

Standardization and the radio frequency spectrum

François Rancy,

director of ITU-R's Radiocommunication Bureau

Abstract:

The radio frequency spectrum is a scarce resource for most applications on which our societies have become so dependent over the past few decades. Its management is based on a system of international standards and regulations adopted under the auspices of the International Telecommunication Union (ITU) following a procedure that, undertaken by member states, associates the major stakeholders (operators, international organizations, trade groups) who use this spectrum. This procedure is intended to result in a regional and worldwide consensus about the best way to manage the spectrum and to help national and international regulatory frameworks evolve together so as to adapt to rapidly changing technology and its uses, but without jeopardizing the investments already made. In place for 112 years now, this process for producing regulations and standards with universal scope has allowed for the development of radio communications as it now exists.

The radio spectrum is a scarce resource used by most of the applications on which our societies have, within a few decades, become so dependent, ranging from GSM to 5G, from Wi-Fi to Bluetooth, from FM radio to DAB, DDTV and television by satellite, from GPS to satellite imagery. Several essential activities rely on this spectrum — transportation by air, river and sea, defense and security systems, scientific and spatial research, meteorology, monitoring of the climate and the Earth's resources....¹

Once wireless telegraphy was invented, the use of the radio spectrum clearly had to be organized and regulated worldwide. The International Radiotelegraph Convention in 1906 opened the way by adopting the first edition of radiotelegraph regulations under the auspices of the International Telecommunication Union (ITU). Two years after the first experiments with television, a conference in 1927 adopted the first table of radio bands, which were allocated among compatible services so as to avoid interference. It also set up an organization for conducting technical studies to draft standards about using the spectrum and do the preparatory work for the decisions to be made by international conferences. The prerequisites thus came together for the long-term development of a worldwide radiocommunication system through the production of recommendations and standards with universal scope, evidence of this being this sector's exponential growth over the past fifty years.

Since 1906, this international organization for managing the radio spectrum has been regularly improved under the powers granted to the ITU's Radio Communication Sector (ITU-R) for seeing to the rational, fair, efficient and economic use of the radio frequency spectrum by all radiocommunication services on Earth and in space. In 1959, two years after the first man-made satellite was launched, these regulations were revised to cover radiocommunication in space.

Nowadays, five billion people subscribe to at least one mobile communications system (three billion of them to wideband). Six billion radionavigation devices receive signals from satellites for determining their position at any time and place on the globe. More than a billion people have digital terrestrial television (DTTV or DTT), and as many TV sets receive broadcasts via satellite. All of this takes place on radio bandwidths that, standardized worldwide, the ITU-R has organized and protected for decades now even as the underlying technology has evolved.

¹This article has been translated from French by Noal Mellott (Omaha Beach, France). All websites have been consulted in April 2019.

The ITU-R has become a mature organization for producing recommendations and standards, a body where the legislative, standard-setting, judicial and executive powers are clearly separated as a consequence of its 112 years of history (*cf.* Table 1) — and without any significant change since 1992. The ITU-R is also a basically autonomous sector within the ITU. The ITU Plenipotentiary Conference directly elects the director of the Bureau of Radiocommunication and the members of its Radio Regulations Board. This structural autonomy is related to the fact that this sector was not incorporated in the ITU till 1947, even though it relied administratively on the ITU’s General Secretariat.

Table 1: The ITU’s activities in radiocommunication			
<i>Normative</i>	<i>Legislative</i>	<i>Judicial</i>	<i>Executive</i>
Production of international recommendations and best practice guidelines for radiocommunication	Production of international regulations about using the radio spectrum	Adoption of rules of procedure and settlement of the problems with applying radio regulations	Administration, publications, information and assistance related to the sector’s activities
1927-1992: The International Radio Consultative Committee (CCIR), Plenipotentiary Conference and study groups	1906-1938: International Radiotelegraph Convention		1906-1947: International Bureau, ITU
	1938-1966: International administrative conferences of radiocommunication		
	1967-1992: Administrative world radiocommunication conferences (CAMR)	1947-1992: International Frequency Registration Board (IFRB)	
1993-: Radiocommunications Assembly (RA) and study groups of the ITU-R	1993-: World radiocommunication conferences (WRC)	1995-: Radio Regulations Board (RRB)	1993-: Radiocommunications Bureau

ITU-R’s success can largely be set down to the fit between its structure and objective. As a worldwide body in charge of managing the radio spectrum, the ITU-R follows seeks to build a consensus among all stakeholders in the sector: governments, regulatory authorities, operators, manufacturers and international organizations. The legitimacy of this consensus-building process stems from its validation during each phase by the legitimate national authorities (governments and regulators) endowed with the power to propose bills of law, make decisions about national regulations and standards for radio frequencies, and enforce them. In this regard, the national, regional and international work on regulations and standards for using radio frequencies form a continuum, with governments being implicated during each phase as actors, decision-makers and moderators of conflicts between stakeholders. This process leads to adopting by consensus two sorts of rules about using the radio spectrum: RECOMMENDATIONS and REGULATIONS.

International regulations about the radio frequency spectrum

Let us examine RADIO REGULATIONS along with the RULES OF PROCEDURE for applying them.

Under international treaty, radio regulations (which include the technical and operational arrangements and procedures associated with them) are binding on the ITU's 193 member states. Their application enables member states to obtain international recognition and protection of the uses of the radio spectrum that they authorize on the state's territory or in space. The rules of procedure are adopted by the Radio Regulations Board (RRB), which, made up of twelve elected members, fine-tunes procedures for applying the radio regulations. These rules of procedure are adopted by consensus, and ITU member states may consult them beforehand.

The radio regulations are updated every four years by a world radiocommunication conference (WRC) in order to take account of how technology and its uses have evolved in relation to the spectrum. This process involves:

- approving the agenda set by the previous WRC;
- conducting preparatory work by ITU-R study and work groups (approximately thirty meetings per year, each attended by 300 delegates from 50 member states and 30 persons from ITU-R);
- finalizing these studies during a preparatory meeting (attended by approximately 1300 delegates from 110 member states and 80 persons from the ITU-R);
- working out, on the basis of these studies, the final drafts of proposals from member states and of the joint proposals made by member states from the same region; and
- holding the conference (typically attended by 3200 delegates from 165 member states and 130 persons from the ITU-R).

As we see, the whole ITU-R sector is involved.

The ITU-R is a place where parties vie to have their viewpoint recognized as being universal. Among these parties are the representatives of member states, which manage the spectrum. A state's representatives defend a national consensus about its interests. In addition, there are the representatives of telecommunication operators, who seek to protect their uses of bands on the spectrum or to gain access to more or wider bands. Finally, there are representatives of the industries that manufacture and sell the equipment that is or could be used for radiocommunication. When this process is successful, the benefits are evident: worldwide harmonization works for you. In case of failure, it works against you. For the aforementioned industries and operators, this means billions of euros in investments are at stake: those already made and those that have to be made. For governments, what is at stake is the risk of having to pay billions of euros in damages and compensation for having made the wrong choice five or ten years earlier. We see why these struggles are intense.

Conflicts flare up once the questions to be placed on the next WRC's agenda have to be approved. The motion to place items on the agenda is usually motivated by the need to modify existing radio regulations in order to take account of either a new form of technology for using a given bandwidth or a new use that, without a band, cannot be developed. Opposition arises from those who, having already made investments on the band in question, see their investments menaced.

A current example of conflict is the decision made by WRC-15 to exclude the 28 GHz band from the scope of the studies to be conducted in preparation of an item (additional bands for international mobile telecommunications, specifically for 5G) on the agenda of WRC-19. Eight countries (including the United States, Japan and South Korea) wanted to use this band but, having failed to convince the others, have to abide by the final consensus, while issuing a declaration expressing their concerns. Although these countries have earmarked heavy investments for rolling out 5G on this band, the prospect of seeing the rest of the world join them has been diminished or, at least, postponed.

Once an item is on the next WRC's agenda, ITU-R study groups will do the preparatory work by examining the implications of sharing the spectrum such that the new, proposed use will be compatible with previously authorized uses. These studies assess new uses, in particular the nuisances (interference) that would result for existing uses. Reaching a positive conclusion requires, therefore, winning the support of parties whose past or future investments might be affected. These are the parties most likely to oppose the new use. All this might seem exorbitant, but this is how science advances and shores up its legitimacy — by offering a maximum of possibilities for rebuttals and by accumulating achievements.

By modifying the radio regulations every four years, the WRC organizes how the frequency spectrum will be used worldwide for several decades, while taking into account new forms of technology and new uses through a process of innovation subject to conditions related to the protection of still productive investments.

In its 112 years of existence, this institution — thanks to the universal engagement of governments, regulators and all stakeholders in its decisions — has made it possible for a system to develop that represents more than 10,000 billion euros of investments. For twenty years now, this system has taken account of the conditions underlying the technological developments that are now maturing (for instance, constellations of nongeostationary satellites or high-altitude platforms). It has also provided for the development of mobile wideband uses by harmonizing bands for the development of 3G, 4G and the coming 5G.

International recommendations about the radio frequency spectrum

The ITU-R's recommendations stipulate the right way to use the radio spectrum for each of the 39 radiocommunication services defined by the Radio Regulations Board; they allocate the spectrum among and within these services so as to avoid prejudicial interference.

Many of these recommendations have been incorporated in the radio regulations and are, therefore, binding. They have to do with, in particular, performance and design objectives, the criteria of protection, the range of broadcasts, numbering plans... parameters for an efficient, harmonious use of the spectrum that take into account the latest techniques.

The other recommendations, as well as the ITU-R's reports and manuals (on guidelines and best practices for using and managing the spectrum), are universally recognized and applied as basic legislative or regulatory instruments. They have to do with pricing, the authorization of permits for using bands, the management and control of the spectrum, radiocommunication equipment, and the rollout of terrestrial and satellite networks.

Table 2: ITU-R regulations and recommendations about using radio frequencies for 3G, 4G and 5G			
	<i>Decisions about regulations</i>	<i>Decisions about recommendations</i>	<i>Commercial deployment</i>
February 1992	CAMR-92: allocation and identification of 1.9/2.1 GHz bands for “ <i>future public land mobile telecommunication system</i> ” (i.e., international mobile telecommunications, IMT)	RA-95: Adoption of “ <i>Recommendation ITU-R M.1036: Spectrum considerations for implementation of International Mobile Telecommunication-2000 (IMT-2000) in the bands 1 885-2 025 MHz and 2 110-2 200 MHz</i> ” available via https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en	2002: 3G
November 1997	WRC-97: <i>identification of bands 450 MHz, 850 MHz, 900 MHz and 1800 MHz for IMT</i>		2012: 4G LTE
June 2000	WRC-2000: identification and allocation of the band 2.6 GHz for IMT	RA-2000: Adoption of “ <i>M.1457: Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000</i> ” available via https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en	2012: 4G LTE
November 2007	WRC-07: identification and allocation of bands 700 MHz (Region 2), 800 MHz (world) and 3.5 GHz (approximately one hundred countries including Europe) for IMT		2009: 700 MHz in the USA for 4G LTE; 2010: 800 MHz in Europe for 4G 2020: target date for 5G at 700 MHz and 3.5 GHz in Europe
January 2012		RA-12: Adoption of “ <i>M.2012: Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced</i> ” available via https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2012-0-201201-S!!PDF-E.pdf	2012: 4G LTE advanced
November 2015	WRC-15: identification and allocation of bands 700 MHz, 1.5 GHz and 3.5 GHz (worldwide) and 600 MHz (eight countries including the USA, Canada, Mexico and New Zealand) for IMT		2020: 700 MHz, 3.5 GHz for 5G in Europe 2020: 600 MHz for 5G in the USA, Canada and Mexico
November 2019	WRC-19: identification and allocation expected in bands above 24 GHz		2020
September 2020		ITU-R study group 5: the expected adoption of a recommendation on international mobile telecommunications (IMT-2020).	2020

The drafting, since 1992, of ITU-R recommendations for international mobile telecommunications (IMT) provides an example of how ITU-R study groups and the WRC have shaped and overseen the development of 3G, 4G and, now, 5G (cf. Table 2). Recall that, at the end of the 1980s, the absence of a set of standards for 2G led to the development of two rival, incompatible standards (GSM and CDMA) and splintered the world market among different standards and frequencies.

As we see in the table, the allocation of frequencies usually preceded commercial deployment by a period ranging from five to twelve years for 3G and 4G. This lag corresponded to the time needed for retrieving the bands in question from the parties who had been authorized to use them,² for authorizing mobile operators to use frequencies, and for installing the mobile network itself. This cannot, after all, happen on a large scale until worldwide harmonization has been clearly established. This was the case for the bands allocated by an administrative world radiocommunication conference (CAMR-92). In general, the process of worldwide harmonization of radio frequencies takes place over a period spanning several world radiocommunication conferences (WRCs) — the time needed for all countries to overcome a national reluctance to change.³

Parallel to the harmonization of frequency allocations by the WRC, standards need to be harmonized for using these frequencies. For this, the ITU-R has successfully applied a process for 3G (IMT-2000) and 4G (IMT-Advanced) that is now under way for 5G (IMT-2020). This process involves all stakeholders (governments, regulatory authorities, standardization organizations, industries and operators) in the following phases:

- Formulation and adoption on 29 September 2018 of IMT-2020: “*IMT Vision - Framework and overall objectives of the future development of IMT for 2020 and beyond*”.⁴
- Adoption on 30 November 2015 of a timeline for drafting specifications about data rates, system capacity and latency (13 October 2016).⁵
- Adoption on 13 October 2016 of guidelines for evaluating the radio interface technologies to be accepted in the future recommendation IMT-2020.⁶
- Submission on 3 September 2019 of proposals for detailed specifications. Independent groups will evaluate whether these proposals comply with general specifications.⁷
- Adoption (depending on the specifications retained following evaluation) of the recommendation on international mobile telecommunications (IMT) in 2020.

The radio interface recommendation IMT-2020 will come out of this process and be formally approved by the ITU’s 193 member states in 2020, thus conferring on it the legitimacy required for enforcement in all countries.

² The 800 MHz band in Europe was used for radio broadcasting and had to be freed for mobile services, but the prerequisite for that was to stop all analog broadcasting and switch to DTTV. For 600 MHz in the United States and 700 MHz in Europe, frequencies usually have to be modified for the migration of broadcasting, and this takes about five years.

³ For instance, WRC-07 opened the 700 MHz band for regions 2 and 3 (America and Asia); but only WRC-15 extended this worldwide. Likewise, the 3.5 GHz band, declared by WRC-07 to be for international mobile technology in approximately one hundred countries, became worldwide only by decision of WRC-15.

⁴ Recommendation ITU-R M.2083 available via <https://www.itu.int/rec/R-REC-M.2083/en>.

⁵ See <https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx>.

⁶ Report ITU-R M.2412 available at <https://www.itu.int/pub/R-REP-M.2412-2017/en>.

⁷ Report ITU-R M.2411 available at <https://www.itu.int/pub/R-REP-M.2411-2017/en>.

The national management of frequencies

Member states apply and enforce the ITU-R's regulations and recommendations. This national management of the radio spectrum is fully ingrained in the context of an international management that is to be followed and swayed. Its timeline runs from the implementation of the decisions made by the most recent WRC to the preparations for the next WRC.

The main legal instrument at the national level for managing the radio spectrum is the national table of frequency allocations. It has to comply with allocations under the radio regulations applicable to the geographic region. International regulations are thus transposed into the regulations of member states whose administrative authorities provide legitimate warranty for this process. The police and system of justice may intervene in cases of failure to comply.

Since the need for frequencies is not necessarily the same in all lands, the ITU's radio regulations often leave open the choice between several allocations in the same band.⁸ The problems that WRCs have to settle usually ensue from different decisions that, made in the past, accumulate and eventually produce cleavages between countries or regions. A country (or region) will then oppose such and such a choice for worldwide harmonization because it would entail a costly modification of frequencies. All countries share the goal of worldwide harmonization, but each of them might have reasons for preferring a different solution.

Even though the ITU-R's international recommendations (unlike its radio regulations) are not binding, they are, despite the principle of "technological neutrality", *de facto* applied by all radiocommunication operators for reasons of economies of scale and of global interoperability, in particular in the case of mobile networks (3G, 4G and, soon, 5G).

As for the radiocommunication equipment used by the general public without permits (*e.g.*, devices using Wi-Fi), the conditions about sharing frequencies set by the ITU's radio regulations can have as a consequence that a recommendation becomes part of a regulation, a situation that entails controlling compliance. In the European Union, regulatory authorities perform this control *ex post facto*, as they oversee the market. After twenty years, this sort of control has shown its limitations. For instance, on the 5 GHz band shared between meteorological radar and Wi-Fi devices, 50% of the latter do not comply with standards, and the resulting interference affects weather forecasts.

The regional management of frequencies

The need to harmonize radio frequencies between neighboring lands so as to benefit from economies of scale and from the interoperability of radiocommunication networks has, over the past few decades, led to setting up regional organizations for managing the spectrum. These organizations tend to work out a common position for meetings of the WRC and the ITU-R study groups. For example, the European Conference of Postal and Telecommunications Administrations (CEPT) represents, since 1959, 48 European countries. Its Electronic Communications Committee (ECC) makes reports and adopts decisions about the spectrum that, while voluntary, have, after nearly sixty years, practically harmonized the spectrum in Europe.⁹ We owe this to the GSM standard. CEPT's Conference Preparatory Group (CPG) adopts joint European proposals to be submitted to WRCs.¹⁰

Given the mandate it has given to the CEPT and the binding decisions made about the spectrum, the EU has bolstered this framework since 2002. It relies on input from member states via the Radio Spectrum Policy Group (RSPG).¹¹

⁸ Whenever the use of different allocations in different countries is not incompatible (owing to technical limitations) or can be made compatible (through procedures of coordination foreseen by the radio regulations).

⁹ <https://cept.org/ecc/>

¹⁰ <https://cept.org/ecc/groups/ecc/cpg/client/introduction/>

¹¹ <http://rspg-spectrum.eu/about-rspg/>

Conclusion

Drafting and adopting international regulations, recommendations and standards about the radio frequency spectrum come out of a process for building a consensus under the auspices of the ITU and its member states. Major stakeholders who use the spectrum (operators, industries, international organizations) are closely involved. This process seeks to build a regional and worldwide consensus about the best way to manage the spectrum by fostering a joint evolution of national and international legal frameworks so as to adapt to rapid changes in technology and in uses but without jeopardizing the already made investments. For 112 years now, this process for making regulations and recommendations with universal scope has enabled the radiocommunication system to develop into what we now know.