

# The global framework for managing the radio-frequency spectrum: Regulation and standardization

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## **Abstract:**

The radio-frequency spectrum is a scarce resource essential to most of the applications on which our societies have come to depend within a few decades. It is managed through a system of international regulations and standards adopted by the International Telecommunication Union (ITU). This process, conducted by ITU member states, involves working closely with major stakeholders who use the spectrum (operators, industries, international and sectoral organizations). It seeks to reach a regional and worldwide consensus about the best way to manage the spectrum by modifying national and international laws and regulations so as to adapt them to the rapid evolution of technology and uses but without jeopardizing the investments already made. Thanks to this 113-year-old process for making regulations and standards with a universal scope, radio communications, as we know them, have developed.

Once the wireless telegraph was invented, it became clear that the use of the radio-frequency spectrum had to be organized and supervised on a global scale. 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 that had been 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 on 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.<sup>1</sup>

Since 1906, this international organization for managing the 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 radio frequencies by all radiocommunication services on Earth and in space.

The ITU-R has become a mature organization for producing recommendations and standards, a body where the legislative, standard-setting, judicial and executive powers have been clearly separated as the outcome of its 113 years of history (*cf.* Table 1) — and without any significant change since 1992. The ITU-R is basically an 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 can be set down to the fact that this sector, though relying administratively on the ITU's General Secretariat, was not incorporated in the ITU till 1947.

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<sup>1</sup> This article has been translated from French by Noal Mellott (Omaha Beach, France). All websites were consulted in October 2020.

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

The ITU-R's success comes largely from the fit between its structure and objective. As a worldwide body in charge of managing the radio spectrum, the ITU-R 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 competent national authorities (governments and regulators) endowed with the power to propose bills of law, make decisions about national regulations, set standards for radio frequencies, and enforce them. In this regard, the national, regional and international work on regulations and standards for using radio frequencies forms 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 the RADIO REGULATIONS along with the RULES OF PROCEDURE for applying them.

Under international treaty, the Radio Regulations (including 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 Radio Regulations Board (RRB), made up of twelve elected members, adopts the rules of procedure and fine-tunes procedures for applying the Radio Regulations. These rules of procedure are adopted by consensus, and ITU member states may consult proposed modifications beforehand.

Every four years, a world radiocommunication conference (WRC) updates the Radio Regulations (RR) by taking account of how the technology relevant to the spectrum and its uses has evolved. 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 representatives from the ITU-R);
- finalizing these studies during a preparatory meeting (attended by approximately 1300 delegates from 110 member states and 80 representatives 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 its member states and 130 representatives from the ITU-R).

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

The ITU-R is a place where stakeholders vie to have their viewpoint recognized as universal. Among them are the representatives of member states, which manage the spectrum and defend national interests. In addition, there are the representatives of telecommunication operators, who strive to protect their uses of frequency bands or to gain access to more or wider bands. Finally, there are representatives of the industries that manufacture and sell the equipment to be used for radio communications.

When this process is successful, the benefits are evident: worldwide harmonization works for everyone. If the process fails, harmonization works against us. For industries and operators, billions of euros in investments are at stake — those already made and those 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 understand 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 regulations in order to take account of either a new form of technology for using a given bandwidth or a new service (use) that cannot be developed without a band being allocated to it. Opposition arises from those who have already made investments on the band in question and see the change as a threat to their investments.

As current example of conflict, I might mention 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 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 other member states, have to abide by the final consensus, while issuing a declaration of 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 figures on the next WRC's agenda, ITU-R groups study the implications of sharing the band in question, the goal being to make any newly proposed use of the band compatible with the services previously authorized on it. These work groups assess the degree to which the new uses risk generating nuisances (interference) for existing services. Reaching a positive conclusion requires, therefore, winning the support of parties whose past or future investments might be affected, namely the parties most likely to oppose the new service. All this might seem excessive, but this is how science advances and shores up its legitimacy — by offering a maximum of possibilities for rebuttals and 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 but subject to conditions about protecting still productive investments.

In its 114 years of existence, this institution — thanks to the universal engagement of governments, regulators and all stakeholders in its decisions — has fostered a system that represents investments of more than €10,000 billion. For twenty years now, this system has taken into account the conditions underlying the technological developments that will be maturing (for instance, constellations of nongeostationary satellites or high-altitude platforms). It has also foreseen the development of mobile wideband uses by harmonizing bands for the development of 3G, 4G and the coming 5G.

## **International recommendations about using the spectrum**

The ITU-R's recommendations stipulate the right way to use the radio-frequency spectrum for each of the 39 radiocommunication services defined by the RRB. The spectrum is thus allocated between 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, in particular, with performance and design objectives, protection criteria, the broadcasting range, numbering plans... and the parameters for an efficient, harmonious use of the spectrum that reckons with 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 deal with pricing, the authorization of licenses to use bands, spectrum management and control, equipment, and the rollout of terrestrial and satellite networks.

The drafting, since 1992, of recommendations for international mobile telecommunications (IMT) provides an example of how ITU-R study groups and the WRCs 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 developing two rival, incompatible standards (GSM and CDMA), thus splintering the world market between different standards and frequencies.

| <b>Table 2: ITU-R regulations and recommendations about using radio frequencies for 3G, 4G and 5G</b> |   |   |   |
|---|---|---|---|
|   | <b><i>Decisions about regulations</i></b>   | <b><i>Decisions about recommendations</i></b>   | <b><i>Commercial roll-out dates</i></b>   |
| February 1992   | CAMR-92: allocation and identification of 1.9/2.1 GHz bands for “future public land mobile telecommunication system” (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)</i> ” available via <a href="https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en">https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en</a>   | 2002: 3G  |
| November 1997   | WRC-97: identification of bands 450 MHz, 850 MHz, 900 MHz and 1800 MHz for IMT  |   | 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 <a href="https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en">https://www.itu.int/rec/R-REC-M.1036-0-199403-S/en</a>   | 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;<br>2010: 800 MHz in Europe for 4G<br>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 <a href="https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2012-0-201201-S!!PDF-E.pdf">https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2012-0-201201-S!!PDF-E.pdf</a> | 2012: 4G LTE advanced   |
| November 2015   | WRC-15: identification and allocation for IMT 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) |   | 2020: 700 MHz, 3.5 GHz for 5G in Europe<br>2020: 600 MHz for 5G in the USA, Canada and Mexico                                       |
| November 2019   | WRC-19: identification and allocation in bands above 24 GHz   |   | 2020  |
| September 2020  |   | ITU-R study group 5: the expected adoption of a recommendation on the IMT-2020 standard.  | 2020  |

As we see in Table 2, frequencies have usually been allocated prior to the commercial rollout of the service — by 5-12 years for 3G and 4G. This advance allowed for corresponded to the time needed: to retrieve the bands in question from the parties previously authorized to use them, to authorize mobile operators to have access to the frequencies, and to install mobile networks. This process cannot play out on a large scale until rules, regulations and standards have undergone worldwide harmonization, as happened for the bands allocated by an administrative world radiocommunication conference (CAMR-92).

In general, the 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. Let me cite a few examples. When, in line with the decision made by WRC-07, the 800 MHz band in Europe used for radio broadcasting had to be freed for mobile services, the prerequisite was to stop all analog broadcasting and switch to DTTV. Furthermore, for 600 MHz in the United States and 700 MHz in Europe, frequencies usually had to be reassigned so that broadcasting could migrate to other bands. This took about five years. Another example: WRC-07 opened the 700 MHz band for regions 2 and 3 (America and Asia); but only WRC-15 extended this decision worldwide. Likewise, the 3.5 GHz band, allocated by WRC-07 to international mobile technology in approximately one hundred countries, became worldwide only by a decision of WRC-15.

Parallel to the harmonization of frequency allocations by WRCs, the standards for using these frequencies also have to be harmonized. For this, the ITU-R has successfully followed a process for 3G (IMT-2000) and 4G (IMT-Advanced) that is now under way for 5G (IMT-2020). This process has involved all stakeholders (governments, regulatory authorities, standardization organizations, industries and operators) as follows:

- 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*”.<sup>2</sup>
- Adoption on 30 November 2015 of a deadline (13 October 2016) for drafting specifications about data rates, system capacity and latency.<sup>3</sup>
- Adoption on 13 October 2016 of guidelines for evaluating the forms of radio interface technology to be incorporated in the future IMT-2020 recommendation.<sup>4</sup>
- Submission on 3 September 2019 of proposals with detailed specifications. Independent groups will evaluate whether these proposals comply with general requirements.<sup>5</sup>
- Adoption (depending on the specifications retained following evaluation) of a 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. It will thus have the legitimacy required for enforcement in all countries.

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<sup>2</sup> Recommendation ITU-R M.2083 available via <https://www.itu.int/rec/R-REC-M.2083/en>.

<sup>3</sup> See <https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx>

<sup>4</sup> Report ITU-R M.2412 available at <https://www.itu.int/pub/R-REP-M.2412-2017/en>.

<sup>5</sup> 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 ingrained in the process of an international management that is to be obeyed and swayed. Its time line 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 spectrum is the national table of frequency allocations. It has to comply with the allocations set in the Radio Regulations for the geographic region. International regulations are 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 noncompliance.

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 on the same band. This mostly occurs when the use of different allocations in different countries is not incompatible (owing to technical requirements) or can be made compatible (through the procedures of coordination foreseen by the Radio Regulations). The problems to be settled at WRCs usually arise out of decisions made in the past that eventually produce cleavages between countries or regions. A country (or region) will then oppose such and such a choice for worldwide harmonization because modifying frequency assignments and uses comes at a cost. All countries share the goal of worldwide harmonization, but each might have its reasons for preferring a different solution.

Even though the ITU-R's international recommendations (unlike its Radio Regulations) are not binding (also on account of the principle of "technological neutrality"), all radiocommunication operators do, in fact, apply them to benefit from economies of scale and global interoperability. This holds especially for mobile networks (3G, 4G and, soon, 5G).

As for the radiocommunication equipment used by the general public without licenses (*e.g.*, Wi-Fi devices), the conditions about sharing frequencies set by the ITU's Radio Regulations can lead to a recommendation being incorporated in a regulation or standard. This means that the equipment has to be controlled for compliance. In the European Union, regulatory authorities perform *ex post facto* controls, as they oversee the market. After twenty years, this sort of control is showing its limits. 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**

Given the need to harmonize radio frequencies between neighboring lands so as to benefit from economies of scale and from the interoperability of radiocommunication networks, regional organizations for managing the spectrum have, over the past few decades, sprung up. They tend to work out a common position for meetings of the WRC and the ITU-R study groups (See Eric Fournier's article in this issue on the ITU's regional organization).

## **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 on 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 investments already made. For 114 years now, this process for making regulations and recommendations with universal scope has enabled the radiocommunication system to develop in the institution as we now know it.