THE SPECIFICITY OF SCIENTIFIC USE OF SPECTRUM.

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Abstract— *The progress of technologies induces a need of bandwidth in the frequency spectrum, which is full in most countries. In consequence administrations have to balance two opposite concepts : public and private, market and progress of basic knowledge*

I. RIGHTS AND PROTECTION:

Article 5 of the RR (Radio Regulations) specifies all allocation bands from 9 kHz to 1000 GHz in the whole world, as well as the rights of protection against harmful interferences.
To day, only frequency bands up to 275 GHz are allocated.

A. Below 275 GHz

1) In primary exclusive frequency bands

The footnote 5.340 of RR indicates a list of bands where emissions are strictly prohibited in all the countries members of ITU. These frequency bands are called "exclusive bands". Obviously, those bands are dedicated to passive services.
Twenty-one frequency bands defined from 1400 MHz to 252 GHz are allocated for passive use to:

- Earth Exploration Satellite Service (EESS)
- Space Research Service (SRS)
- Radio Astronomy (RAS)

2) In primary shared frequency bands.

The footnote 5.149 of the RR asks to Administrations to take "all practicable steps to protect passive services against harmful interference". Thirty-nine frequency bands are defined all over the world, from 13360 kHz to 114.25 GHz. These frequency bands are shared principally with space borne and airborne stations.
Regulation agencies of each country are responsible of application of these footnotes, so the difference in interpretation of the RR by different governments could moderate the protection of scientific bands in some countries.

3) In secondary shared frequency bands.

A secondary allocation does not give any right to any protection in this frequency band. So, passive services may only be "victim" inside of these frequency bands.

4) Outside of attributed frequency bands.

Users of non-attributed frequency bands have strictly no right to practice emission. On another hand, if the EMC field is sufficiently low, the interferences produced are not detectable by so called "victims".
Reversely, scientific use outside of attributed bands is very difficult, considering the increasing number of operators. Use or Radio Quiet Zone could be envisaged. Also device development in a Faraday Cage is generally used when observation of distant phenomena is not required.

B. Between 275GHz and 1000 GHz

Article 5.565 of the RR gives recommendations on this part of the spectrum, for experimental applications : "The frequency band 275 – 1000 GHz may be used by administrations for experimentation with, and development of, various and passive services. In this band a need has been identified for the following spectral line measurement for passive service"
Are listed eight bands for Radio astronomy and seventeen bands for passive EES and SRS.
As these bands are not allocated, so this article could conclude : "Administrations are urged to take all practicable steps to protect these passive services from harmful interference until the date when the allocation is established"

C. Above 1 THz

The spectrum actually covered by ITU-R rules has an upper limit at 1 GHz. Part of the agenda of the next World Radio Conference in 2007 (WRC-07) is to discuss on the part of spectrum above 1 THz up to 3 THz.
Radio astronomers have identified twenty-three frequency bands of interest to the community, taking in account a Doppler shift of ± 300 km/s. Some scientists believe that a red shift of +300 / -1000 km/s is more appropriate. Other people believe that it could be more efficient to keep five very wide bands free of interferences.
It is to be noticed that agenda of WRC-07 (In 2007) was approved in WRC-03, so the WRC-07 will decide of the agenda of WRC-11 (in 2011).

II. SCIENTIFIC FREQUENCY BANDS IN JEOPARDY.

The progress of technologies induces a need of bandwidth in the frequency spectrum, which is full in most countries. In consequence administrations have to balance two opposite concepts : public and private, market and progress of basic knowledge. If traders are able to compute the price of one megahertz, the scientists couldn't.

A. The impact of new technologies.

The introduction of new technologies and new applications requires new access to the spectrum. But in most industrial countries, there is no part of spectrum unallocated. For some years, making part of spectrum available to satisfy the European harmonization has required the relocation of many users. Some users have the possibility to move from one frequency band to another, with appropriate funding from administration.
This flexibility is not possible for the scientific frequency bands whose numerical values are derived from universal physical laws.
So the administrations have to balance with the economical (short term) value and the scientific (long term) value of each part of the spectrum attributed for the scientific use.

Everybody can imagine the weight of scientists compared to operators.
Frequency management politics is very different depending on different countries; fortunately, in France, ANFR plays an important role to prevent the degradation of the quality of the spectrum.

Some new technologies such as Ultra Wide Bandwidth (UWB) will be very soon used by a large amount of users. This technology is dedicated to the global market (not subject to licensing). This justifies technical studies at international (European) level to protect the quality of spectrum. Scientific users (and particularly passive users) of spectrum are highly concerned with these studies, due to the high sensitivity of the receivers (radio telescopes). This action, by CEPT ECC TG3 / 63 and IUT-R TG 1/8, is now under development.

The European «Radio Spectrum Policy Group» engages an action called «Scientific Use of Spectrum». The main objective of this request is to develop a policy approach, which ensures that the specific constraints on spectrum used by scientific services, and in particular by passive services, are taken into account within the overall European policy goals. A list of frequency bands used for scientific purpose, will be bring for discussion. The public consultation is to be finalized in August 2006. The opinion will be presented for approval in October 2006. This action does not concern frequencies above 270 GHz.
The result of this request for opinion is not obvious. In some countries, the goal is to preserve the frequency bands used for science, but in others countries it is to balance costs and benefits of scientific use versus costs and benefits economical use.

III. THE NEED OF BANDWIDTH FOR OPERATORS

A. In primary exclusive bands

Primary exclusive bands are protected by footnote 5.340 of the RR. This footnote was created to protect passive services from active services noting the vulnerability of passive measurements. The text ix very clear and explicit: "All emissions are prohibited in following bands", and the bands are listed.Nevertheless, an exception has occurred: the Automotive Short Range Radar between 23,6 and 24 GHz. The band 23.6-24 GHz is of primary interest by itself to measure water vapour and liquid water.

1) The SRR24 short story.

A group of car manufacturers and suppliers organise themselves in a consortium called "SARA" who plans to implement SRR's in cars. This device operates around 24 GHz.
European Commission for licensing was approached for a standard development
A work group, including scientific community was constituted by ECC to study SRR compatibility with allocated services (EESS passive, RAS)
Following a very hard discussion, an interim implementation of SRRs in band 23.6 - 24 GHz was applied, despite of scientific community protest.
On the other hand, it was admitted that SRR (assuming use of power levels defined by US) cannot share the band 23.6 - 24 GHz without limitations including:

- Permanent band attributed for SRRs will be around 79 GHz
- Implementation of SRRs in band 23.6 - 24 GHz is temporary
- Maximum of 7 % of cars with SRR will be allowed
- Sale of cars with SRR24 will end in 2013, and be replaced by cars with SRR79.
- Automatic switch off facilities is mandatory inside specified areas (radio telescopes).

As an example the radio telescope of IRAM in Plateau de Bure and Observatoire de Bordeaux have received a protection in a 35 km radius area. The CE report says : "The temporary introduction of automotive short-range radar in the 24 GHz range radio spectrum band has an exceptional character and must not be considered as a precedent for the possible introduction of other applications in the bands where ITU Radio Regulations footnote 5.340 applies, be it for temporary or permanent use."

For the first time there will be an active use in a band protected by footnote 5.340, people could believe this is a unique exception.

B. In shared bands

Up now, the sharing of frequency bands protected by the footnote 5.149 was not so difficult to be managed, due to the large availability of frequency modification from the concerned operator.
Due to the extension of the bandwidth occupancy (asked by the operators) the part of the spectrum not used inside of a given geographical area has become scarce.
Other techniques of management, like time sharing inside of a given frequency bands, are now taken in account. For example, if a radio observatory did not use a specific frequency band during a defined time interval (some weeks, some month) some operator wishes to use this frequency band during this time.
The same technique is used in non-attributed bands: in this case observations are done during low radio traffic hours.

C. Quiet zones for science.

1) The frequency "quiet" parts of the spectrum

It could seem obvious that the upper part of the spectrum (approximately above 50 GHz) is free of interferences, including the lines not legally attributed to science. This may be true to day, because the technology for current applications (telecom, UWB, broadcasting, etc) is not yet ready to use this part of spectrum. Tomorrow, the quick improvement of technology will allow the occupancy by the operators of the upper part of the frequency spectrum.
The scientific community must be aware to attach importance to the protection of this part of spectrum. This could be done by the way of each national administration, accordingly with the RR.

2) The geographical radio quiet zones (RQZ)

The increase of radio telescopes sensitivity has enabled the detection and the study of objects at very long distance, presenting a very important red shift. Most of the time, this phenomenon shifts the observed lines out of the allocated bands. This is particularly restrictive for the Square Kilometre Array (SKA) telescopes at 21 cm, but all the future ground based radio telescopes are concerned (ALMA, etc)

It is obvious that the increase of scientific frequency bands is very unlikely, so the installation of future radio telescopes (SKA, ALMA, etc.) in a Radio Quiet Zone is the best compromise.
A good example is the National Radio Quiet Zone, which is a 13000 square miles region in West Virginia and Virginia around the Green Bank Observatory site.

IV. Conclusion

The introduction of new technologies requires new access to the spectrum. But in most industrial countries, there is no part of spectrum unallocated. Flexibility is not possible for the scientific frequency bands whose numerical values are derived from universal physical laws.
Everybody must be aware that operators and traders are now looking at the part of the spectrum used for science.