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## **ELECTROMAGNETIC SPECTRUM MANAGEMENT**

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**Abstract:**

The electromagnetic spectrum is a limited national resource with a huge economic potential. This resource is concerned not only by the applications in the military domain, but also by those in the civil domain, generators of value in terms of economy. If because of the spreading features, radio waves don't follow the administrative boundaries, effort coordination of international standardization and regulation has a capital importance. In context of telecommunication market globalization, standardization and procedural regulation of this field is of great interest. Because of this a lot of institutions were founded. The goal of those institutions is represented by the standardization and field regulation for optimizing administrative radio frequency activities.

This article presents the reasons that electromagnetic spectrum resource is so valuable and describes the main institutions involved in this area.

*Key words: spectrum management, frequency management, administrative procedures, international coordination, national bodies, international bodies, spectrum resources.*

### **1. Introduction**

The radio frequency spectrum is a limited and natural resource administrated by each nation. Electromagnetic spectrum frequencies have an economical value. They can be commercialized and represent an important element for economical development and industrial competition. Because of propagation particularities electromagnetic waves trespass administrative boundaries. This resource must be distributed and coordinated between nations. At the same time the nations want to impose their total sovereignty in terms of frequency allocation. To make electromagnetic spectrum accessible in those circumstances it's necessary for all nations to agree on some standards and regulations to respect.

The necessity of leading and coordinating the process of electromagnetic spectrum management became more significant in comparison with the last years. In the last two decades the radio spectrum's political environment has changed significantly. In this period services and equipment which have been developed are being implemented rather worldwide than on national scale. Traditional radio spectrum users which assure public services at a national level are now in competition in radio spectrum utilization with global commercial players, especially in broadcast and telecommunication areas.

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The radio spectrum availability appears due to solutions promoted by commercial transactions. In consequence, when liberalization of telecommunication market is considered, radio frequency issues represent a major topic. All of these aspects highlight the importance of international cooperation in respect with radio spectrum policy in order to speed up promotion and provision of services and equipment at international level.

Nowadays, in most states, the majority of frequency resources are reserved for military services. In the same time, a rising pressure is felt for the disposal of these resources to commercial services. In this context it's important to underline the fact that NATO, an alliance of nations, doesn't have the right of property neither over frequencies nor frequencies bands anywhere in the world.

### **2. Electromagnetic spectrum as a national resource**

The electromagnetic spectrum consists of an infinite number of frequencies any of which can be utilized to transmit electromagnetic energy. It includes radio waves, the infrared radiation, ultraviolet rays, x-rays, visible light, etc.

According to ITU (International Telecommunication Union), radio waves are electromagnetic waves with less than 300 GHz wavelength, waves that are classified in frequency bands standardized at international level as you can see in "Table 1".

<b>Band</b>		<b>Frequency (Hz)</b>	<b>Abrev.</b>	
<b>Hertian wave</b>	Extremely Low Frequency	$< 3 \times 10^1$	ELF	
	Super Low Frequency	$3 \times 10^1 \dots 3 \times 10^2$	SLF	
	Voice /Ultra Low Frequency	$3 \times 10^2 \dots 3 \times 10^3$	VF/ULF	
	Very Low Frequency	$3 \times 10^3 \dots 3 \times 10^4$	VLF	
	<b>Radiowave</b>	Low Frequency	$3 \times 10^4 \dots 3 \times 10^5$	LF
		Medium Frequency	$3 \times 10^5 \dots 3 \times 10^6$	MF
		High Frequency	$3 \times 10^6 \dots 3 \times 10^7$	HF
		Very High Frequency	$3 \times 10^7 \dots 3 \times 10^8$	VHF
	<b>Micro-wave</b>	Ultra High Frequency	$3 \times 10^8 \dots 3 \times 10^9$	UHF
		Super High Frequency	$3 \times 10^9 \dots 3 \times 10^{10}$	SHF
Extremely High Frequency		$3 \times 10^{10} \dots 3 \times 10^{11}$	EHF	
<b>Infra-red</b>	Far Infrared	$3 \times 10^{11} \dots 10^{14}$	FIR	
	Moderate Infrared	$10^{14} \dots 2,14 \times 10^{14}$	MIR	
	Near Infrared	$2,14 \times 10^{14} \dots 4 \times 10^{14}$	NIR	
<b>Visible Light</b>		$4 \times 10^{14} \dots 7,5 \times 10^{14}$	VL	
<b>Ultra-violet</b>	Ultraviolet A	$7,5 \times 10^{14} \dots 9,55 \times 10^{14}$	UV A	
	Ultraviolet B	$9,55 \times 10^{14} \dots 1,07 \times 10^{15}$	UV B	
	Ultraviolet C	$1,07 \times 10^{15} \dots 3 \times 10^{15}$	UV C	
<b>X-rays (Soft X-rays, Hard X-rays)</b>		$3 \times 10^{16} \dots 3 \times 10^{20}$	SX, HX	
<b>Gamma Rays</b>		$> 3 \times 10^{20}$	$\gamma$	

**Table 1 Electromagnetic spectrum**

Because of technological impossibility of using frequency with wavelengths smaller than visible light, the part of the spectrum that can be taken into consideration for the international regulation is only the radio frequency one. Unfortunately the radio frequency

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spectrum is a limited natural resource. This frequency band can not be divided as much as we want without the allocated frequencies to interfere with each other.

The first man to utilize radio waves was the Italian G. Marconi in 1895. At that time all frequencies were natural. Today, over little more than a century, due plenty of technological developments there is a huge request of spectral resources. Today the radio frequency spectrum is utilized for all wireless types of communication including television, broadcasting, cellular telephony, maritime communication, aeronautical communication, satellite communication and others. The radio communication spectrum is used as support for a variety of commercial, governmental or personal applications [2].

As a result of those discoveries some areas of the spectrum, in particularly radio frequency band, are completely polluted. Other spectrum areas develop limitation features in terrestrial environment because of the propagation conditions not raising compatibility issues inter or intra frequencies bands. That is why for some spectral areas (others than radio frequency ones) no international coordination is needed. Some examples of frequency bands in which there are many communication applications are: infrared band and visible light band [5].

The development of informatics and communication services led business companies and governmental agencies to request more frequency resources. Because two or more collocated communication signals could interfere with each other, the frequencies must be coordinated. The process of spectrum management includes setting up regulation structures usually owned by national governments, structures that develop general politics, allocates frequency bands for different services, establish work rules for services, assign frequencies for specific users and impose rules that they must obey.

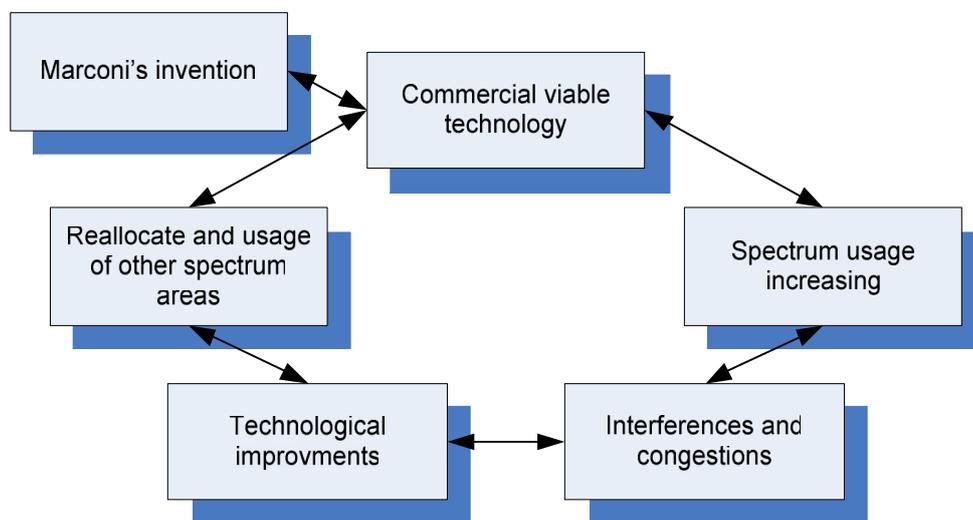


Fig. 1. The cycle of spectrum management challenges

The process of frequency coordinating is more complex as a series of new technologies were developed. As the new technologies became commercially viable, congestions and interferences between users have raised [4]. The last technological developments requested the utilization of some new spectrum bands and redistribution of the old ones. Those actions imply a new raise of congestion, the appearance of other interferences, so a new cycle is initiated (fig.1).

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This is the reason why, for optimizing simultaneous emissions of more users, administrative measures must be used with the main purpose of interference mitigation.

## **3. Spectrum coordination and regulation structures at global level**

The electromagnetic spectrum is a public resource. To assure a balanced distribution of the resources as to promote the public interest, utility or necessity, the spectrum is administrated by the government of each state. At international level spectrum resources utilization is coordinated by ITU. This is an ONU agency that has the responsibility to standardize the telecommunications sector including the radio frequency spectrum. It is structured in 3 big sectors of which the radio communication sector of ITU, ITU-R, has the responsibility of radio spectrum regulation. Because of this, ITU-R has a list of frequency allocation (Table of Frequency Allocations – TOFA) which identifies spectrum bands for 41 radio services as to avoid the apparition of interference between them [6]. Once these large classes are set, each state can allocate specter for these services between its borders, according to TOFA. TOFA divides the world in 3 big regions (fig. 2). Region 1 includes Europe and Africa, Region 2 includes North and South America and Region 3 includes Asia and Australia.

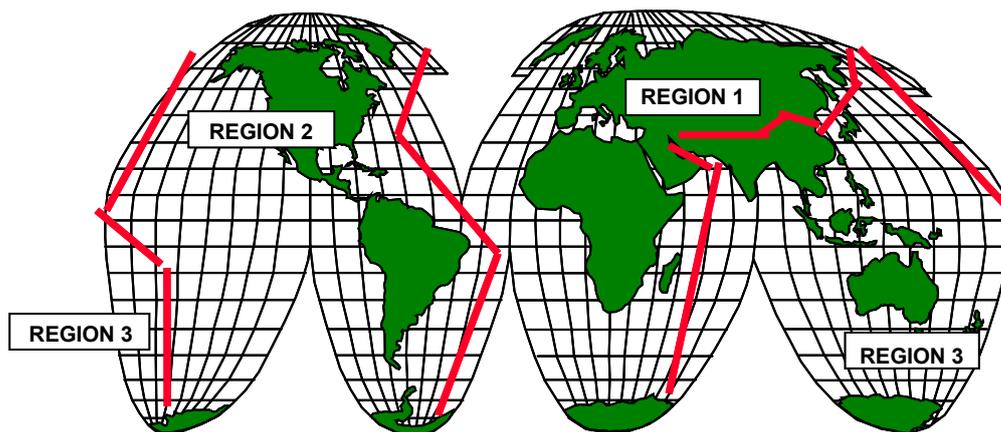


Fig. 2 The Regions set by ITU for worldwide frequency allocation

The ITU-R coordinates the efforts of removing interferences between radio equipment of different states and seeks to improve the utilization of the specter and orbits by geostationary satellites utilized in telecommunication services. The ITU-R the organizer of WRCC (World Radio Communication Conferences) which is held every 2 or 3 years to update TOFA in agreement with the new needs of specter allocation. The last WRCC was held in 2012. The development sector of ITU, ITU-D, is concerned by communication problems and needs of developing states so it can also take part in issues related to spectrum policy.

The most important documents produced by this institute are: The Constitution of ITU, The ITU Convention, The International Telecommunication Regulation and Radio Regulations.

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## **4. Coordination and regulation structures of the spectrum at regional level**

The spectrum management became so economically and politically important that regional organization started to manifest the intention of intervening in the standardization of its politics. For example, the European Union adopted in 2001 a “Decision of Regulatory Framework for Radio Spectrum Policy in The European Community”. This regulatory package reflects the raise of The European Commission’s importance in relation with European national authorities for spectrum regulation [3].

In relation with this trend, by its decision in the spectrum policy, The European Union invites European regulation organizations in this domain to cooperate to assure the coordination of politics, the harmonization and efficient utilization of the spectrum in domains like electronic communications, transport, research and development. This decision establishes procedures to facilitate the implementation of politics on economic, health, public interest, freedom of speech, cultural, scientific, social and technical aspects with the purpose of optimizing the utilization of the spectrum and avoidance of harmful interference occurrence.

In The European Union two organizations were established with the role of regulation and standardization of the radio spectrum. RSC (Radio Spectrum Committee) assists The European Committee in the development and acceptance of technical measures for the harmonization and efficient utilization of the spectrum. The second organization Radio Spectrum Policy Group assists and approves European Commission in political problems for spectrum management.

The coordination of technical, regulator, commercial and operational standards realization, for communication in Europe as part of ITU Region 1 is realized by CEPT (European Conference of Postal and Telecommunication Administrations). CEPT has the task of attribution of frequency bands which will be presented to WRCs as the point of view of European Commission. In its framework a civil/military group exists to annually meet as to harmonize the interests of EU with NATO’s.

In Region 2, the similar responsibilities of The European Commission are realized by CITELE (Inter-American Telecommunication Commission). This organization represents 35 member states and, through the second committee (Radiocommunications and Broadcasting Committee) it realizes the standards coordination and harmonization as well as efficient planning and utilization of the radio spectrum in Region 2[1].

## **5. Spectrum regulation structures at national level**

Romania’s national authority with regulation and administration attributions of the electromagnetic spectrum is ANCOM (Autoritatea Nationala pentru Administrare si Reglementare in Comunicatii). It was established based on OG nr. 22/2009 and has the role of applying national policy in electronic communications, audiovisual communications, radio equipment and terminal equipment of electronic communications domains, including from the point of view of electromagnetic compatibility, information technology and postal services.

ANCOM continues the activity of ANRC which has imposed its activity since September 25<sup>th</sup> 2002. ANRC was established with the target of promoting the competition in the electrical communications and postal services domain and to protect the rights and

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interests of service and network electronic communications and postal services utilizations, in what concerns the transpiration of the providers towards the users, referring to rates and utilization conditions of the services, but also concerning personal character data processing and the assurance of exertive conditions of the right to every Romanian citizen universal service. The transformation was made concerning the full harmonization of national legislation with the community one and the need of regulation in the domain of information technology in relation with the electronic communication and postal service, as convergent domains.

The assurance of electromagnetic spectrum management found in MoD's administration and the representation of its interests in relation with the institutions and military and civil organizations with responsibilities in this domain, on the line of specific regulation harmonization and correct utilization of the radio frequencies is realized by Agentia Militara pentru Managementul Fregventelor Radio a Statului Major General (AMMFR).

This organization was established in March 1<sup>st</sup> 2001, by order of the SMG leader, for efficient use of electromagnetic spectrum resources available to MoD, to represent and defend MoD's interests in the competition with the other big users (G&NG) for this type of resources, to represent and defend MoD's interests at NATO/EU level and to harmonize the national regulations with those of NATO/EU.

## **6. Conclusion**

The radio frequency spectrum is a limited resource found in the administration of each nation. Radio frequencies are allocated with the respect of noninterference's principles and the assurance of radio electric activity mean's compatibility. Due to the specific of propagation electromagnetic waves do not follow the national borders. That is why at national and international level a lot of institutions exist to allocate and assign those resources.

The target of frequency management in the radio spectrum, regardless of the exertive level, national or international is:

- To regulate and standardize the utilization of frequency spectrum;
- To establish and impose rules and procedures for the allocation of spectral resources coordination with the purpose of minimalizing inter-user interferences;
- To realize a balanced repartition of the resources in support of governmental and commercial activities, without affecting the population by exposure to electromagnetic radiation;
- To solve the situations of interference when they still appear.

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