
  a) an evaluation of tasks relating to strategic targets set out in the work plan for the given year;
  b) the actual values of indicators defined for strategic goals;
  c) strategic priorities derived from the NMHH's strategy and the 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 goals but related to the strategy that have been suggested for the upcoming year's work plan.
- deviations from tasks specified in the approved strategy may be permitted by the party having approved the strategy.

# 12. Financial impacts

Building on its basic pillars and horizontal considerations, one of the main purposes of the spectrum strategy is to maximise social and economic utility by achieving set targets 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 final owner of frequency assets and engages in the sale of pertaining spectrum licences. 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. As one of its key financial impacts – in addition to stipulating the scheduled sale of frequency assets and the permanent renewal of the fee mechanism – the strategy calls for the value assessment of radio frequencies and better planning with the Authority's spectrum revenue figures (and expenses). Parallel to this, expenses related to spectrum use become more predictable, with users and bidders – that is, market participants – also becoming better equipped to prepare sound business plans.

To implement such a complex task, international practices on the valorisation of frequency bands must be consulted and the appropriate methodology devised, which in turn can yield more accurate value estimates for both the entire radio spectrum and the frequencies available for sale, as well as the fees charged for their use.

# 13. Acronyms and abbreviations

| Acronym | Definition | Hungarian translation |
|---|---|---|
| ADCO | Administrative Cooperation | Adminisztratív együttműködés |
| AFIL | Audio-Frequency Induction Loop | Hangfrekvenciás indukciós hurok |
| ANSI | American National Standards Institute | Amerikai Nemzeti Szabványügyi Intézet |
| ASA | Authorised Shared Access | Engedélyezett megosztott hozzáférés |
| BEREC | Body of European Regulators of Electronic Communications | Európai Elektronikus Hírközlési Szabályozók Testülete |
| CDMA | Code Division Multiple Access | Kódosztásos többszörös hozzáférés |
| CEPT | European Conference of Postal and Telecommunications Administrations | Postai és Távközlési Igazgatások Európai Értekezlete |
| CGC | Complementary Ground Components | Földi kiegészítő elemek |
| DAB | Digital Audio Broadcast | Digitális hang műsorszórás |
| DNFP | Digital Nation Development Programme | Digitális Nemzet Fejlesztési Program |
| DRM | Digital Radio Mondiale | Digitális rádió világ |
| DSMR | Digital Single Market Roadmap | Egységes digitális piac megvalósítása |
| DVB-H | Digital Video Broadcasting-Handheld | Digitális mobil televíziózás |
| DVB-T | Digital Video Broadcasting-Terestial | Földfelszíni digitális TV-műsorszórás |
| ECC | Electronic Communications Committee | Elektronikus Hírközlési Bizottság |
| EDR | Unified Digital Radio Communications System | Egységes Digitális Rádiótávközlő Rendszer |
| EMC | Electromagnetic Compatibility | Elektromágneses kompatibilitás |
| ETSI | European Telecommunications Standards Institute | Európai Távközlési Szabványosítási Intézet |
| FCFS | First-Come, First-Served | Érkezési sorrend |
| FDD | Frequency Division Duplex | Frekvenciaosztásos duplex |
| FMS | Frequency Management Software | Frekvenciagazdálkodási Szoftver |
| GDP | Gross Domestic Product | Bruttó hazai termék |
| GPS | Global Positioning System | Globális helymeghatározó rendszer |
| GSM | Global System for Mobile Communications | Világméretű mobilhírközlő rendszer |
| HEVC | High Efficiency Video Coding | Magas hatásfokú videókódolás |
| HSPA | High Speed Packet Access | Nagy sebességű csomagkapcsolt hozzáférés |
| IEC | International Electrotechnical Commission | Nemzetközi Elektrotechnikai Bizottság |
| IETF | Internet Engineering Task Force | Internet Engineering Munkacsoport |

| Acronym | Definition | Hungarian translation |
|---|---|---|
| IPTV | Internet Protocol Television | Internet protokoll alapú TV |
| ISM | Industrial Scientific Medical | Ipari, tudományos és orvosi |
| ISO | International Organization for Standardization | Nemzetközi Szabványügyi Szervezet |
| ISON | Intelligent Self-Organizing Networks | Intelligens önszervező hálózat |
| ITS | Intelligent Transport System | Intelligens közlekedési rendszer |
| ITU | International Telecommunication Union | Nemzetközi Távközlési Egyesület |
| KKV | Kis- és középvállalat | Small and Medium-sized Enterprise |
| KRTK | Centre for Economic and Regional Studies | Közgazdaság- és Regionális Tudományi Kutatóközpont |
| KTI | Institute of Economics | Közgazdaságtudományi Intézet |
| LAA | License Assisted Access | Licenccel segített hozzáférés |
| LSA | Licensed Shared Access | Használati jogosultság megosztása |
| LTE | Long Term Evolution | Hosszú távú fejlődés |
| MATESZ | Hungarian Audit Bureau of Circulations | Magyar Terjesztés-Ellenőrző Szövetség |
| MBMS | Multimedia Broadcast Multicast Services | Multimédiás broadcast, multicast szolgáltatás |
| MCA | Mobile Communications on (board) Aircraft | Mobil hírközlés légi járműveken |
| MFCN | Mobile/Fixed Communications Networks | Mobil/fix kommunikációs hálózat |
| MIMO | Multiple-Input and Multiple-Output | Többszörös bemenet és többszörös kimenet |
| MNO | Mobile Network Operator | Mobilszolgáltató |
| MSS | Mobile Servicing System | Mobil szolgáltató rendszer |
| MTA | Hungarian Academy of Sciences | Magyar Tudományos Akadémia |
| MUX | Multiplex | |
| MVNO | Mobile Virtual Network Operator | Virtuális mobilszolgáltató |
| NATO | North Atlantic Treaty Organisation | Észak-atlanti Szerződés Szervezete |
| NFFF | National frequency allocation and the rules of the use of frequency bands | Nemzeti Frekvenciafelosztás, valamint Frekvenciasávok Felhasználási szabályai |
| NFV | Network Functions Virtualization | Hálózati funkcióvirtualizálás |
| NGA | Next-Generation Access | Következő generációs hozzáférés |
| NIS | National Infocommunication Strategy | Nemzeti Infokommunikációs Stratégia |
| NIST | National Institute of Standards and Technology | Nemzeti Technológiai és Szabványügyi Intézet |
| NJFA | NATO Joint Civil/Military Frequency Agreement | Polgári és nem polgári közös frekvenciahasználatra vonatkozó |

| Acronym | Definition | Hungarian translation |
|---|---|---|
| | | megállapodás |
| NMHH | Nemzeti Média és Hírközlési Hatóság | National Media and Infocommunications Authority |
| OFDM | Orthogonal Frequency-Division Multiplexing | Ortogonális frekvenciaosztásos multiplexálás |
| PDMA | Pattern Demand Multiple Access | Mintázatosztásos többszörös hozzáférés |
| PMR | Personal Mobile Radio | Professzionális/magán mozgórádió |
| PMSE | Programme Making and Special Events | Műsorgyártás és különleges események |
| PPDR | Public Protection and Disaster Relief | Közrendvédelem és katasztrófavédelem |
| QAM | Quadrature Amplitude Modulation | Kvadratura amplitúdó moduláció |
| RAME | Association of Radio Media Providers | Rádiós Médiaszolgáltatók |
| RAN | Radio Access Network | Rádiós elérési hálózat |
| RFID | Radio Frequency Identification | Rádiófrekvenciás azonosító |
| RLAN | Radio Local Area Network | Rádiós helyi hálózat |
| RRS | Reconfigurable Radio Systems | Újrakonfigurálható rádiós rendszer |
| RSC | Radio Spectrum Committee | Rádióspektrum Bizottság |
| RSD | Radio Spectrum Decision | Rádióspektrum határozat |
| RSPG | Radio Spectrum Policy Group | Rádióspektrum Szabályozási Csoport |
| RSPP | Radio Spectrum Policy Programme | Rádióspektrum szabályozási program |
| SDL | Supplemental Downlink | Kiegészítő Downlink |
| SDN | Software Defined Network | Szoftveres hálózat |
| SDR | Software Defined Radio | Szoftveres rádió |
| SEDDIF | South European Digital Dividend Implementation Forum | Dél-Európai Digitális Hozadék Implementációs Fórum |
| SFN | Single Frequency Network | Egyfrekvenciás hálózat |
| SIC | Self-Interference Cancellation | Saját interferencia elnyomás |
| SIM | Subscriber Identity Module | Előfizetői azonosító modul |
| SON | Self-Organizing Networks | Önszervező hálózat |
| SRD | Short Range Devices | Kis hatótávolságú eszközök |
| STB | Set Top Box | vevőkészülék, beltéri egység |
| STIR | Spectrum Management Information System | Spektrumgazdálkodást Támogató Informatikai Rendszer |
| SZEUSZ | Regulated Electronic Administration Service | Szabályozott elektronikus Ügyintézési szolgáltatás |

| Acronym | Definition | Hungarian translation |
|---|---|---|
| SZIP | Superfast Internet Project | Szupergyors internet projekt |
| TDD | Time Division Duplexing | Időosztásos duplex |
| TEDS | TETRA Enhanced Data Service | |
| TETRA | Terrestrial Trunked Radio | Földfelszíni nyalábolt rádiórendszer |
| TRS | Telecoil Replacement System | Javasolt helyettesítő rendszer |
| UAS | Unmanned Aerial Systems | Személyzet nélküli légi rendszer |
| UAV | Unmanned Aerial Vehicle | Személyzet nélküli légi jármű |
| UHD | Ultra High Definition | Ultra nagy felbontású |
| UHF | Ultra High Frequency | Ultra nagy frekvencia |
| UIC | International Union of Railways | Nemzetközi Vasúti Egyesület |
| URH | Ultra Shortwave | Ultrarövid hullám |
| UWB | Ultra Wideband | Ultra széles sávú |
| VHF | Very High Frequency | Nagyon magas frekvencia |
| VSAT | Very Small Aperture Terminal | Kis apertúrájú végfelhasználói állomás |
| WAN | Wide Area Network | Nagy területű hálózat |
| WHO | World Health Organization | Egészségügyi Világszervezet |
| WRC | World Radiocommunication Conferences | Rádió-távközlési Világértekezlet |
| WSD | Web Services for Devices | Web szolgáltatás eszközöknek |

# 14. References

[1] European Commission, „C0M(2014) 228 final – REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation of the Radio Spectrum Policy Programme". 22 April 2014