The Spectrum Behind the Information

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Technology today allows aviation to participate in missions where a timely response is critical, as in the case of disaster assistance and coordinated operations among allied nations in the fight against illegal drug trafficking. In order to do this, aviation currently uses sophisticated navigation systems that allow it to operate safely in conditions that at other times would have made flying impossible. However, the above-mentioned activities require the use of the radioelectric spectrum as its principal input, and this resource currently is becoming more and more necessary for private economic activities that also try to improve their productivity with the use of information and communication technologies. In facing this reality, it is necessary to be conscious of the need for appropriate management of the spectrum in order to be able to find coordinated solutions that permit satisfying the parties involved without affecting the capacity of military aviation to fulfill its mission.

The electromagnetic spectrum and the radioelectric spectrum

The term "spectrum" presented here is broad, so it is helpful to be more precise. When reference is made to the electromagnetic spectrum, this includes "the group of wave lengths of all electromagnetic radiation"[1], that is, all those waves that transport energy in the world around us, such as ultraviolet and infrared rays, visible light, the sound of the voice, etc. The most common way to identify these emissions is through the use of the frequency in Hertz (Hz) and its multiples (KHz, MHz, GHz), which represent the quantity of cycles per second. However, many are not useful for communications, and a range more specifically of interest emerges that is known as the radioelectric spectrum, defined as "a natural resource formed of the group of electromagnetic waves whose frequencies are conventionally set from 9 kHz to 300 GHz and which belong to state" according to the standard in effect in Peru.[2]

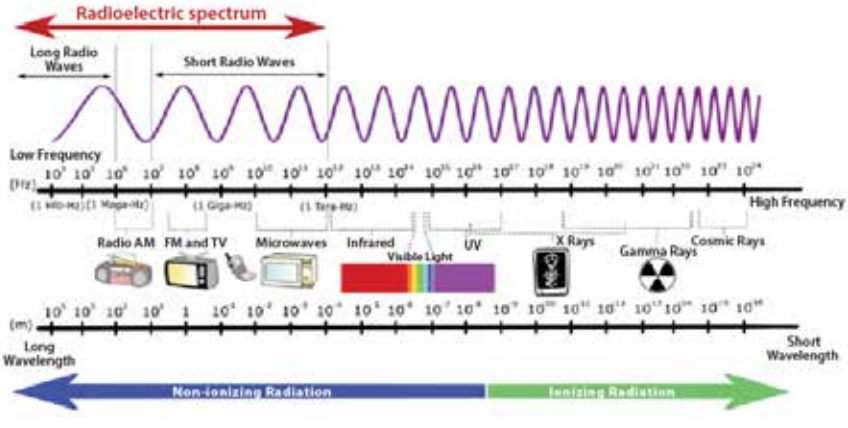

Figure 1 Comparison of the radioelectric and electromagnetic spectra. Source: web Esopo, Uruguay (https://iie.fing.edu.uy/proyectos/esopo/eem/)

[a]*Hereinafter in this article the term "spectrum" will be used in reference to the radioelectric spectrum.*

In Figure 1, one can see some examples of the most common emissions and their location within the radioelectric spectrum.[a]

The more specific nature of the second definition is due to their great economic interest because of their possible use for telecommunications. Even though everyone takes advantage of the spectrum when we use our cellphones, a wireless internet device, a GPS navigator, or a radio receiver, it is a resource that the service provider does not administer nor perceive the importance of its appropriate administration, therefore it is up to the stations and broadcasters to coordinate its management, along with the corresponding authorities, so that no interference is generated and users always have a quality of service in accordance with their contracts. While commercial services offer and forecast coverage according to demand, in the case of military activities, the management of the spectrum must allow for high demand that can arise suddenly (such as in a natural disaster), in difficult geographic zones, and that, additionally, allows the interchange of information with other agencies and even other countries, with spectrum being one of the keys to interoperability among organizations and nations.[3]

This article poses two challenges to consider in the management of the spectrum in the medium term: on the one hand, the increase in the need for spectrum generated by unmanned systems, and on the other hand, the need to assure spectrum use for aerial navigation. In addition, ideas are presented based on the international reality that may be applicable in the region.

Demands from unmanned systems

Telecommunications are a fundamental part of the cooperative security model that has been undergoing implementation since the first decade of this century. There is a change in the dynamics of defense that has been taking place since the beginning of the new millennium, from the old focus on the external enemy, typical of the Cold War, to the establishment of means of mutual trust and mechanisms of solidarity in facing new threats. It is expected that the defense efforts in Latin America against drug trafficking, in favor of caring for the environment, and in response to disasters tend to intensify military cooperation, with an increased requirement for information in real time, not only in voice or data form, but also, and above all, in video and images.

An important capability for obtaining aerial information is that offered by unmanned systems, since they have reduced acquisition and operational costs. At the beginning of 2015 there was already talk of the launch of unmanned development projects in our region, as well as the growth of the import and use of drones for civil purposes.[4]

In this regard, it is necessary to be cautious in order to be able to tend to the requirements imposed by the rapid growth in demand with military purposes, as can be learned from reviewing the experience of the United States since the last decade of the last century until the present.

Figure 2 shows the growth of the demand for satellite communications through the evolution of the flow and speed of data used[b], which is due as much to the growth in the number of UAVs as the improvement in their offerings, with better quality sensors that produce more information per second of recording. One can see the increase of consumption during the latest conflicts, and in the case of the United States there is, in a little over 10 years, an exponential ten-fold increase.[5] In the case of Kosovo, the force was one tenth the size of that of Desert Storm. And during Operation Iraqi Freedom, at peak moments 30 times more bandwidth was consumed than was available in Desert Storm, much of which was consumed by the sensor links aboard UAVs.[6]

b. This flow is connected to bandwidth. For better understanding, the analogy is usually made to a multi-lane road that allows the circulation of large traffic. Greater bandwidth implies a greater amount of allocated frequency and allows a better flow of information..

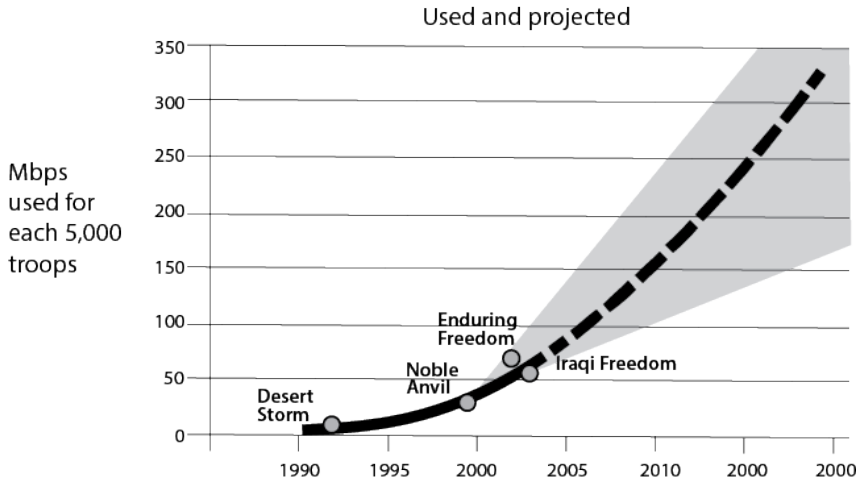

Figure 2. Growth of satellite communication demand of the United States. Taken from Milsat Magazine (http://www.milsatmagazine.com/story.php?number=855426811), translation by the author.

This is due to the main benefit of UAVs, independent of the size of the platform or whether the device weighs a few grams or a few tons, which allows for real time operations, for which it will necessarily use the spectrum.

Thus, the International Telecommunications Union (UIT) recognizes unmanned systems as a growth market on the global level. In the beginning they were in the hands of government entities due to their high cost, but the trend is toward strong growth in commercial users, as shown in Figure 3, driven by the appearance of low cost systems and powerful technology from manufacturers in various countries who compete for the market.

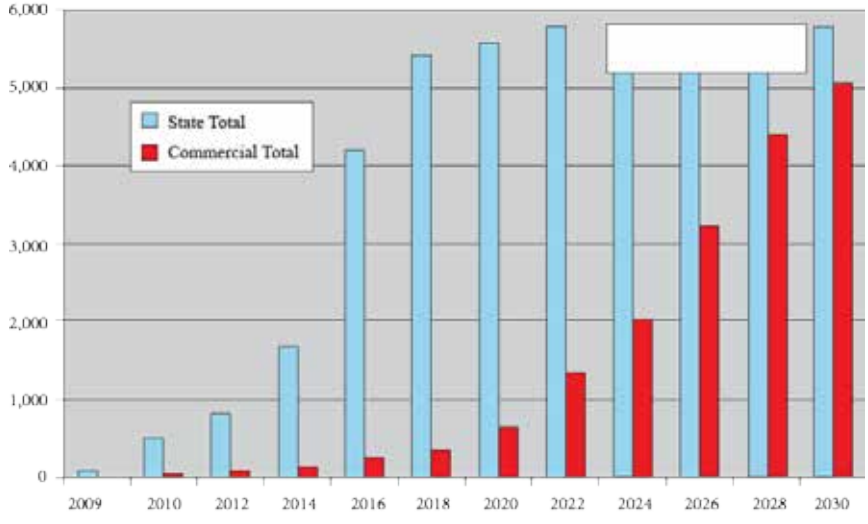

Figure 3. Projection of the accumulated total of available UAS. Source: Report ITU-R M.2171 (2009). Translated and adapted by the author

A report from the UIT in 2009 anticipates significant growth of the use of UAS in the next decade, again making essential the integration of those systems with conventional air traffic.[7] This organization considers three communication links for the UAVs:

- Radiocommunications for air traffic control, operating in unsegregated air space. This link is critical for security in controlled space, especially in areas of final approach in high traffic, and refers to links across the platform from the ground control station of the UAV with ATC control.
- Radiocommunications for command and control of the UAV, which form the typical link between the platform and its control station, to send the flight commands and receive the telemetry and information from sensors.
- Radiocommunications for collision avoidance.

These links, in an estimate by the UIT to evaluate the demand for spectrum in the report mentioned, were initially calculated to be 34 MHz for the ground systems and 56 MHz for the satellite systems.[8] However, the expansion of users casts doubt that these calculations are still effective, and at the WRC Conference (World Radio-communication Conferences, World Radio-communication Conference by UIT) in 2015, there was consideration of the use of bands assigned to satellite services for the control and communications of autonomous systems in non-segregated spaces. As regulations do not always keep up with the speed of the market, a case was presented on the use of spectrum assigned to cellular services and unlicensed spectrum (for free use) for domestic applications of UAVs, such as filming of events and marketing campaigns. This use has already been causing instances of disruption and interference, since the UIT has spectrum assigned for Mobile Aeronautic Service specifically for links to and from aerial systems, while the cellular and unlicensed bands have not been planned for ground transmitters, and generate a much greater interference that could lead to the saturation of communications.[9]

Currently in the region, the first regulatory standards are being issued for the use of UAS, however these focus mainly on the requirements for security, aerial navigability and protection.[10] It is necessary to have a prospective focus at the moment of managing the spectrum for aviation and defense in order to combine on one hand the telecommunications technologies in effect in the market and on the other hand the assignments of spectrum in each country.

The spectrum for aeronautical purposes

The Manual for Management of the Spectrum from the International Organization for Civil Aviation (OACI), 2009 edition, recognized that internationally the aeronautical services are the main users of radio frequencies. As a reference, the spectrum of frequencies used by aeronautics at that time was about 14% of the total available, with two main functions: air-ground communications and radio navigation, forecasting a strong tendency toward gradual increase of satellite services.[11] Currently there are 29 uses of the radioelectric spectrum recognized for aeronautical purposes, in 11 bands, from the low frequencies to the ultra high. Among those uses, a report from the International Association for Air Transportation (IATA) of July 2017 considered that 3 were at risk, 3 should be monitored and there were other cases that presented potential interference.[12]

However, it is the UIT that manages at the highest level the spectrum for all purposes (including aviation), and for this purpose every four years it holds the WRC Conferences, where the international regulations of radio are updated. At these conferences aviation is one of the interested parties, together with cellular telephone operators, governmental networks for disaster response, radio enthusiasts and satellite service operators, among others.

[c.] Usually under the care of the Communications Ministry or the equivalent governmental authority.
[d.] https://www.citel.oas.org/es/
[e.] Understood as the best use for transmitting more data in a band width. It is result of the appearance of technological improvements.

Coordination for expressing the requirements of aviation is carried out on three levels: at the national level, the position is developed and coordinated with the National Authority for the Frequency Spectrum,[c] within which aviation is one of the participating elements. The representative of this authority stands for the official position, having to reconcile the requirements of all of the elements and prioritize according to the dispositions of the government. Then, at the level of the Americas, the National Authorities coordinate in the Interamerican Telecommunications Commission (CITEL)[d], where aviation representatives may not have the right to a voice, given that there is only one official position. However, in this instance the OACI is allowed to participate. Finally, at the international level, the positions are agreed by means of study groups at the UIT, and they are made known at the WRC, in which the aviation representatives may be part of the national delegations, but again have no voice since they do not represent the official position.

Keeping in mind the concern manufacturers have for developing systems that allow them to increase security in skies that are more and more congested, the makers of avionic equipment develop systems to avoid collision with the ground and other aircraft, and to optimize navigation. As a result, airspace is becoming more complex and the demand for frequency allocation (and the resulting distribution of the spectrum) is growing. While part of this demand can be absorbed through an improved spectral efficiency[e] of the existing radio sistems in bands already assigned to the aeronautical services, it is inevitable that these bands must grow or additional bands must be assigned in order to cover this necessity.[13]

Spurred by the next WRC to be held in 2019, the OACI has propagated its position to oppose new distributions for other services in bands/ranges of frequencies that could impact aviation systems, unless studies exist that demonstrate that there is compatibility for sharing these bands.[14] It is necessary that aeronautical organizations analize this document and, if convenient, lend their support to assure the availability of resources that allow aviation to operate securely. Also, the OACI recognizes that competition on the international scale to expand radio services obliges all users (for all purposes, including aviation, as well as the armed forces in general) to permanently sustain and optimize the retention of frequency bands. For this it is necessary that the users act in a coordinated manner to create policies that assure the continued availability of adequate spectrum around the world.[15]

Spectrum Management in the Armed Forces

Part of the coordination required to assure the availability of frequencies implies the appropriate management of the spectrum for military purposes. If it is true that there is a trend toward reducing the size and optimization of the armed forces at the world level, in the particular case of Latin America this is accompanied by the appearance of new roles with their corresponding demands.[16] That is to say, although there is a lesser quantity of personnel and equipment, now they must attend to more requirements, there being cases such as disaster response, in which time is critical. For this a modernization process has been undertaken, in which limited budgets make it necessary that many means that border on obsolete technology be used together with modern low cost technologies.

The transformation toward a more agile scheme implies the availability of communication links that allow carrying out operations under a network model that makes possible sharing of situational awareness without restricting mobility.[17] This statement, originally proposed for the United States Army at the beginning of the century, is applied to the rest of the armed forces who must efficiently respond to new demands. For that, it is necessary to anticipate the spectrum re-

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sources that allow secure links for completely military operations, as well as flexible links for situations in which cooperation among governmental and non-governmental agencies and allied countries may be required. However, reserving spectrum for contingency purposes in emergency situations deprives a state of exploiting it economically, and thus there is permanent tension between the defense sector and private enterprise.

There is a notable increase in the communications sector in civilian life, for which growning quantities of spectrum are being requested, including some which previously were allocated for military use. The majority of developments in the telecommunications area are oriented toward wireless devices for broadband services, that is, cellphones and wireless internet. In the face of permanent demand for more data speed, the companies request greater allocations of spectrum, arguing that many of the current allocations are underutilized. For political purposes, it is more practical to displace government users and specifically the defense sector.[18] Specialists in the region recognize that there is an insufficient allocation of the spectrum and conflict is caused with the armed forces in order to recover spectrum for commercial purposes. However, a larger problem is the lack of planning and forecasting with respect to frequency management that allows for closing the digital divide.[19]

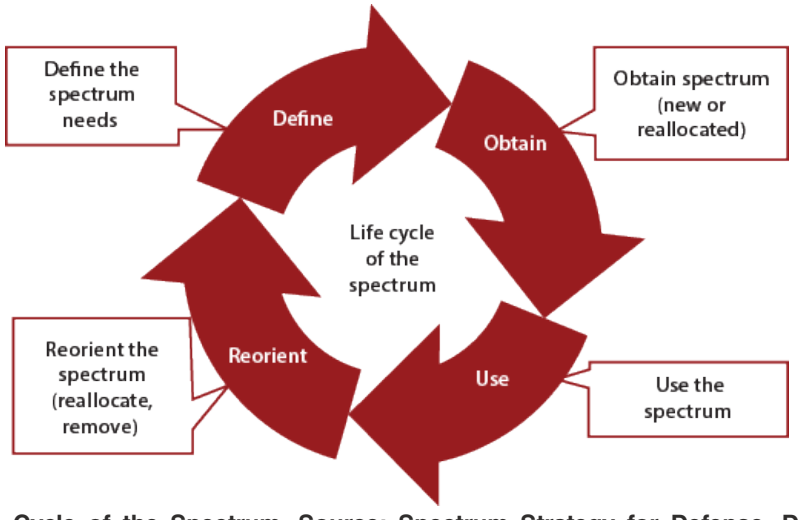

Figure 4. Life Cycle of the Spectrum. Source: Spectrum Strategy for Defense. Department of Defense, Government of Australia (translation and adaptation by the author)

Since this is a common reality at the world level, alliances of countries such as NATO and the CCEB[f] have established working groups for the purpose of formulating standards that permit having spectrum available and assuring the integration of their communications. Among the objectives for the management of military frequencies of the CCEB, are, for example[20]:

- Coordination of frequency band allocation to equipment where its operation could affect existing or future equipment used by another nation
- Information interchange regarding the national allocation of frequencies
- Offer frequencies when two or more countries are conducting combined operations or exercises, or in coalition
- Assure that the national administration adequately understands the military requirements for spectrum.

The last objective is particularly important because many times the management of the spectrum is perceived as a highly technical issue that only involves military specialists, losing the opportunity to harmonize criteria with other sectors. Among the experiences in management of the spectrum through civil-military cooperations in the world, it is interesting to mention the case of Australia. In its strategy for the defense spectrum, the Australian Department of Defense has established a focus on the management of the life cycle of the spectrum that says that this critical resource should not be seen as a one-time acquisition, but rather its necessity, obtainment, use for specific purposes, reorientation and reutilization should be defined.

Enlarging and adapting the ideas of this life cycle, we can identify each stage of the life cycle:

- Define the necessity: determine the user systems that operate in short, medium and long term. It requires identification of the scenarios in which the defense policies determine the participation of the Armed Forces and the spectrum user systems that intervene, based on strategic plans and doctrinal concepts.
- Obtainment of spectrum: process of assignment that the state authority for spectrum management grants to the Armed Forces, that requires identification of the quantity needed, and the area (national or local assignment). On this point, it is necessary to evaluate if this causes conflict with other interested organizations of the same spectrum.
- Use of the spectrum: verify that the equipment effectively uses the spectrum allocated. For such a purpose correct maintenance is needed, since defective transmitters can generate interference to other users by using more spectrum than assigned.
- Reorientation of the spectrum: currently technolocial advancements in the telecommunications area make it such that equipment is ever more efficient, and at the same time civil use systems appear with different spectrum demands. As equipment is taken out of operation, it is necessary to define if its replacement will use the same band of frequencies or will migrate to another; in the latter case, an eventual reallocation to another user, be it defense, public or private, will allow that the State owner obtains better use.

Conclusion

The spectrum allows aviation to have available the information it requires for its operations and for decision-making. To assure it, management of the spectrum requires a proactive focus and strict coordination with the civilian environment. In this regard, of fundamental value is understanding its dynamic nature and the valuable orientation role offered by organizations such as the OACI in order to be able to defend aviation's necessities in international forums in facing the demands of commercial activities. ❑

Notes

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