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## Regulation development on licensed shared access and TV white spaces

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**Title:**  
Regulation development on licensed shared access and TV white  
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# 1. INTRODUCTION

## 1.1 MOTIVATION

For several years, the demand for data has increased. Furthermore, this is a growing trend. There are three ways to meet this demand. One option is to make the network denser; this implies large investments. We can work on improving the bandwidth efficiency; unfortunately, the channel limit is about to be reached[1]. Finally, the bandwidth allocated to telecommunication can be enlarged. Indeed, there are large spaces on spectrum which have been underused by the army or by the TV broadcasters. These players employ only a part of their allocated frequencies or use them only in a restricted area or time. Thus, regulatory frameworks are under construction to allow second users to exploit the locally unused frequencies without harming the incumbent. The two most advanced projects in this area are Licensed Share Access (LSA) and TV White Spaces (TVWS).

Under LSA, an agreement is settled between an incumbent who underuses its spectrum (e.g: the Army) and one to several second users (share licensees). The agreement states, among other things, the area where the share licensees can deploy their networks and the conditions leading to its termination. In the case of TVWS, which takes advantage of the locally unused TV frequencies, the number of second users is unlimited and there is no direct contract with the incumbents (TV broadcasters and PMSE<sup>1</sup>). Instead, second users have to obtain the regulator authorization. Concretely, second users inform a database of their localization and the characteristics of their devices and will get in return available channels and power limitations.

Even if there is a common understanding of these regulatory frameworks, regulators[2][3] are still working on the definition. This paper aims at presenting in several countries the trends in the regulation of TVWS and LSA. Aspects such as normalization, authorized uses, and allocated bandwidths will be highlighted. From this overall regulatory picture, this research will provide insight on the business development around TVWS and LSA.

## 1.2 RESEARCH QUESTIONS

In this paper, two research questions are discussed:

- 1) How the regulation on TVWS and LSA is developing in different countries?
- 2) How the regulatory choices on TVWS and LSA could affect the telecom ecosystem?

## 1.3 METHODOLOGY

For the first research question, in several countries, the regulator's consultations, draft decisions and decisions, but also the contribution from the industry will be studied. The decisions enable to determine the regulators' positions. Studying the decision chronology for different regulators may

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<sup>1</sup> Programme Making and Special Events.

enable to determine leadership and follower strategy regarding LSA and TVWS. The contributions from the industry provide a picture of the actors' views on this topic.

The first research question outcome will be taken as a starting point to analyse the upcoming business development around TVWS and LSA. These results will be presented to telecommunication experts and actors to obtain their views. To supplement this, the first tests[4] and deployment based on LSA and TVWS will be studied in order to determine the actors' behaviour. Finally, using Porter[5] methodology, a picture of the telecommunication ecosystem[6] evolution will be drawn.

## 2. TV WHITE SPACES

### 2.1 PRINCIPLE

Large cells are used to broadcast the TV signal. In order to avoid interferences where cells overlap, different channels are used in adjacent areas. Away from the edge of a cell, a different channel from the one used for the TV broadcasting in the cell could be used for another purpose. For a long time, PMSE (Programme making and special events) has been using such frequencies. The idea behind TV white spaces is to use the bandwidth leftover for providing connectivity. As sporting and entertainment venues are located randomly, mapping the use of PMSE cannot be achieved. That is why an unlicensed system (with limitation of radiated power) is the most appropriated regime.

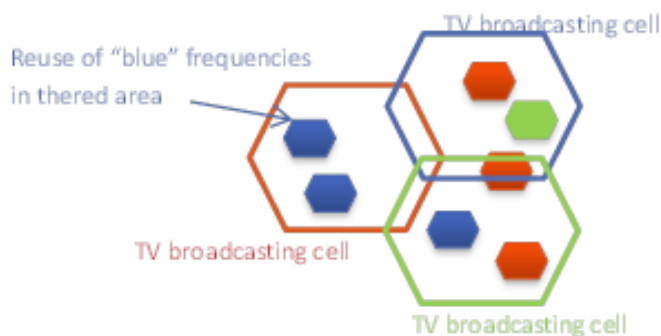


FIGURE 1 - TV WHITE SPACES PRINCIPLE

### 2.2 REGULATORY FRAMEWORK

In 2012, the ITU (International Telecom Union) decided to allocate on co-primary basis to TV broadcasting, PMSE and mobile service the band 694-790MHz. This decision concerned region 1 (Europe, Africa, and a part of Asia) and is to be enforced after WRC-15. Furthermore, the ITU considers the work lead in Europe and in the US on this topic. [14] This means that the ITU fosters the development of TVWS and/or digital dividend.

European Commission, which is in favor of TVWS development [15], mandated ETSI to standardize the technologies for TVWS. A large-scale test was conducted in Cambridge in the UK to verify the technological feasibility and make actors collaborate [16]. The British regulator, Ofcom, authorized the use of TV white spaces. A database system (presented in the next sub-section) validated by Ofcom should be used to protect the incumbents (TV broadcasters and PMSE). A Listen Before Talk solution was elected to protect secondary users from each other. Sensing solutions are envisaged for the next TV white spaces equipment generation. [17]

The American regulator, the FCC, authorized the uses of TV white spaces in an unlicensed regime[18]. To protect the incumbents from any harmful interference, a database system and power limitations have been set up.

Besides, Kenya's, South Africa's and Tanzania's regulators have allowed conducting test with TV white spaces. Unlike in Europe or in North America where the interest in TV white spaces is motivated by spectrum shortage, African regulators value the low frequencies which, from a coverage perspective, reduce the number of base stations to deploy.

Singaporean regulator reckon that TVWS "is well placed to increase the capacity of mobile bandwidth and provide high-speed wireless connectivity to provide wireless broadband Internet access services, machine-to-machine connectivity, smart metering and outdoor environment or security monitoring networks". Singaporean regulator launches a consultation. [19]

To conclude, there is a worldwide common understanding of what TVWS is and how to take advantage of it. Furthermore, national and international authorities propose very similar regulatory and technical frameworks. However, it is still unclear which of TVWS or digital dividend will be encouraged by the regulators in the future.

## 2.3 TECHNICAL REGULATION

### 2.3.1 DATABASE SYSTEM

Even though there are some differences in the way to implement the incumbent protection system, almost all regulators chose the system described in this section. A database is informed on a regular basis of the frequencies used by the incumbents (TV broadcasters, PMSE, adjacent users) for each geographical position. The database might also consider its peer databases' activities. Thus, when a white space master device, which is able to provide its location, wants to broadcast, it must prior to that provide a database with its location and technical characteristics. In return, the database informs the device of the available channels and their associated power limitations. In case where a slave white spaces device seeks to communicate with a white spaces master, the slave must provide its technical characteristic and the master will allocate it a channel. White spaces slaves must stop broadcasting if it has not received information from the database after a certain amount of time, usually 1s to 1min. Likewise, the white spaces master device should contact the database at least one a day.

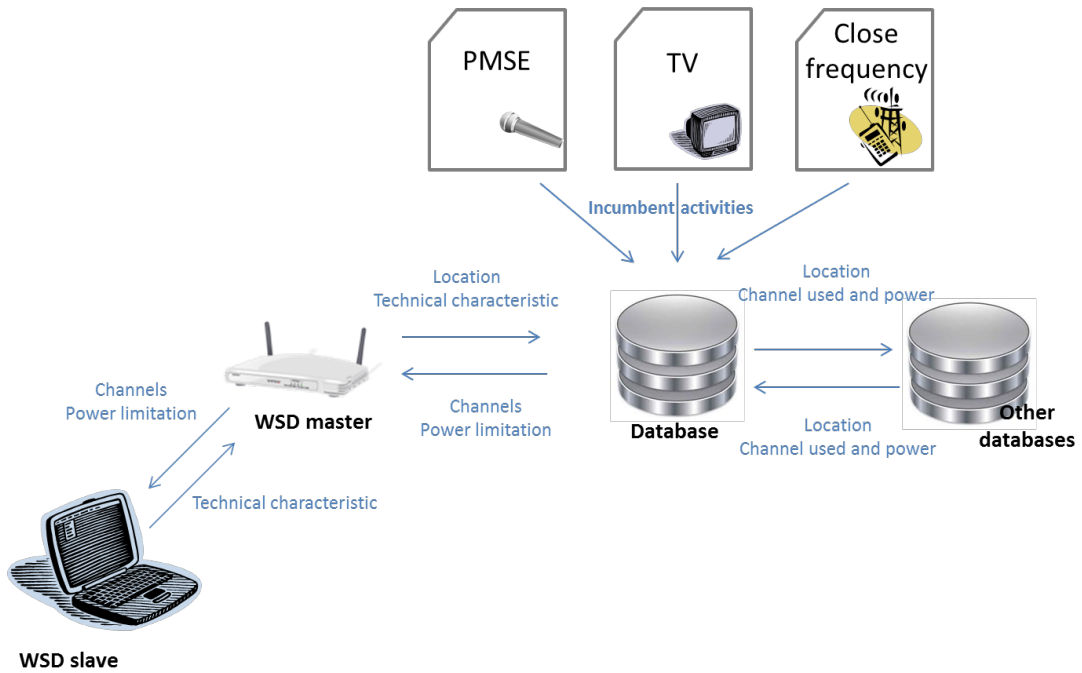


FIGURE 2 - DATABASE SYSTEM FOR TVWS

### 2.3.2 TECHNICAL DEVICES

The following categorization was proposed by the FCC[20]. Even though the power limitations may vary from one country to another, the categorization is consistent among regulation.

- **Fixed device** is a TVWS device whose geo-graphic coordinates have been automatically or by an installer communicated to the database. Power emission limitation: 4W EIRP
- **Mode II device** is a portable TVWS device that does have internal geo-location capabilities and access the database. Power emission limitation: 100mW EIRP
- **Mode I device** is a portable device that does not have an internal geo-location capability and cannot access the database. It gets the list of available channels from a Mode II or Fixed device. It is also called a slave device. Power emission limitation: 100mW EIRP

### 2.3.3 STANDARDS

**IEEE 802.11** is a standard aiming to provide internet connectivity wirelessly. The standard also enables aggregation. Microsoft is involved in the ongoing standardization process.

**IEEE 802.22** is designed for rural broadband. With this standard, the range can reach up to 100km.

**Weightless 1.0** is an open standard developed by Neul for M2M applications. The standard provides low data rate at extended range (> 3 km), and ultralow power battery consumption (up to ten years in certain cases). This standard was released in 2011.

**IEEE 802.15** is an ongoing standardization process for delivering low rate (40 kbps – 2 Mbps), long range WPAN in TVWS bands.

**Cognea** aims at developing a standard for home network applications, such as distribution of HD content and broadband access. [16], [21]

#### 2.3.4 PERFORMANCE

Finding accurate information on the TVWS performance is challenging since the industry is inclined to inflate the figures. However, the figures provided in this section is in the same order of magnitude as the actual figures. Click4Internet, a small ISP, claims that they provide up to 30Mbps downlink and 10Mbps uplink[22]. For its part, Airspan states that they can offer up to 20Mbps downlink with a 7MHz channel[23]. Microsoft and NSN put forward the figure of 16Mbps downlink.

#### 2.3.5 TECHNICAL SUMMARY

The consistency in terms of database architecture and devices' categorization may develop the confidence of investors and bring economy of scales, providing that a consensus is emerging on standards.

### 2.4 OPERATIONAL REGULATION

#### 2.4.1 TRIALS AND COMMERCIALIZATION

Several trials around the world have been conducted or are being conducted, especially in the US, in the UK, in Finland, and in Africa.

Even though a part of these trials are underway, some companies already commercialized solution based on TVWS. A British company, Click4Internet, commercialized rural connectivity in the Isle of Wight. Their commercial ads claim that they provide up to 30Mbps downlink and 10Mbps uplink. For instance, it costs £78 for 40GB. More information can be found in appendix **Error! Reference source not found.**

#### 2.4.2 SPECTRUM AVAILABLE

Between 150MHz and 400MHz are dedicated to TV broadcasting [24]. Ofcom considers that 25% to 50% are unused in a city like London[25]. Microsoft states that between 50% to 70% remains unused in the countryside [26]. Thus a significant part of the spectrum is "free" to be either part of a digital dividend or used under TVWS.

### 2.5 STATE SUMMARY

First of all, there is a common understanding of TVWS and regulators are implementing similar framework. However, regulators have not stated their position on the balancing between TVWS and digital dividend, which may change the value of investing in TVWS. Despite an agreement on the architecture for TVWS, there is a need of clarification for transmission standard. This is key to bring economy of scale, which would decrease the necessary investment. In spite of these hurdles, the industry and regulators have launched plenty of trials, which may result in the development of ecosystems. As a conclusion, the industry and some regulators seem really interested in developing TVWS and the standard development might be considered as a minor setback; however, the amount of channel available for TVWS activities will decide the market take-up.

## 3. LICENSED SHARED ACCESS

### 3.1 PRINCIPLE

Licensed Shared Access (LSA) is an under construction regulatory framework. It is intended to be applied when an exclusive user underuses in term of time, place, or frequency its allocated spectrum. In this case a contract may be signed between the incumbent and one to several secondary users (or

share licensees), who can employ the underused bandwidth for providing services. The agreement states, among other things, the area where the share licensees can deploy their networks and the conditions leading to its termination.

## 3.2 REGULATION

The ITU, an agency of the United Nation in charge of telecommunication, voted in favour of cognitive radio development [28], which is a category that includes LSA. Furthermore, the ITU is listening to the regulatory development in Europe[29]. The European Commission considers favorably the development of LSA [15], [30]. It mandated the Radio Spectrum Policy Group and CEPT to formulate recommendation on this matter. Thus, they state that[31], [32]:

- LSA is not intended to be an initial phase for refarming. In other words, LSA could be set up only in the case where the spectrum cannot be cleaned in a foreseeable future;
- LSA is particularly suited when the incumbent needs to be guaranteed that its primary activities will be protected;
- LSA could be static or dynamic in the sense that the agreement can state that the allocated frequencies or/and the authorised area may or may not evolve;
- LSA can ensure a predictable Quality of Service;
- The 2.3GHz band (100MHz) is intended for LSA. This is in line with ITU WR-07 which affected the 2.3GHz band for Mobile/Fixe Communication Network (MFCN). This band is used in Europe by different incumbents (the Army in France, TV broadcasters for supporting the broadcast)[33]. Yet, these activities are localised, which should not impede the development of LSA;
- NRAs should lead national studies.

At the national level in Europe, 16 countries declared to be ready to move towards LSA in the 2.3GHz band and 12 are not ready to do so[33]. As of January 2014, the two most advanced countries in the path toward the LSA are the UK and Finland. OfCom, the British regulator, has launched a consultation on LSA in the 2.3GHz band. It offered the industry the opportunity to react to the technical and regulatory propositions[34]. For its part, the Finish regulator, Viestintavirasto in collaboration with the industry has conducted a trial and a second one will be led in spring 2014.

The FCC, the US regulator, is currently considering authorizing secondary users in the 3.5GHz band (100MHz). In this band, the incumbents are satellites and naval radars. First, the FCC designed a so-called three-tierd sharing spectrum. This framework takes into consideration three actors: the incumbents, the priority access, and the general access. The priority access encompasses actors which “need for uninterrupted spectrum access to support mission critical uses” such as governmental facilities or hospitals. As their activities are geographically or temporally separated from incumbent activities, they are protected from incumbent’s harmful interferences. Furthermore, qualified priority access users are protected through a database based system from interferences due to other activities from the same or lower tier. Thus, according to the FCC qualified priority access users may expect a predictable quality of service. Eventually, the general access regime enables companies and the general public to use the leftover bandwidth. Yet, they need to register their activities and there is no guarantee regarding the Quality of Service. [35], [36]



Following Qualcomm's proposal, the FCC is considering setting up a Licensed Shared Access on the 3.5GHz. The FCC values this option since European Commission is looking into this direction. Yet, it is still unclear which framework the FCC will adopt.[36]

Despite minor differences in the implementation, there is a common understanding of the LSA concept among the regulatory bodies:

- LSA is allowed only when no refarming could occur within a reasonable timeframe;
- LSA is not a first step towards refarming;
- The incumbent activities are protected;
- Secondary users can expect a predictable Quality of Service.

## 4. REGULATORY IMPACTS ON MARKET DEVELOPMENT

Now that an overview of the regulatory frameworks built around TVWS and LSA, this part stresses the impacts of regulation on the ecosystem development. A particular focus is set on the potential upcoming decision.

### 4.1 COMMON ISSUES

Among other things, regulation aims at ensuring investment in technology and services. Furthermore, regulatory decisions often have consequences on investment level. As of today, there is a common understanding of LSA and TVWS among regulators and the industry which may foster investment. However, as seen previously, differences in technical implementation might appear in some areas. This might lead to the development of different sub-technologies, which endanger economy of scale and render investment less profitable. Moreover, there are few estimates of the spectrum available for TVWS or LSA and there are no schedules associated. This lack of visibility might impede investment in these technologies. All these uncertainties could postpone investment in TVWS and LSA.

### 4.2 ISSUES RELATED TO TVWS

The largest uncertainty for TVWS is the regulator's position on frequencies space freed up in the TV-band. There are two main options. Regulators could widely authorize TVWS to take advantage of the locally unused frequencies. Otherwise, they may refarm some TV-band. In this case, TV broadcasting is concentrated on a narrower band thus reducing the locally unused frequencies and making TVWS technologies less attractive.

### 4.3 ISSUES RELATED TO LSA

Agreement from first users is needed before any LSA deployment. Generally, first users are the Army or civil protection which might not perceive any interest in sharing the resources. They, instead, may think of potential disturbances. Thus, a challenge is to develop LSA awareness, assure first users of the technology reliabilities and present them opportunities in sharing. If incentives are not enough to make first users ready to share their unused frequencies, the British example might be interesting to consider. Ofcom make the Ministry of Defence pay fees for its uses of spectrum. Thus, the first thing that the Army did was to free up some frequencies and ask Ofcom to sell them. We can easily imagine that the second move will be to set up LSA agreement to offset the annual fees.

## 5. ABBREVIATIONS

<b>B to B</b>	Business to Business
<b>B to C</b>	Business to Customer
<b>Capex</b>	Capital Expenditure
<b>CR</b>	Customer Relation
<b>FCC</b>	Federal Communication Commission
<b>ISP</b>	Internet Service Provider
<b>ITU</b>	International Telecommunication Union
<b>LSA</b>	Licensed shared Access
<b>MNO</b>	Mobile Network Operator
<b>MSP</b>	Managed Service Provider
<b>MVNO</b>	Mobile Virtual Network Operator
<b>NEM</b>	Network Equipment Manufacturer
<b>OPEX</b>	Operational Expenditure
<b>O&amp;M</b>	Operation & Maintenance
<b>PMSE</b>	Programme Making and Special Events
<b>QoS</b>	Quality of Service
<b>TVWS</b>	TV white spaces

## 6. BIBLIOGRAPHY

- [1] « Analysis : No boom for telco equipment firms in 4G revolution | Reuters ». [En ligne]. Disponible sur: <http://uk.reuters.com/article/2012/07/17/uk-telecoms-4g-idUKBRE86G0DB20120717?feedType=RSS&feedName=GCA-GoogleNewsUK>. [Consulté le: 03-sept-2013].
- [2] « There will be no 5G. We have reached the channel limits: Ericsson CTO - Money - DNA ». [En ligne]. Disponible sur: <http://www.dnaindia.com/money/1546408/interview-there-will-be-no-5g-we-have-reached-the-channel-limits-ericsson-cto>. [Consulté le: 03-sept-2013].
- [3] T. Irnich, J. Kronander, Y. Selén, et G. Li, « Spectrum Sharing Scenarios and Resulting Technical Requirements for 5G Systems », 2013.
- [4] « Cambridge Consortium Completes Successful Trial of Next-Generation Wireless ». [En ligne]. Disponible sur: <http://www.microsoft.com/presspass/emea/presscentre/pressreleases/April2012/24-04CambridgeTVWhiteSpacesConsortium.aspx>. [Consulté le: 04-sept-2013].
- [5] « Protecting customers and national security in - GSMA-Policy-Position-on-LSA-ASA.pdf ». .
- [6] Qualcomm, « 1000x-more-spectrum-especially-for-small-cells ».
- [7] Jamshid Khun-Jush, Michael Gundlach, Paul Bender, et Benoist Deschamps, « Licensed shared access as complementary approach to meet spectrum demands: Benefits for next generation cellular systems ».
- [8] « FM53(13)34\_Definition-of-Licensed-Shared-Access-(LSA).docx ». [En ligne]. Disponible sur: [http://www.cept.org/Documents/fm-53/11780/FM53\(13\)34\\_Definition-of-Licensed-Shared-Access-\(LSA\)](http://www.cept.org/Documents/fm-53/11780/FM53(13)34_Definition-of-Licensed-Shared-Access-(LSA)). [Consulté le: 04-sept-2013].
- [9] Qualcomm, « Authorized Shared Access, A Novel Spectrum Policy Vision ».
- [10] R. K. Yin, *Case Study Research: Design and Methods (Applied Social Research Methods)*, Fifth Edition edition. SAGE Publications, Inc, 2013.
- [11] *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*, First Edition edition. Harper Paperbacks, 1997.
- [12] Chesbrough et Rosenbloom, « The role of business model in capturing value from innovations: Evidence from Xerox Corporation's technology spin-off companies ».
- [13] A. Osterwalder, « Clarifying Business Models: origins, present, and future of the concept ».
- [14] « Use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and related studies », IUT - Radiocommunication Bureau, 2012.
- [15] « STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI FOR RECONFIGURABLE RADIO SYSTEMS », European Commission.
- [16] « Cambridge TV White Spaces Trial A Summary of the Technical Findings », Cambridge White Spaces Consortium.
- [17] « The future role of spectrum sharing for mobile and wireless data services », OfCom.
- [18] « THIRD MEMORANDUM OPINION AND ORDER », the FCC, avr. 2012.
- [19] « PROPOSED REGULATORY FRAMEWORK FOR TV WHITE SPACE OPERATIONS IN THE VHF/UHF BANDS », THE INFO-COMMUNICATIONS DEVELOPMENT AUTHORITY OF SINGAPORE, 2013.
- [20] « SECOND MEMORANDUM OPINION AND ORDER », the FCC, sept. 2013.
- [21] I. Ghazi, « TV White Spaces », IUT - Radiocommunication Bureau.
- [22] « Portsmouth and Isle of Wight Megaband Provider (ISP) - Click4Internet - UK's fastest Megaband(tm) Internet Access. » [En ligne]. Disponible sur: <http://click4internet.com/products.html>. [Consulté le: 27-janv-2014].
- [23] « Airspan Networks Positioned for TV White Space Spectrum - Airspan ». [En ligne]. Disponible sur: <http://www.airspan.com/2011/10/18/airspan-networks-positioned-for-tv-white-space-spectrum/>. [Consulté le: 28-janv-2014].
- [24] « Television channel frequencies », *Wikipedia, the free encyclopedia*. 16-févr-2014.
- [25] D. Thomas et T. Correspondent, « Google and Microsoft back UK trial to use 'white space' bandwidth », *Financial Times*, 02-oct-2013.

- [26] L. T. | O. 3 et 2013-- 09:54 Gmt, « Microsoft, Google joins TV white-space broadband road test », *ZDNet*. [En ligne]. Disponible sur: <http://www.zdnet.com/uk/microsoft-google-joins-tv-white-space-broadband-road-test-7000021505/>. [Consulté le: 28-janv-2014].
- [27] « Zones enclavées et rurales : la 4G en remplacement de la fibre ? », *ZDNet*. [En ligne]. Disponible sur: <http://www.zdnet.fr/actualites/zones-enclavees-et-rurales-la-4g-en-remplacement-de-la-fibre-39797191.htm>. [Consulté le: 28-janv-2014].
- [28] *RESOLUTION ITU-R 58*.
- [29] « TV WHITE SPACES: MANAGING SPACES OR BETTER MANAGING INEFFICIENCIES? », ITU.
- [30] « Digital Agenda: Maximising radio spectrum efficiency by sharing it », European Commission.
- [31] « Report on Collective Use of Spectrum (CUS) and other spectrum sharing approaches », RADIO SPECTRUM POLICY GROUP.
- [32] « ECC Report 172 », CEPT.
- [33] « Results of the WG FM QUESTIONNAIRE to CEPT ADMINISTRATIONS on the current and future usage of frequency band 2300-2400 MHz », CEPT, 2012.
- [34] « Ofcom | 2.3 and 3.4 GHz spectrum award: Consultation on a 3.4 GHz band plan, varying UK Broadband Limited's licence and a call for inputs on other aspects of the award ». [En ligne]. Disponible sur: <http://stakeholders.ofcom.org.uk/consultations/2.3-3.4-ghz/summary>. [Consulté le: 20-janv-2014].
- [35] M. Dano, « The looming conflict over spectrum sharing », *FierceWireless*. [En ligne]. Disponible sur: <http://www.fiercewireless.com/story/looming-conflict-over-spectrum-sharing/2013-06-21>. [Consulté le: 20-janv-2014].
- [36] « NOTICE OF PROPOSED RULEMAKING AND ORDER », FCC, déc. 2012.
- [37] « Up to 18% more bandwidth for mobile broadband users with spectrum sharing », VTT.
- [38] « List of LTE networks », *Wikipedia, the free encyclopedia*. 19-janv-2014.
- [39] N. G. on J. 19 et 2012 at 7:07 Am, « AT&T and Sirius XM propose rules to allow LTE on WCS », *ExtremeTech*. [En ligne]. Disponible sur: <http://www.extremetech.com/electronics/131316-att-and-sirius-xm-propose-rules-to-allow-lte-on-wcs>. [Consulté le: 20-janv-2014].
- [40] P. Goldstein, « AT&T proposes deploying LTE in WCS 2.3 GHz band », *FierceWireless*. [En ligne]. Disponible sur: <http://www.fiercewireless.com/story/att-proposes-deploying-lte-wcs-23-ghz-band/2012-06-19>. [Consulté le: 20-janv-2014].
- [41] « ZTE pushes 3.5GHz as LTE band - Rethink Wireless ». [En ligne]. Disponible sur: <http://www.rethink-wireless.com/2012/03/21/zte-pushes-35ghz-lte-band.htm>. [Consulté le: 20-janv-2014].
- [42] « The future role of spectrum sharing for mobile and wireless data services », OfCom.
- [43] « Ministry of Defence forced to pay more than double for airwaves », *This Is Money*. [En ligne]. Disponible sur: <http://www.dailymail.co.uk/money/markets/article-2276252/Ministry-Defence-forced-pay-double-airwaves.html>. [Consulté le: 20-janv-2014].
- [44] OfCom, « Public Sector Spectrum Release ».
- [45] « The Spectrum Crunch - busting the solutions myth », 22-mai-2013. [En ligne]. Disponible sur: [http://www.ericsson.com/openarticle/the-spectrum-crunch\\_1473414408\\_c](http://www.ericsson.com/openarticle/the-spectrum-crunch_1473414408_c). [Consulté le: 20-janv-2014].
- [46] « Relief Ahead for Mobile Data Networks as 63% of Traffic to Move Onto Fixed Networks via WiFi and Femtocells by 2015, Finds Juniper Research », *Marketwire*. [En ligne]. Disponible sur: <http://www.marketwired.com/press-release/relief-ahead-mobile-data-networks-as-63-traffic-move-onto-fixed-networks-via-wifi-femtocells-1503808.htm>. [Consulté le: 22-janv-2014].
- [47] « Mobile traffic forecasts 2010-2020 », IDATE.
- [48] A. Ghanbari, « Indoor multi-operator solutions, Network sharing and Outsourcing network management and operation », 2013.