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ANALYSIS OF RADIO FREQUENCY SPECTRUM PLANNING AND ALLOCATION FOR THE DEPLOYMENT OF NEW MODERN BROADBAND NETWORKS AND TECHNOLOGIES

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Abstract: When analyzing the planning and distribution of the radio frequency spectrum on a global and European scale, the need to manage the radio frequency spectrum is taken into account, which is in accordance with the provisions of the Radio Regulations of the International Telecommunication Union, the decisions and recommendations of the European Commission and the Electronic Communications Committee of the European Conference by post and telecommunications. The analysis in the management of the radio frequency spectrum is also in accordance with the Bulgarian legislation, in which the principles of legality, predictability, transparency, publicity, consultativeness, equality, proportionality, neutrality in relation to the technologies used and/or the services provided and reducing the regulatory intervention to the minimum required. The basic principles of spectrum management and allocation involve a combination of technical, regulatory and organizational considerations. The purpose of writing the article is to analyze spectrum efficiency and the adaptation of spectrum management policies to evolving technologies and market dynamics.

Keywords: Radio, Spectrum, Management, Frequency, Range.

1. INTRODUCTION

Spectrum management is the process of regulating and allocating radio frequencies and radio frequency bands to different users and services to avoid interference and ensure efficient use of the limited resource. This includes planning, assigning and coordinating the use of frequencies for various communication services such as broadcasting, telecommunications, satellite communication, etc.

The key aspects related to spectrum management are:

- Regulatory Framework - Governments and regulatory bodies play a crucial role in spectrum management. They establish policies, regulations and standards to govern the allocation and use of spectrum. Regulatory frameworks vary by country, but typically include spectrum allocation plans, licensing requirements, and guidelines for efficient spectrum use.
- Frequency allocation - frequency bands are allocated for specific services and applications based on International agreements and National needs. The International Telecommunication Union (ITU) is a key organization that helps to harmonize the global use of spectrum through the Radio Regulations. Different frequency bands are designated for specific applications, such as mobile communication, radio broadcasting, aviation, satellite communication, etc.
- Licensing - governments issue licenses to entities (operators or service providers) allowing them to use certain frequency bands for a certain period. Licensing can be exclusive or shared, depending on the regulatory framework. Auctions, administrative assignments, and market approaches are common methods used to allocate spectrum licenses.
- Technological advances - spectrum management is affected by advances in technology, such as the development of new wireless communication standards (eg 5G) and increasing demand for bandwidth. For example, the deployment of 5G networks and the future development of 6G will require adjustments to

spectrum allocation and management strategies. Regulators must adapt to these technological changes by updating spectrum allocation plans and license conditions.

- Interference management - effective spectrum management involves minimizing interference between different users and services. This is crucial to ensure the quality and reliability of communication services. Techniques such as frequency coordination, power control, and the use of advanced technology help mitigate interference problems.
- Spectrum sharing - with increasing demand for radio spectrum and limited available resources, there is a tendency to explore mechanisms for sharing radio frequency spectrum. Dynamic spectrum access (DSA) and cognitive radio are examples of technologies that enable more flexible and dynamic use of spectrum.
- International coordination - given the global nature of the spectrum, international coordination is essential. Countries cooperate through international organizations such as the ITU to harmonize spectrum use, particularly along borders where interference problems may arise.
- Future challenges - spectrum scarcity remains a challenge, especially with the growing number of connected devices, IoT applications and emerging technologies. Balancing the interests of various stakeholders, addressing cybersecurity concerns and ensuring fair competition are ongoing challenges in spectrum management .

2. ANALYSIS ON THE PLANNING AND ALLOCATION OF THE RADIO FREQUENCY SPECTRUM ON A GLOBAL AND EUROPEAN SCALE

When analyzing the planning and distribution of the radio frequency spectrum on a global and European scale, the need to manage the radio frequency spectrum is taken into account, which is in accordance with the provisions of the Radio Regulations of the International Telecommunication Union, the decisions and recommendations of the European Commission and the Electronic Communications Committee of the European Conference by post and telecommunications.

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The basic principles of spectrum management and allocation involve a combination of technical, regulatory and organizational considerations:

- Satellite spectrum management - Satellite communication is an important part of global connectivity, providing services such as broadcasting, weather monitoring and remote sensing. Spectrum management for satellite services involves coordination to prevent interference and ensure efficient use of orbital slots and frequency bands. The ITU plays a significant role in the international coordination of satellite orbits and frequencies through its Radio Regulations and the Geostationary Satellite Orbit Registration System.
- Public Safety and Critical Infrastructure - Certain spectrum bands are reserved for public safety and critical infrastructure communications, including emergency services, law enforcement and utilities. Ensuring the resilience and reliability of these communications during emergency situations is a priority for spectrum managers.
- Spectrum monitoring and enforcement - spectrum monitoring is essential to detect and address unauthorized or harmful interference. Regulatory authorities use

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monitoring systems to track spectrum usage and enforce licensing conditions. Enforcement actions may include fines, license revocation or legal action against entities that violate spectrum regulations.

- Spectrum efficiency and cognitive radio - spectrum efficiency is a key goal in spectrum management. Cognitive radio (CR) technologies enable dynamic and opportunistic spectrum usage, allowing devices to intelligently adapt their transmission parameters to maximize spectrum usage while avoiding interference.
- National broadband plans - many countries are developing national broadband plans to meet the growing demand for high-speed internet access. These plans often include spectrum allocation strategies to support the deployment of broadband services, particularly in rural and underserved areas.
- 5G and next generations - the deployment of 5G networks and ongoing research into 6G technologies pose new challenges and opportunities for spectrum management. Higher frequency bands, such as millimeter wave, are being explored to accommodate the increased data rates and low latency requirements of these modern networks.
- Environmental considerations - spectrum management also includes environmental monitoring and protection considerations. Certain spectrum bands are allocated for Earth observation and environmental monitoring in support of activities such as climate monitoring and disaster response.
- Spectrum and industry collaboration - collaboration between spectrum regulators, industry stakeholders and standards organizations is critical to addressing the evolving needs of the wireless ecosystem. This collaboration helps ensure that spectrum management practices are in line with technological advances and industry requirements.
- Spectrum database and sharing platforms - the development of centralized databases and sharing platforms facilitates efficient spectrum sharing. These platforms provide real-time information on spectrum availability, helping users identify suitable frequencies for their applications and encouraging dynamic sharing.
- Policy considerations - spectrum management policies must be able to adapt to evolving technologies and market dynamics. Policymakers should consider fostering innovation, fostering competition, and targeting social and economic goals when developing and revising spectrum regulations.

As an example, in connection with the increased need for broadband connectivity, trends should be expanded for the use of radio frequency spectrum in the 74-76 GHz and 84-86 GHz bands for high-capacity radio relay sections (over 1500 Mbps).
Interest in the use of the high bands by business remains, which is a prerequisite for defining the technical conditions for the use of the radio frequency band 57-64 GHz by the fixed radio service.
Some general recommendations for the above ranges are:

- 6 GHz band - this band offers good capacity and reasonable propagation characteristics. It is suitable for shorter range connections requiring higher data rates. It is also relatively less congested than lower frequencies, making it favorable for point-to-point and point-to-multipoint connections in urban areas.

- 7 GHz band - similar to the 6 GHz band, offers decent capacity and is suitable for short to medium range connections. Its use can vary depending on regional regulations and available spectrum, but is typically used for point-to-point microwave links.
- 11 GHz range - often used for long-distance communication links due to its ability to penetrate atmospheric conditions such as rain and fog. It is preferred for its reliability in such scenarios and is used for transmission links in telecommunication networks.
- 13 GHz range - this frequency band is suitable for medium-range wireless communication links, often used for point-to-point and point-to-multipoint links. Its reliability and moderate data rates make it suitable for a variety of applications, including rural connectivity and transmission.
- 18 GHz band - known for its higher data rates and relatively short range characteristics, it is generally used for high-capacity short-distance communication links. This is beneficial for urban or densely populated areas where high data throughput is required.
- 23 GHz band – this band offers high-capacity connections and is often used for urban or suburban point-to-point connections, especially for high-bandwidth applications such as cellular backhaul and enterprise networks.
- 28 GHz range - Considered a millimeter wave frequency, it offers extremely high data rates, but has limited range and penetration capabilities. It is often used to deploy small cells in 5G networks, providing ultra-fast connectivity in dense urban environments.
- 38 GHz band - another millimeter wave band, it offers ultra-high data rates, but has an even shorter range and more limited penetration capabilities compared to 28 GHz. It is primarily used for specific applications requiring extremely high bandwidth in very dense urban environments.

Factors such as regulatory constraints, antenna technologies, spectrum availability, link distance, throughput requirements, and environmental conditions should be considered as recommendations for dedicated wireless communication links in these frequency ranges.
Ensuring proper line of sight, using advanced modulation techniques, and using interference mitigation strategies are key to maximizing performance in these frequency bands.
Another key aspect is increasing the digital dividend. It is critical to meeting the growing demand for wireless connectivity, improving rural broadband access and fostering technological innovation. This represents an opportunity to optimize spectrum resources and stimulate the expansion of digital services across Europe.
The provision of one of the most suitable 800 MHz radio frequency bands for terrestrial systems enabling the provision of electronic communications services will facilitate the achievement of economies of scale without requiring the use of special technology, based on optimized parameters for the most likely use of the tape. This is of utmost importance in the convergence of the mobile, fixed and broadcasting sectors, reflecting the advent of technical innovation. The services provided in this radio frequency band should be primarily aimed at end-user access to broadband communications, including broadcast content. The specified technical conditions apply to the 800 MHz band, optimized but not limited to fixed and/or mobile communications networks, paying particular attention to the general and minimum (i.e. least restrictive) technical conditions, the optimal allocation of frequencies and of the recommendation regarding the treatment of PMSE services.
Specifying the technical conditions for base stations and terminal devices operating in the 800 MHz band will facilitate the achievement of economies of scale without requiring the use of special technology, based on optimized parameters for the most likely use of the band.

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Regarding cross-border coordination, the guidelines are of particular importance at the coexistence stage, i.e. where some Member States may already apply technical conditions optimized for fixed and/or mobile communications networks, while other Member States still operate powerful radio and television transmitters in the 800 MHz band.
The Final Acts of the Regional Radiocommunication Conference of the International Telecommunication Union for the Planning of Digital Terrestrial Broadcasting Services in Parts of Regions 1 and 3 in the Radio Frequency Bands 174-230 MHz and 470-862 MHz (the GE06 Agreement) contain the necessary regulatory procedures for cross-border coordination.
Operators of terrestrial systems enabling the provision of electronic communications services in the 800 MHz band may use less stringent technical parameters than those specified below, provided that the use of these parameters is agreed between all parties concerned and that the activities of those operators continues to comply with the technical conditions applicable to the protection of other services, applications or networks and with the obligations arising from cross-border coordination.
Equipment operating in this radio frequency band may use power limits other than those specified below, provided that appropriate radio interference mitigation methods are applied that comply with Directive 1999/5/EC. The term "block boundary" refers to the radio frequency boundary of a legitimate right of use. The term "band limit" refers to the limit of a radio frequency range designated for a particular use.
Within the radio frequency band 790-862 MHz, radio frequencies are allocated as follows:

- The sizes of the defined blocks are multiples of 5 MHz;
- The duplex mode of operation is FDD with the following parameters - the duplex spacing is 41 MHz, with base stations transmitting in the right direction (downlink) in the lower part of the radio frequency band, starting from 791 MHz and ended at 821 MHz, and the end devices transmit in the opposite direction (uplink) in the upper part of the band, starting at 832 MHz and ending at 862 MHz.

Alternative allocations of radio frequencies may be introduced in order to achieve objectives of general interest; ensuring higher efficiency through market-oriented spectrum management; providing greater efficiency when sharing with existing rights during a period of coexistence; or avoiding harmful radio interference.
It is important to note the technical conditions for base stations implementing FDD or TDD, as well as their limits within a block. For base stations, it is not mandatory to set an EIRP limit within a block. Limits may be set, unless otherwise justified, these limits are typically in the range of 56 dBm/5 MHz to 64 dBm/5 MHz.
Table 1 presents out-of-block limits, basic block-border mask requirements and equivalent isotropically radiated power (EIRP) limits from an out-of-block base station.

Table 1. Basic requirements - block boundary mask: limit values of equivalent isotropically radiated power (EIRP) from a base station outside the block:

Frequency range of broadcasts outside the block	**Maximum average EIRP outside the block**	**Measured bandwidth**
Radio frequencies used for the reverse ("uplink") link in FDD mode	49.5 dBm	5 MHz

Radio frequencies used for TDD	49.5 dBm	5 MHz

Table 2 presents the transition requirements - block boundary mask with limit values for an EIRP antenna from a base station outside the block for FDD forward ("down") and TDD link radio frequencies.

Table 2. Transition requirements - block boundary mask: antenna EIRP limits from a base station outside the block for FDD forward ("down") and TDD link radio frequencies.

Radio frequency range of emissions outside the block	**Maximum average EIRP outside the block**	**Width of the measured radio frequency band**
From – 10 to – 5 MHz from the lower block limit	18 dBm	5 MHz
From – 5 to 0 MHz from the lower limit of the block	22 dBm	5 MHz
From 0 to + 5 MHz from the upper limit of the block	22 dBm	5 MHz
From + 5 to + 10 MHz from the upper limit of the block	18 dBm	5 MHz
Remaining radio frequencies for forward (downstream) FDD connection	11 dBm	1 MHz

Table 3 illustrates transient requirements - block boundary mask, antenna EIRP limits from a base station outside the block for radio frequencies used as a guard band.

Table 3 Transient requirements - block boundary mask: antenna EIRP limits from a base station outside the block for radio frequencies used as a guard band.

Radio frequency range of emissions outside the block	**Maximum average EIRP outside the block**	**Measured bandwidth**
Guard band between the broadcast band limit at 790 MHz and the forward (downstream) FDD link band limit	17.4 dBm	1 MHz
Guard band between the broadcast band limit at 790 MHz and the TDD link band limit	15 dBm	1 MHz
Guard band between the FDD link lane boundary in the forward direction ("down") and the FDD link lane boundary in the reverse direction (duplex spacing)	15 dBm	1 MHz
Guard band between the straight-line ("down") FDD link band boundary and the TDD link band boundary	15 dBm	1 MHz
Guard band between the FDD link band boundary in the reverse ("up") direction and the TDD link band boundary	15 dBm	1 MHz

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Table 4 presents the basic requirements — block boundary mask, limit values for equivalent isotropically radiated power (EIRP) from a base station outside the block for radio frequencies below 790 MHz.

Table 4. Basic requirements — block boundary mask: limit values for the equivalent isotropically radiated power (EIRP) from a base station outside the block for radio frequencies below 790 MHz.

Option	Condition on base station inblock EIRP, P dBm/10 MHz	Maximum average EIRP outside the block	Width of the measured radio frequency band
For TV channels for which the transmission is protected	P ≥ 59 36 ≤ P < 59 P < 36	0 dBm (P – 59) dBm – 23 dBm	8 MHz 8 MHz 8 MHz
For TV channels for which the transmission is subject to an intermediate level of protection	P ≥ 59 36 ≤ P < 59 P < 36	10 dBm (P – 49) dBm –13 dBm	8 MHz 8 MHz 8 MHz
For TV channels for which transmission is not protected	No conditions	22 dBm	8 MHz

The options listed in Table 4 may be applied per broadcasting channel and/or broadcasting region, so that the same broadcasting channel may have a different level of protection in different geographical regions, and different broadcasting channels may have different levels of protection in the same geographical area.
The baseline requirement of option 1 shall apply when digital terrestrial broadcasting channels are used during the deployment of terrestrial systems enabling the provision of electronic communications services. The basic requirements of options 1, 2 and 3 may apply where, during the deployment of terrestrial systems enabling the provision of electronic communications services, the relevant broadcasting channels are not in use. They should bear in mind that options 1 and 2 preserve the possibility of future commissioning of relevant digital terrestrial broadcasting channels, while option 3 is appropriate where there are no plans to commission relevant broadcasting channels.
The allocation of the 800 MHz band to networks other than high-power broadcasting networks should be made on a non-exclusive basis for terrestrial systems enabling the provision of electronic communications services.
Systems intended for this range must be ensured to provide adequate protection for systems operating in adjacent radio frequency bands.

3. CONCLUSION

In summary, spectrum management is a complex and dynamic field that requires continuous adaptation to technological advances and changing communication needs. Effective spectrum allocation, coordination and monitoring are essential to support the growth of wireless communication services and ensure optimal use of this limited resource. Continued cooperation at the national and international level is essential to address emerging challenges and exploit new opportunities in the field of wireless communications.

With the writing of the article, through the analysis and research done, results have been achieved regarding spectrum efficiency and the adaptation of spectrum management policies to the advancement of technology, innovation and overall market development. With the analysis of the parameters and radio technical characteristics of some radio frequency bands suitable for the deployment of new technologies, a complete and clear picture of real research settings, norms and procedures in radio frequency spectrum research is determined.

Comparisons are made with current specifications, norms and directives, with which complete and correct results of the analysis are achieved.

The scope and possibility of effective and efficient use of the radio spectrum is being expanded, which is in connection with the deployment of new radio communication and mobile telecommunication services in the community. Also, through analysis, the procedure for establishing the possibility of joint work of existing users in the radio frequency bands and those intended for the implementation of new technologies is determined.

The present analysis was developed to provide guidance and solutions for specific measurement settings that objects with the appropriate measurement equipment could be a real study by NBU faculty and students. It will be possible to gain a real insight into the scenarios of mutual influence on the normal functioning of radionavigation systems and radioelectronic equipment and mobile terminals, often radio range opportunities for deployment of new technologies and networks.

ИЗПОЛЗВАНИ ИЗТОЧНИЦИ (REFERENCES)

[1] ПАСАРЕЛСКИ, Росен. *Универсални мобилни телекомуникационни системи: Радиоинтерфейс-изследване на каналите, слоевете и протоколите*. София: Нов български университет, 2013. ISBN 978-954-535-770-1. [PASARELSKI, Rosen. *Universalni mobilni telekomunikatsionni sistemi: Radiointerfeys-izsledvane na kanalite, sloevete i protokolite*. Sofia: NBU, 2013. ISBN 978-954-535-770-1.]

[2] ПАСАРЕЛСКИ, Росен. Изследване на мощност на мобилна радиопредавателна апаратура. *Годишник Телекомуникации* [онлайн]. 2017, Т. 4, с. 19 - 24 [прегледан 15.05.2024]. ISSN 2534-854X. Достъпен на: https://telecommunications.nbu.bg/bg/godishnik-telekomunikacii [PASARELSKI, Rosen. Izsledvane na moshtnost na mobilna radiopredavatelna aparatura. *Godishnik Telekomunikatsii* [onlayn]. 2017, T. 4, c. 19 – 24 [pregledan 15.05.2024]. ISSN 2534-854X. Dostapen na: https://telecommunications.nbu.bg/bg/godishnik-telekomunikacii

[3] ПАСАРЕЛСКИ, Росен и Теодора ПАСАРЕЛСКА. Методика за изследване и анализ на радиотехнически праметри на универсални мобилни телекомуникационни системи. *Сборник доклади от годишната университетска научна конференция на НВУ „Васил Левски“, 27-28 юни 2013*. В. Търново: Нац. воен. унив. „Васил Левски“, 2013, Т. 11. ISSN 1314-1937. [PASARELSKI, Rosen i Teodora PASARELSKA. Metodika za izsledvane i analiz na radiotehnicheski prametri na universalni mobilni telekomunikatsionni sistemi. *Sbornik dokladi ot godishnata universitetska nauchna konferentsia na NVU „Vasil Levski“, 27-28 yuni 2013*. V. Tarnovo: Nats. voen. univ. „Vasil Levski“, 2013, T. 11. ISSN 1314-1937.]

[4] PASARELSKI, Rosen and Teodora PASARELSKA. The development of the telecommunications market in Republic of Bulgaria. *International Scientific Journal „Science. Business. Society”* [online]. 2016, vol. 1(4), pp. 31-32 [viewed 15.05.2024]. ISSN 2367-8380. Available from: https://stumejournals.com/journals/sbs/2016/4/31.full.pdf

eISSN 2534-854X https://telecommunications.nbu.bg/bg/godishnik-telekomunikacii

DOI: https://doi.org/10.33919/YTelecomm.23.10.8

[5] ПАСАРЕЛСКИ, Росен, Васил КЪДРЕВ и Теодора ПАСАРЕЛСКА. Петото поколение (5G) – мобилни системи и технологии за комуникации на бъдещето. *Конференция ТЕЛЕКОМ 2017.* 2017, с. 18-26. ISSN 1314-2690. [PASARELSKI, Rosen, Vasil KADREV i Teodora PASARELSKA. Petoto pokolenie (5G) – mobilni sistemi i tehnologii za komunikatsii na badeshteto. *Konferentsia TELEKOM 2017*. 2017, s. 18-26. ISSN 1314-2690.]

[6] PASARELSKI, R., K. ANGELOV, K. POSTAGIAN, S. SADINOV. Implementation and Analysis of a Customized Encryption Algorithm in 5G Networks for Educational Purposes. *2023 4th International Conference on Communications, Information, Electronic and Energy Systems (CIEES), 23-25 November, 2023, Plovdiv, Bulgaria* [online]. 2023, pp. 1-5 [viewed 15.05.2024]. IEEE Xplore Digital library. eISBN 979-8-3503-3691-7. Available from: DOI: 10.1109/CIEES58940.2023.10378834

[7] SADINOV, S., P. KOGIAS, K. ANGELOV, M. MALAMATOUDIS and A. ALEKSANDROV. The Impact of Channel Correlation on the System Performance and Quality of Service in 5G Networks. *7th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE), 2020, Ruse, Bulgaria* [online]. 2020, pp. 1-4 [viewed 15.05.2024]. IEEE Xplore Digital library. eISBN 978-1-7281-0362-4. Available from: https://ieeexplore.ieee.org/document/9278982

[8] АЛЕКСАНДРОВ, Ангел и Тереза СТЕФАНОВА. Предизвикателства и проблеми пред 5G. *Сборник доклади от годишната университетска научна конференция на НВУ „Васил Левски“, Велико Търново, 27-28 май 2021*. В. Търново: Нац. воен. унив. „Васил Левски“, 2021, с. 2445-2454. ISSN 1314-1937. [ALEKSANDROV, Angel i Tereza STEFANOVA. Predizvikatelstva i problemi pred 5G. *Sbornik dokladi ot Godishna universitetska nauchna konferentsiya na NVU „Vasil Levski“, Veliko Tarnovo, 27-28 may 2021*. V. Tarnovo: Nats. voen. univ. „Vasil Levski“, 2021, s. 2445-2454. ISSN 1314-1937.]

[9] ПАСАРЕЛСКИ, Росен, Тереза СТЕФАНОВА и Теодора ПАСАРЕЛСКА. Анализ на управлението на мобилността в 5G мобилни клетъчни мрежи. *Сборник статии от научна конференция „Знание, наука, иновации, технологии“, 28 април 2023*. Велико Търново, 2023, с. 586-601. ISSN 2815-3480. [PASARELSKI, Rosen, Tereza STEFANOVA i Teodora PASARELSKA. Analiz na upravlenieto na mobilnostta v 5G mobilni kletachni mrezhi. *Sbornik statii ot nauchna konferentsia „Znanie, nauka, inovatsii, tehnologii“, 28 april 2023*. Veliko Tarnovo, 2023, s. 586-601. ISSN 2815-3480.

[10] КЪДРЕВ, Васил и Росен ПАСАРЕЛСКИ. Приложение на подходи на изкуствен интелект и машинно обучение в киберсигурността. *Годишник Телекомуникации* [онлайн]. 2021, Т. 8, с. 53 - 64 [прегледан 17.05.2024]. eISSN 2534-854X. Достъпен на: https://telecommunications.nbu.bg/bg/godishnik-telekomunikacii-broeve/godishnik-telekomunikacii-2021-g-tom-8 [KADREV, Vasil i Rosen PASARELSKI. Prilozhenie na podhodi na izkustven intelekt i mashinno obuchenie v kibersigurnostta. *Godishnik Telekomunikatsii* [onlayn]. 2021, (8), s. 53 - 64 [pregledan 17.05.2024]. eISSN 2534-854X. Dostapen na: https://telecommunications.nbu.bg/bg/godishnik-telekomunikacii-broeve/godishnik-telekomunikacii-2021-g-tom-8]

[11] СИМЕОНОВА, Цветелина и Васил КЪДРЕВ. Развитие на изкуствения интелект и неговото приложение в телекомуникационните мрежи и услуги. *Сборник доклади от Научна конференция с международно участие на НВУ „Васил Левски“, Велико Търново, 27-28.05.2021*. Велико Търново: Издателски комплекс на НВУ „Васил Левски“, 2021, с. 2376- 2386. ISSN 2367-7481. [SIMEONOVA, Tsvetelina i Vasil KADREV. Razvitie na izkustvenia intelekt i negovoto prilozhenie v telekomunikatsionnite mrezhi i uslugi. *Sbornik dokladi ot Nauchna konferentsia s mezhdunarodno uchastie na NVU „Vasil Levski“, Veliko Tarnovo, 27-28.05.2021*. Veliko Tarnovo: Izdatelski kompleks na NVU „Vasil Levski“, 2021, s. 2376- 2386. ISSN 2367-7481.]

[12] Commission Decision 2010/267/EU on harmonised technical conditions of use in the 790-862 MHz frequency band for terrestrial systems capable of providing electronic communications

services in the European Union. *Eur-lex* [online]. [viewed 22.05.2024]. Available from: https://eur-lex.europa.eu/eli/dec/2010/267/oj

[13] Commission Implementing Decision (EU) 2019/784 of 14 May 2019 on harmonisation of the 24,25-27,5 GHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services in the Union (notified under document C(2019) 3450). *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/eli/dec_impl/2019/784/oj

[14] Commission Implementing Decision (EU) 2019/785 of 14 May 2019 on the harmonisation of radio spectrum for equipment using ultra-wideband technology in the Union and repealing Decision 2007/131/EC (notified under document C(2019) 3461). *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/eli/dec_impl/2019/785/oj

[15] Commission Implementing Decision (EU) 2019/235 of 24 January 2019 on amending Decision 2008/411/EC as regards an update of relevant technical conditions applicable to the 3400-3800 MHz frequency band (notified under document C(2019) 262). *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/eli/dec_impl/2019/235/oj

[16] Decision No 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community (Radio Spectrum Decision). *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002D0676

[17] Commission Implementing Decision (EU) 2022/2324 amending Decision 2008/294/EC, to include additional access technologies and measures for the operation of mobile communications services on aircraft (MCA services) in the Union. *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022D2324

[18] Commission Implementing Decision (EU) 2022/179 on the harmonised use of radio spectrum in the 5 GHz frequency band for the implementation of wireless access systems including radio local area networks. *Eur-lex* [online]. [viewed 23.03.2022]. Available from: https://eur-lex.europa.eu/eli/dec_impl/2022/179

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