A Comparison between European and North American Wireless Regulations

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***Abstract* — Following the European unification, the world's wireless regulation and standardisation are divided into two major camps, Europe and North America, which differ in their approach to top-down mandated standards, licensing and harmonisation. The diverse cellular penetration and digital TV standards are derived from dissimilar coverage zones and population densities. Attitudes to RF human hazards and the regulation of licence-exempt, spurious emissions, UWB emission masks and cognitive radios reveal that the US and Canada are generally less conservative than Europe. The fundamental differences are presented, analysed and explained, and predictions outline the worldwide anticipated adoption of new technologies.** [1]

Keywords — 4G mobile communication, broadcast technology, communication standards, cognitive radio systems, interoperability, radiation effects, spectrum management, UWB, wireless communication.

I. Introduction

This paper is based on the author's broad study of 235 countries, and detailed case studies of the UK, France, the US and Ecuador [1], and the author's expertise in international, regional and national spectrum management. The European RF harmonisation framework is unique. Africa and West Asia generally follow Europe, whereas Central and South America generally follow North America. This paper compares and contrasts RF regulation and standardisation in the European and North American hemispheres. The most up to date data is used in order to define the technical and administrative differences across the Atlantic. The dependent comparative attributes are all related to wireless communications: the leading applications (cellular and TV), permitted RF spurious emissions, emission masks of Ultra-Wideband (UWB), Short Range Devices (SRD), Cognitive Radio Systems (CRS) and RF thresholds for human hazards. Most of the compared attributes are similar amongst the US and Canada, as well as amongst the 27 E.U. countries. After specifying the divergence between these two major world regions in Section II, discussion on the attributes and explanation of the differences are provided in Section III.

II. Europe versus North America

A. Different Cellular Technologies and Penetration Rates

Different cellular technologies and penetration rates characterise Europe and North America. The European GSM standard is accepted and operated in the entire world; throughout recent years most North American cellular providers were either supporting GSM or transitioning to it. The cellular penetration is indicative: the average mobile cellular subscriptions per 100 inhabitants in 2010 [2] in 27 European Union (E.U.) countries was 113.6, versus 89.9 in the US and 70.7 in Canada. France has the lowest cellular penetration in the E.U. (99.7), which is still higher than in the US and Canada.

There are some core reasons for this divergence: most of the world operates with the Calling Party Pays (CPP) billing scheme, whereas in the US and Canada the cellular Receiving Party Pays (RPP) (or WPP - Wireless Party Pays), whereby charges are incurred by the wireless subscriber for both originating and terminating calls. The superior landline telephone services in North America, which has always offered free local calls, may have also contributed to the low cellular penetration in North America. It is to be further noted that the fragmented cellular standards in North America (TDMA, CDMA, GSM) reduced cellular penetration over the years, impeded international and domestic interoperability, and even competition, since it necessitated the purchase of a new cellular telephone when moving from one service provider to another [3]. Meanwhile, globalisation led to the development of cost effective technology permitting cellular devices to accommodate all GSM-family frequency bands, including those allocated for use in North America; thereby accelerating the acceptance of GSM as the leading global standard.

In Europe, ownership of multiple SIM (Subscriber Identity Module) cards is common practice, while in North America single subscriptions are more common. In addition, the average cost per time and call charges are greater in the US and Canada, perhaps due to the large geographic expanse and low population density in much of the two countries. The fact that most European countries typically licensed GSM to a core group of 3-5 Mobile Network Operators (MNOs) allowed each to build up sufficient scale in their national markets, to rapidly drive investment in infrastructure. New mobile bands in Europe are aligned not only across the

[1] Paper presented on 27 October 2011 at the "Technical Symposium at ITU Telecom World 2011" www.itu.int/worl2011 .The Article represents the opinion of the Author and does not imply any endorsement of said opinion by the Organizer or MoC.

European Union, but also across the whole CEPT [2] (48 countries). The US does currently have national network operators but its licensing process has always been more piecemeal/ regional.

The cellular standards set the framework of a huge industry. For many years the US has been dominant in networking, computing, microprocessor technologies and software industries, whereas Europe has been leading in the cellular market- base stations and handsets[3]. The European GSM standard was imposed by a Council Recommendation 87/371/EEC, and the GSM frequencies were carefully harmonised in Europe; i.e. the European cellular market was defined by one common standard (GSM) and common frequencies (900MHz and later 1800MHz): a monopoly technology within Europe.

The total success of GSM and the European leadership of the cellular industry may be attributed to the top-down European enforced harmonisation and higher penetration rates. The success of GSM paved the way to global adoption of UMTS/HSPA and, more recently, to its natural successor LTE. The 3GPP (3rd Generation Partnership Project) evolved GSM core networks are: GSM (second generation of cellular technology or '2 G'), GPRS (2.5G), EDGE (2.75G), W-CDMA/UMTS (3G), HSPA (3.5G), and LTE (4G). Moreover, the success of GSM opened markets outside Europe to other ETSI standards, such as the digital TV standard DVB (Digital Video Broadcasting).

B. *TV Standards*

Over-the-air analogue and digital TV standards are completely different in Europe and North America. The European hemisphere, characterised by 50 Hertz electrical power mains, operates analogue PAL and SECAM colour TV and switches toward DVB-T; whereas the US and Canada hemisphere, characterised by 60 Hertz electrical power supply, operated NTSC colour TV and switched to ATSC (Advanced Television Systems Committee) in 2009 in the US and in 2011 in Canada.

The increased penetration of cellular in Europe has created the demand for mobile TV and fuelled the market for it. Trains move relatively slowly in the US and Canada, whereas many of them move very quickly in Europe, necessitating a more robust TV modulation scheme, which further motivated the choice of OFDM. The digital American TV ATSC was initially not designed for mobility[4] (now it supports it), while the European DVB-H (Digital Video Broadcasting - Handheld) was designed to allow reception at speeds of more than 300 km/h. The population density also influenced the adoption of the standard; the modulation scheme of ATSC (8-VSB) is suited to the relatively rural North America, providing large coverage zones; whereas the OFDM scheme is suited to the more compact Europe.

An important factor in defining the digital standard is to consider the channel bandwidth (BW) of existing analogue standards. Countries using the analogue PAL or SECAM with an 8 MHz UHF BW are likely to choose a standard that can handle such channels (e.g., DVB-T), while Americans using NTSC or PAL (Brazil) with 6 MHz BW may choose any of the digital standards (ATSC, DVB-T, ISDB-T and DMB-T fitted to 6 MHz), thus maintaining the BW compatibility. The limit of operation at 6 MHz BW (to use properly the RF, the bit-rate for higher BW should be fixed) is one of the reasons that ATSC is rarely operated outside America, while the European DVB-T has spread to all continents (as the GSM).

DVB-S2 (the satellite component of DVB) is already the leading preferred standard for satellite digital broadcasting.

C. *Spurious Emissions*

Spurious emissions are unwanted RF transmissions, whose level may be reduced without affecting the corresponding emission of information. The *spurious emissions* are fundamental in regulating RF systems, as their levels affect the seamless introduction of any new system that could potentially interfere with adjacent receivers. There are significant differences between ITU-R Category B (Europe) and Category C (the US and Canada). Each grouping represents a compromise between lower *spurious emissions* (reduced RF interference) and the cost of equipment. Table I compares the *spurious emission* limits (dBm) for various systems in Europe and North America, with lower power levels (e.g., -50dBm versus -13dBm) indicating more restrictive thresholds.

TABLE I. SPURIOUS EMISSION LIMITS FOR VARIOUS SYSTEMS [1] , [4]

Type of equipment	Category B: Europe (dBm)	Category C: The US and Canada (dBm)
Land mobile service, 465MHz, 1 W, 12.5 kHz channels	-36	-20
Fixed Service, 325 MHz, 10 W	**-50**	**-13**
HF Broadcasting, 100 kW	17	0
FM Broadcast, 100 MHz, 10 kW	-15	-10

The permitted *spurious emission* levels in North America are significantly higher than those of Europe. For example, in the US/Canada the allowed spurious levels for fixed service are up to 37 dB higher than in Europe (bolded values in Table 1).

Europe is the most stringent in its limits and protection of the natural RF resource, whereas North America is more

[2] *Conférence Européenne des Administrations des Postes et des Télécommunications*.
[3] This is starting to change with non-Europeans becoming big providers of user-equipment.
[4] Taiwan (mainly follows the US standards, e.g., analogue TV NTSC) preferred the DVB-T to ATSC, due to its mobility features.

sensitive to the market needs. Europe also regulates the *spurious emissions* of unlicensed short-range-devices (SRD), whereas North America does not.

Another example is the significant difference in emission masks allowed for UWB transmission, as shown in Fig. 1. Based on a comparative study by WiSAIR Israel, from March 2011 (see also [5]), the differences are up to 49 dB at 900-960 MHz. Moreover, the US is more progressive in advancing UWB: Europe allowed operation of UWB in 2005 and the US in 2001 (Canada did not follow the US in this case). In Europe the regulator's approach is generally to protect existing services, and to convince all the countries to agree, with both these issues delaying the penetration of UWB and resulting in a conservative emission mask.

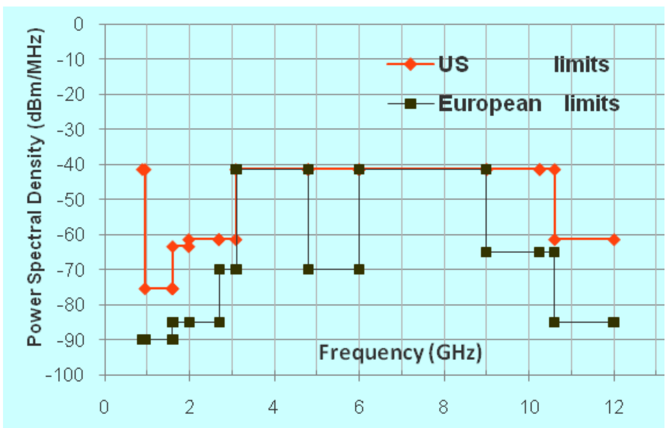

Figure 1: UWB emission masks in Europe [7] and the US [6]

D. Licence-Exempt Devices, Short Range Devices

The Licence-Exempt device is a successful example of an unregulated field; WRC 2012 Agenda Item 1.22 [8] "to examine the effect of emissions from short-range devices on Radiocommunication services…" highlights its importance and complexity. The FCC 47CFR Part 15 Radio Frequency Devices [9], originated in 1938 (had major revisions in 1948 and 1989), inspired the European Short Range Devices' (SRD) concept (circa 1990) and the ERC/REC 70-03 [10], resulting in the proliferation of many wireless consumer-market products operating in the license-exempt bands.

In the US and Canada most of the RF spectrum is available to SRD. The US even allows license-exempt operation in the TV bands, under specific conditions: geo-location, database querying and possible RF sensing [11]. License-exempt operation in TV bands has not been allowed in Canada; preference was given to "light licensing" of Remote Rural Broadband Systems to facilitate deployment of broadband access systems in less populated areas of Canada [12]. Europe generally permits lower levels of emission, e.g., 0.1W versus 4W in the international ISM band 2.4 GHz. Europe also allocates less RF bandwidths for applications such as Wi-Fi and RFID. Moreover, Europe constrains the operation of Wideband Data Transmission systems in the 5150–5350 MHz band to only indoor use [10].

It is important to note that the European Radio Equipment & Telecommunications Terminal Equipment (R&TTE) Directive [13] goes much further than the FCC in its liberal approach, where type approvals are concerned. Instead of the European self-conformity and the UK specifying that Short Range Devices require less intervention from the state, the FCC asks for certification for these low power transmitters. The European self-conformity concept of '*laissez passer*' for equipment in harmonised RF bands means that the R&TTE norm allows the introduction of equipment into the market (undergoing tests only later *ex-post*, if and when there are complaints), and imposes the responsibility onto manufacturers. The FCC still has a prior *ex-ante* certification regime (noting the FCC identification number on the equipment), which does not exist anymore in the Europe, in the case of SRD (and GSM equipment).

E. Cognitive Radio System (CRS)

The ITU definition for a Cognitive Radio System (CRS) is [14]: "A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained". A CRS allows more flexibility in the spectral allocation, as its operation is not tied to one specific band and it is assumed to be able to dynamically select its band and mode of operation based on the need and spectrum availability at a given instance. It interoperates with different communication systems (modulation schemes, bandwidths, etc.) and can opportunistically use the RF spectrum in places that are typically occupied by other users.

"Super Wi-Fi" was allowed recently by the FCC, but there has not been any push by the industry so far in Canada for such license-exempt use of the TV bands. "White Space" is "a label indicating a part of the spectrum, which is available for a radiocommunication application (service, system) at a given time in a given geographical area on a non-interfering/non-protected basis with regard to other services with a higher priority on a national basis" [15]. In the US, the TV "white space" is the first public application of geo-location and a spectrum data-base, after the cognitive approach has failed in field trials. It is being watched closely by its proponents and opponents. The UK is a frontrunner in regulating wireless telecoms, and is the main leader of the European liberalisation in e-Communications [1]. The UK has proposed to allow access to the TV bands by "white space" devices, by implementing geo-location and use of a database system to ensure protection of other licensed services. It is an ambitious framework to bring local TV throughout the country, with the main delivery mechanism being the digital terrestrial television (DTT) platform using the TV white spaces [16].

Before it is widely accepted, CRS will need to demonstrate ability to effectively use vacant or unused RF spectrum without interfering with incumbent services. CRS and SDR (Software Defined Radio) are often linked together, although they are different terms, with CRS being a feature of radio systems, whereas SDR is a way to implement reconfigurable radios. The ability for cognitive radio to be commercially attractive relies also on the costs and availability of SDR technologies. However, if the CRS uses geo-location and database query, it may be implemented with relatively limited software in the radio, and it would probably not need a SDR. Meanwhile, Europe and North America are both in "locked step" with little or no regulatory actions on SDR. Since the technologies of SDR and CRS are still immature, Europe and North America are proceeding cautiously.

F. Human Hazards

Human Hazards from RF electromagnetic fields and especially cellular radiations (base stations and handsets) attract much public interest, as can be seen in the reactions to the 31 May 2011 IARC (International Agency for Research on Cancer) press release [17]. The national thresholds reveal the regulator's risk tolerability [18]. At 400-1500 MHz (which includes the cellular transmission bands), the maximum allowed power density level of ICNIRP (International Commission on Non-Ionizing Radiation Protection) and Europe for the general public is *f (MHz)*/200 W/m^2 [19]. The US [20] and Canada [21] thresholds are *f(MHz)*/150 W/m^2, which is higher by 4/3 (200/150), compared to the ICNIRP threshold. Europe in general [5] follows the ICNIRP levels [19].

It is important to observe that the US and Canada are more risk averse than Europe, with regards to the permitted SAR (Specific Absorption Rate) from the cellular terminal. The ICNIRP threshold (adopted by EC [23]) is 2.0 W/kg, while the limit in the US [24] and Canada [21] is 1.6 W/kg. The North American perception seems more rational (at least compared to Switzerland and Italy, dividing ICNIRP power levels up to 100), as the RF radiation power absorbed from the handset is much stronger, being much nearer to the user's body, compared to the signal from the base stations.

III. Analysis of the Compared Values

The influence of E.U. on the rest of Europe is parallel to the influence of the US on Canada: similar wireless communications' standards and emission levels are in use in the US and Canada, similar resemblances are found between the E.U. and Europe. Europe (ITU Region 1) and North America (ITU Region 2) zones of influence divide the world[6]. The European sphere can be identified by these characteristics: CEPT RF allocations [5], ERC/ECC decisions and ETSI standards (such as GSM 900[7] and DVB). The North American hemisphere can be charactrerised by the US CFR47 RF rules (including the liberal Part 15 [9]), representing higher tolerability to risks (spurious emissions, human hazards, power levels and bands of SRD and UWB emission mask). American standards (such as CDMA2000 and ATSC) and the RF innovations (like Cognitive Radio Systems and UWB) are indicative of the American regulation.

The success of the top-down GSM family and the bottom-up Wi-Fi standards reveal how the different European top-down central-planning and the North American market-based approaches have thrived. However, the European harmonisation enabled Europe to triumph in the cellular market: the GSM technology is operated in practically **all** countries; far more than the American CDMA2000 standard. The European standardisation process seems more efficient, when considering its results.

Cellular operators mostly buy from "Tier 1" suppliers, which are the main vendors supplying the GSM family equipment. When service providers buy UMTS/HSPA base stations, the 4G LTE is already integrated in. Therefore, 4G WiMAX is rarely deployed. Due to international roaming, interoperability, interconnection and cheap handsets, cellular operators abandoned CDMA2000 and prefer the GSM family. A common LTE device advances interoperability and promotes competition in the supply/delivery/pricing, since there are more suppliers and larger economies of scale.

The restrictive SRD power and RF bands, *spurious emission* levels, UWB mask and *human hazards* thresholds in Europe are typical of risk-averse regulators. The North American policy of innovation and the European fear of harmful interference to primary services are contrasted. The European approach is to conserve the spectrum resources; well aligned with Europe's policy, also more sensitive to ecological issues than North America; as spurious emissions, UWB masks, SRD permitted powers and human hazards may be regarded as forms of ecological pollution. The US represents the entrepreneur and Europe the 'command-control' style. The US pioneers new technologies -such as analogue TV NTSC (1954), ATSC, UWB, Cognitive Radio Systems; later, when Europe follows, it can start with a more advanced position, such as PAL/SECAM (1967) and DVB, on the evolution time axis.

Unlike the US and Canada, where a nationwide harmonized approach could be ensured, the European regulatory bodies are in a much more difficult position, since they have to coordinate and synchronise with many national regulatory bodies. Surprisingly, Europe adopted common cellular standards, not as in N. America. Reference [1] explains *how* and *why* geography (continent and distance from the Equator) and culture (language, post-colonialism,

[5] Despite an E.U. Recommendation some E.U. countries, such as Italy (0.03 ICNIRP power level for base stations) and Slovenia (0.1 ICNIRP level) adopt more restrictive thresholds [1], [22].

[6] Chinese standards (e.g., the cellular TD-SCDMA and TV DTMB) are not adopted outside their own geographical boundaries.

[7] N. America can't operate GSM 900 MHz due to the FCC Part 15 Low Power Devices operating at the "ITU Region 2" ISM band 902-928 MHz.

religion and legal origin) influence regulatory frameworks, RF wireless communications (including cellular penetration), risk concerns (RF *human hazards* and *spurious emissions*) and the adoption of RF standards (TV and cellular).

Wealthy countries are similar[8]; the British and French colonial inheritance and the parallel latitude of Europe and North America (both are above 30^0) explain their similarities. The goal in Europe and N. America is the same: the benefit of the consumer. Their wireless regulation is objective, transparent, non-discriminatory, flexible, dynamic, fair and proportionate; it promotes competition and secures an optimal use of RF.

The difference between the camps is the higher tolerability to risk (RF interference and *human hazards*) of the North American approach compared to the European approach. North America relies more on technology developments overcoming possible problems. The discrete longitudes define the two ITU Regions ("1" for Europe, "2" for America); N. America is isolated and European countries must coordinate among many neighbours. Europe is older, and conservative; America is younger and is not so meticulous. Reference [1] indicates that the European (continental) *civil law* may favour *collectivism* and "intervention", while the UK [9] and N. American *common law* favours *individualism* and 'light touch'.

IV. CONCLUSION

The most influential powers in wireless regulation and standardisation are Europe and North America. Their different approaches have been presented, analysed and explained. Rather than developing new regulations and standards, administrations worldwide typically follow European or North American rules. Emerging economies may decide if they develop their own technologies or adopt leading standards. The worldwide triumph of the European GSM eases the penetration of the European DVB-T and DVB-S and also paves the way to LTE.

Europe is more densely populated and divided into many countries, as compared with North America, such that the probability of interference is higher. Europe assertively implements wireless harmonisation, thus realising *E Pluribus Unum* (*Out of Many, One*; dictum on the seal of the US!).

The tolerability of the human body to RF radiation is independent of geography, so there is no technical justification for the different allowed exposure levels around the world, from cellular base stations or handsets; but such do exist. Similarly, different limits for *spurious emissions* are defined. The success of Wi-Fi has been due to the global availability of the 2.4 GHz ISM band. Globalisation creates a "connected world", where global sport or emergency events necessitate a worldwide free circulation of wireless equipment. The RF spectrum allocation and the development of standards for cellular have become global, through ITU IMT2000 regulation and the 3GPP standardisation effort.

[8] So begins Tolstoy's *Anna Karenina:* happy families are all alike; every unhappy family is unhappy in its own way.

[9] One leg in Europe and one leg in North America.

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