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Wireless Access Policy for Electronic Communications Services (WAPECS): Collision between Theory and Practice*

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Abstract

“As I see it, progress in understanding the working of the economic system will come from an interplay between theory and empirical work” Roland Coase, 2006.

Fifty five years ago, Coase suggested in his seminal article “The Federal Communications Commission” that spectrum assignments should be treated in a similar way to property rights where market forces allocate these flexible tradable rights to users with the highest valuations for it. While Coase’s idea was appealing and gathered huge momentum in academia scene, the practice did not show much success.

One of the first practical implementations was initiated in Europe in 2005 under the name “Wireless Access Policy for Electronic Communication Services (WAPECS)”. WAPECS aimed at providing more flexibility in the European spectrum management framework by allowing using the spectrum on a technology and service neutral basis. At the international level, the European Conference of Postal and Telecommunications Administrations (CEPT) have been keen to introduce more flexibility at the international service allocation framework via different measures.

One of the main findings of this paper is the identification of different negative perceptions and disagreement on WAPECS and that WAPECS was driven mainly by the European Commission (EC) and few European countries. In addition, concerns over WAPECS include that the flexibility associated with WAPECS may contradict with spectrum use efficiency and that the responsibility of resolving interference moves from the regulator to operators.

The assessment of WAPECS influence on the market shows that while WAPECS concept aimed mainly on removing the spectrum usage restriction for the industry, the later did not appreciate nor welcome that due mainly to the high cost and uncertainty associated with flexibility. On the other hand, the interviews revealed several positive impacts of WAPECS including removing technology designation from CEPT decisions.

The paper shows also that the international Radio Regulations (RR) can accommodate the WAPECS concept to a certain extent. Finally, the paper explains that the opposition from the other countries to the European attempts to introduce flexibility to the international service allocation framework is due to the potential implications at the national level.

* The authors are solely responsible for the opinions expressed in this article.

I. Introduction

Fifty five years ago, Coase suggested in his seminal article “The Federal Communications Commission” that spectrum assignments should be treated in a similar way to property rights where market forces allocate these flexible tradable rights to users with the highest valuations for it (Coase, 1959). In addition, Coase argued that the aim of the regulator should be to maximize the output and not to minimize the interference and that interference should not be an issue as long as the gain from it is much more than the harm it produces. Moreover, it was suggested that interference could be resolved by delimiting users’ spectrum usage rights and could be accepted by users if they were paid more than the amount by which their service was decreased. Coase generalised his argument afterward in his Nobel Prize article “The Problem of Social Cost” and suggested an approach towards dealing with harmful effects on others that is based on comparing the total social product yielded by alternative social arrangements (Coase, 1960). Therefore, interference by one user against other could be allowed if society benefits are much more rather than in the case of delimiting interference.

Coase’s idea was appealing and gathered huge momentum in the academia scene. Furthermore, there have been several theoretical attempts to define spectrum property rights (Cave and Webb, 2012, Cave and Webb, 2003, Vries and Sieh, 2012, Vany et al., 1969). However, for many decades, there have been no practical implementations of such idea until the convergence between the different services has brought back to life the notion of spectrum property rights called by Coase more than 50 years ago. More specifically, there have been calls to perceive spectrum as an infrastructure asset used to deliver different applications to the end user instead of traditionally allocate spectrum exclusively for particular services (Legutko, 2008).

One of the first practical implementations of Coase’s idea was initiated in Europe in 2005 under the name “Wireless access policy for electronic communication services (WAPECS)”. This paper aims to examine the issue of spectrum use flexibility with a focus on the WAPECS concept in terms of perceptions of the different stakeholders, influence on the market, conformity with the international spectrum regulations, and the European attempts to align the international service allocation framework with WAPECS. In order to achieve that, the paper seeks the different views of the industry stakeholders on the WAPECS concept, and it also assesses the influence of WAPECS on the market. Moreover, the paper examines the interaction between WAPECS and the international Radio Regulations (RR). The paper also addresses the European efforts in the Radio Sector of the International Telecommunication Union (ITU-R) to introduce flexibility.

The main rationale for focusing on the WAPECS concept is that it is one of the few empirical applications of spectrum property rights on a large scale. Other countries that adopt similar concepts are geographically separated such as Australia (Cave and Webb, 2003), have a small population and area like Guatemala (Hazlett and Muñoz, 2006), or abandon the concept due to implementation difficulties such as interference temperature in the US (Weiser and Hatfield, 2008) and spectrum usage rights (SUR) in the UK (Eurostrategies and LS-Telecom, 2007). In addition, it is argued that when known, the impact of WAPECS could confirm or refute the hypothesis that rigidity in regulation is the root cause of inefficient spectrum use (Forge et al., 2012).

The rest of the paper is organised as follows. The following section gives a brief over the WAPECS concept and then section three explores the methodological stance adopted. Section four explores perceptions regarding WAPECS, and then section five assesses the influence of WAPECS on the market. Section six examines the influence of the international spectrum regulations on WAPECS, and then section seven traces the European attempts to introduce flexibility to the international service allocation framework. Section eight is a discussion over the different issues related to WAPECS and section nine concludes.

II. Understanding WAPECS

WAPECS was the response to the different calls within the European Union (EU) to reform the traditional approach to spectrum management, Command and Control, towards “Spectrum Market” regime (Akalu, 2006). The roots of these calls could be traced back to the European Commission (EC) green paper on spectrum policy which aimed to facilitate competition via flexible planning of spectrum use (European Commission, 1998). Moreover, WAPECS was proposed in the context of the i2010 Information Society Initiative to ensure that spectrum is available across a wide variety of services and applications within the EU (Akalu, 2006).

Furthermore, WAPECS was also motivated by the perception that any communication service could be delivered through any platform and that removing restrictions associated with individual spectrum bands would promote competition between the different delivery systems (Forge et al., 2012). Besides, spectrum use liberalisation and WAPECS specifically are perceived to limit anti-competitive behaviours (Cave, 2010). Moreover, there are different issues which called for a concept such as WAPECS including the calls by the 2G operators for more flexibility in their licenses in order to upgrade to 3G, the measures taken by other regulators outside Europe towards flexibility, and the convergence on the technological level (Delaere, 2007).

The beginning was in 2004 when the EC issued a request for opinion to the Radio Spectrum Policy Group (RSPG)¹ to develop and adopt an opinion on a coordinated EU spectrum policy approach concerning what was called “wireless access platforms for electronic communications services (WAPECS)”. The RSPG conducted a public consultation on WAPECS and different views were received from the industry (ComReg, 2005). Firstly, most of the responses did not support the definition of WAPECS arguing that it is not clear what it is intended to address. They also disagreed to the use of the term “Platform” and the term “System” was suggested instead. The RSPG issued their final opinion on WAPECS in 2005 and it was decided that the designation of WAPECS, which initially referred to “Platforms”, should be modified into “Policy” (RSPG, 2005).

Therefore, the acronym of WAPECS changed to be “wireless access policy for electronic communications services”. In addition, WAPECS was defined as “*a framework for the provision of electronic communications services within a set of frequency bands to be identified and agreed between the EU Member States in which a range of electronic communications networks and electronic communications services may be offered on a technology and service neutral basis, provided that*

¹ RSPG advises the EC on spectrum policy issues.

certain technical requirements to avoid interference are met, to ensure the effective and efficient use of the spectrum, and the authorisation conditions do not distort competition” (RSPG, 2005).

In addition, the EC instructed CEPT in 2006 to develop least restrictive technical conditions in frequency bands addressed in the context of WAPECS (European Commission, 2008a). Accordingly, CEPT worked on the issues and the Block Edge Mask (BEM) methodology was chosen to drive the least restrictive technical conditions for frequency bands addressed in the context of WAPECS with a focus on the 2.5 GHz and 3.5 GHz spectrum bands. BEM are technical parameters that apply to the entire block of spectrum of a specific user and cover both emissions within the block of spectrum (i.e. in-block power) as well as emissions outside the block (i.e. out-of-block emission) (CEPT, 2007). It is worth mentioning that CEPT developed similar least restrictive technical conditions based on BEM for the 790 - 862 MHz and 2 GHz bands (CEPT, 2009, CEPT, 2010).

III. Methodology

While the previous section explores the theory behind the WAPECS concept, however, the practice of WAPECS is largely overlooked in the literature. More specifically, it is not clear how the different stakeholders perceive WAPECS and how the implementation of WAPECS has influenced the market. This section explains the undertaken research strategy in order to find out answers for these questions.

A qualitative methodology is adopted for this paper that examines the activities of the European countries towards spectrum use flexibility with a focus on the case study of WAPECS. Case studies require conducting a detailed investigation of specific case(s) in order to obtain a closer insight into the context and processes involved in the research subject (Meyer, 2001). Moreover, case studies can ensure accuracy, facilitate the emergence of alternative explanations and can bring out more details through using multiple sources of data (Tellis, 1997).

The paper is based mainly on primary data collected from more than twenty semi-structured interviews with the main stakeholders from industry, CEPT, the EU, regional ITU-R organisations, and European national regulators. Moreover, interviewees were partially identified based on the participation of the first author for several years in the ITU-R. A list of different topics and related questions were prepared and selected for each group of interviewees based on their background. In addition, most interviews were recorded upon permission of the interviewees and notes were also taken during the interviews. For confidentiality reasons, the names of the interviewees are not disclosed. A software called Nvivo is used for the data reduction of the interviews’ transcriptions in order to identify the important themes (Bazeley, 2007). Within Nvivo, the main themes which were emphasised during the interviews were identified (e.g. perception on WAPECS).

The difference between unstructured and semi-structured interview is that the former is similar to a conversation and could contain one question, while the later comprises a list of questions on specific topics (Bryman and Bell, 2007). On the other hand, structured interviews have a rigid structure that cannot be easily modified (Bryman and Bell, 2007). Interviews were selected for different reasons (Saunders et al., 2009). Firstly, they enable the researcher to build on their responses. Secondly, personal contact assures achieving more response rate as interviewees may hesitate to

provide sensitive data or to spend time explaining their answers. Other data collection methods were also considered such as questionnaires. However, questionnaires have the disadvantage of potential low response rate. They also require knowing all the possible answers for each question. Moreover, questionnaires are not a flexible collection data method (Saunders et al., 2009). The paper also draws on secondary data illustrating the contributions of the European countries in the ITU-R in addition to the European documents on spectrum use flexibility.

IV. Perception of WAPECS

One of the main goals of this paper is to examine the different perception on WAPECS after several years of its implementation. The first remarkable note during the interviews was the extreme negative views on WAPECS by some of the stakeholders and that WAPECS was perceived by many as a complete failure “*We played for a couple of years on WAPECS concepts, we ended up with this...this was useless*”, “*it was a stupid idea*”. Moreover, one interviewee explains that one of the reasons why WAPECS was not successful is that it was not well explained and that it was a mysterious concept.

One of the responses from regulators outside Europe is that there is no motivation to apply WAPECS because there is no clear effect and tangible benefit. Besides, it was pointed out that WAPECS may reduce the regulator control over spectrum management. Furthermore, flexibility may create uncertainties and additional costs for the market without tangible benefits. Besides, it was also argued during the interviews that harmonization and technology neutrality contradict each other. This is due that there is a need for harmonized equipment with lower prices for efficient mass scale deployment. However, it was also noted that flexibility is important to promote innovation in spectrum use in order to avoid situations where spectrum was set aside for a specific technology just like the case of GSM in Europe.

The collected data indicated that there was no agreement on WAPECS at its early day within Europe. For instance, the Council of Europe and the European Parliament had concerns regarding deploying the flexible neutral approach of WAPECS in the digital dividend band (Cullell March, 2011). More specifically, there were few countries such as the UK in addition to the EC that promoted WAPECS. Secondly, several interviewees expressed that WAPECS may contradict with spectrum use efficiency. This is due that it is quite difficult to have different services with different technical characteristics operating next to each other without reducing the effectiveness of these services. More specifically, one of the interviewees explains that it would be quite difficult to predict the necessary filters for the different deployment scenarios and to have fully flexible equipment.

It was also explained by another interviewee that the more flexibility that you have, the more requirements that would be needed to protect against interference. This could be reflected in larger guard band or higher out of band emission (OOBE) restriction on users' equipment. More specifically, the more flexible spectrum use you have in terms of implementation parameters, the more it becomes necessary to consider worst case scenarios from the technical viewpoint to have protection against interference (CEPT, 2007). This is further explained out by Forge et al. (2012) who point out the paradox mentioned in one of the CEPT reports on the issue of flexibility

which argues that introducing more flexibility in spectrum use management restrict the flexibility in band use (CEPT, 2006).

Thirdly, one main concern that was exposed during the interviews is the potential interference associated with WAPECS. More specifically, the main problem with full implementation of WAPECS is that there is no longer a stable definition of harmful interference. In other words, it would be difficult to determine the source of interference and that resolving interference issues would become the responsibility of the operators instead of the regulator. Forge et al. (2012) confirm that and explain that there is a trade-off between flexibility and interference where in cases where users have more flexibility, they are more responsible of resolving interference issue. In addition, the conditions of complying with the BEM parameters are not easy to be measured and checked which make operators worried in case of interference.

In addition, BEMs do not always provide the required level of protection of victim services and additional mitigation techniques would need to be applied. For instance, in adjacent geographical areas (co-channel or adjacent bands), the BEM has to be applied in conjunction with other conditions such as deriving power flux density (pfd) values for areas within the territory of one administration or with cross-border coordination developed by bilateral or multi-lateral agreements (CEPT, 2009).

Fourthly, one critical point that was raised during the interviews is that it is impossible to be completely neutral as eventually the technical conditions associated with WAPECS favour a particular technology. In particular, the WAPECS implementation assumes that the most likely use of the spectrum is by technologies using a cellular network topology based on a two ways communication system (CEPT, 2010). This includes technologies such as LTE and WIMAX which have a lot of similarities such as channel bandwidth (e.g. 5, 10 MHz). Hence, if a new technology emerges that has different technical characteristics; it may not fit within WAPECS. In other words, although the technical conditions of WAPECS are defined in a neutral way (e.g. BEM), they are not themselves neutral as they are associated with particular technologies.

Another point that was explained by one of the interviewees is that the original referring to a platform in the early days of WAPECS development created some sort of contradiction with technology neutrality as platform is usually related to a particular type of technology. One other difficulty that was mentioned is setting the parameters for the BEM especially if there are differences between the available standards or in case there are some missing parameters of one standard because it has not been widely deployed.

Fifthly, the EC was one of the promoters of WAPECS as part of their calls for spectrum use flexibility to encourage spectrum trading "*it is part of their mind set...liberalisation...flexibility*". The main motivation was to remove boundaries and constraints for an internal European market where you can work in the different spectrum bands across Europe. In other words, it was more of a political decision from the EC to allow more flexibility to the market, but it was not a proposal from the industry. Furthermore, one interviewee explains that some European administrations do not like ideas such as WAPECS just because it is imposed by the commission "*the rules has to be set by politicians and the technician should implement them. The technician doesn't like the politics application*".

Finally, it was noted through the collected data that WAPECS is perceived as something that is obsolete although in fact WAPECS is currently implemented in Europe in several frequency bands *“I can't remember very much about it...I mean it's, in a way it is history because no one is talking about it”*. One explanation about that is that the term WAPECS is rarely used nowadays as it is replaced by other term which is TRA-ECS. TRA-ECS stands for terrestrial radio applications capable of providing electronic communications services and it describes a regulatory status that could applied in principle to all terrestrial applications in a given frequency band. It was pointed out during the interviews that TRA-ECS is like one implementation of WAPECS. TRA-ECS is at the layer 1 of the European Frequency information System (EFIS) which accommodates applications and definitions that are broad in scope such as maritime and land mobile (ECC, 2012a, ECC, 2012c).

What happened was that after identifying different frequency bands for the implementation of WAPECS, BEM was developed for them and no other bands were considered. As explained by one of the interviewees *“you don't hear the term so much anymore, maybe because the work on it is finished”*. In addition, Europe's approach to flexibility has developed since the introduction of WAPECS towards what is called *“Flexible Bands”* where WAPECS is only limited to ECS and the flexible bands concept covers a more diverse range of radio applications and services (e.g. scientific or public use) (ECC, 2010).

In summary, it could be argued that there are different negative perceptions on WAPECS which varies between proofing a case of failure, being a vague concept, contradicting with spectrum use efficiency, associating with potential interference, and creating uncertainties to the market. Furthermore, it was also indicated that there was no agreement on adopting WAPECS at its early day within Europe and that it was promoted mainly by few countries and the EC.

V. Influence of WAPECS on the Market

The previous section shows the different perceptions of the industry stakeholders on the WAPECS concept. While this is important in terms of understanding the theoretical limitations of WAPECS, a closer look is needed to explore the practical limitations as well. In order to achieve that, an analysis of the decisions related to frequency arrangements in the spectrum auctions in Europe in the 2.6 GHz and 3.5 GHz is conducted to assess the practical influence of WAPECS on the market. It should be noted that the decision on channel planning or frequency arrangements is considered as an intermediate stage between decision on service allocation and technology standardisation (Chaduc and Pogorel, 2008).

Firstly, the European Commission issued a decision in 2008 on the harmonisation of the 2500-2690 MHz frequency band for terrestrial systems capable of providing electronic communications services. More specifically, the decision determines that the sub-band 2570–2620 MHz can be used by Time Division Duplexing (TDD) or other usage modes complying with the value of BEMs in the decision and that the usage of the rest of the band can be decided at national level (European Commission, 2008a). In general, regarding frequency arrangements for implementation of IMT in the band 2500-2690 MHz, the ITU-R provides a recommendation containing three main options (ITU-R, 2012b). The first option accommodates preconfigured paired (70 MHz for Frequency Division Duplexing

(FDD) operation) and unpaired (50 MHz for TDD operation) frequency blocks, while the second option includes only paired frequency blocks (FDD). The third option permits flexibility in the frequency arrangement of the band for TDD and FDD. In other words, the ITU-R does not constrain national administration flexibility when it comes to frequency arrangements. In fact, the third option is the one that was promoted by the EC.

The industry response was that they prefer harmonised frequency arrangement and that the cost associated with a more flexible use of spectrum in terms of band plan neutrality is high. Moreover, it was pointed out that the band plan neutrality creates uncertainties and a challenging coexistence situation at country borders when countries make different decisions (CEPT, 2010). In addition, it was explained that full flexibility in frequency arrangement has the drawbacks of reducing utilised spectrum due to the need for guard bands, decreasing harmonisation and international roaming, and finally losing economies of scales and therefore resulting in more expensive users equipment (GSMA, 2010).

On the contrary of the EC, CEPT was in favour of a band plan consistent with ITU-R option 1 where the frequency band 2500 – 2570 MHz is paired with 2620 – 2690 MHz for FDD operation and the frequency band 2570 – 2620 MHz could be used either for TDD or for FDD downlink (ECC, 2005). Marsden et al. (2010) point out that while European countries are not obliged to follow the CEPT plan, they should apply a flexible duplexing mode according to the EC directives. However, what has happened in reality was that most of the 2.6 GHz auctions that were conducted in Europe have resulted in FDD networks and similar frequency arrangements (TDD, FDD) (GSMA, 2010). The explanation of that was one of the main questions during the interviews.

Firstly, it seems that there was more demand for FDD over TDD which supported the case for a fixed plan for the 2.6 GHz which allows wider bandwidth for FDD than TDD (Marsden et al., 2010). Roetter (2009) further explains that although there are constraints on the amounts of spectrum for TDD and FDD modes of operation in the ITU option 1, these amounts are consistent with relative strengths of demand for these two modes of operation. Secondly, one of the main motivations for a flexible band plan is to be neutral against technologies which have only TDD duplex mode which was the case at that time for the WiMAX standard (ITU-R, 2009). Therefore, a concept such as WAPECS was important for the WIMAX development as it gives sufficient flexibility in adopting FDD or TDD modes. However, the development of FDD component of WIMAX has further weakened the case of flexible frequency arrangements (GSMA, 2010). In addition, the decline of WIMAX market has undermined the need for the flexibility inherited within WAPECS (Marsden et al., 2010).

Thirdly, Roetter (2009) points out that having flexible band plan puts indirect constraints by its bi- and multi-lateral obligations with respect to frequency coordination. More specifically, interference management would be quite difficult task due to the need to coordinate between diverse arrangements of TDD and FDD spectrum blocks. In addition, this would increase the uncertainty of operators on how much usable bandwidth they will eventually acquire if they win the frequencies for which they decide to bid.

Another example of how WAPECS was not appreciated is the 3.5 GHz band which has a flexible spectrum framework according to the ECC Decision of 30 March

2007 which determines some technical conditions for implementing flexible usage mode for BWA in 3400-3600 MHz and/or in 3600-3800 MHz (ECC, 2007) and according also to Commission Decision of 21 May 2008 which decides that member States shall allow the use of the 3400-3800 MHz band for fixed, nomadic and mobile electronic communications networks according to some parameters described as BEM (European Commission, 2008b). One of the interviewees explained that the framework was simply too flexible so that there was nothing in terms of development nor investment “*too much flexibility kills the flexibility issue*”. It was also explained that the industry is technically capable of providing equipment to accommodate more flexibility but they don’t want to deploy it commercially as it would be costly for them.

In general, one of the issues that make the assessment of WAPECS influence difficult is the market dominance of few mobile technologies. More Specifically, only three 3G technologies namely, TD-SCDMA, CDMA 2000 and WCDMA, and one 4G technology, namely LTE Advanced were dominant in terms of market deployment (Blust, 2012). Besides, one point that was mentioned during the interviews is that it is difficult to assess the influence of WAPECS because it was deployed mainly in mobile bands which defeats the purpose of flexibility. This is due that there is already a lot of flexibility for operators within the mobile radiocommunication service (e.g. point-to-point communication, point to multi-point, broadcasting). In addition, the IP platform on which new mobile technologies (e.g. LTE) are based enables operators to provide different applications to the end users.

The previous section shows how the influence of WAPECS is limited and that while some regulators have embraced flexibility, the industry has chosen harmonisation. However, there are other positive impacts that were revealed during the interviews. Firstly, WAPECS has been successful in removing the technology designation from CEPT decisions. In particular, one of the main influences of WAPECS was the review of the GSM directive which exclusively reserved the 900 MHz band for operation under the GSM standard. This has resulted in allowing other technologies (e.g. UMTS 900) to get access to the band (Guijarro and Alabau, 2013). Secondly, WAPECS has also indirect influence in the sharing and compatibility studies in Europe as before WAPECS, these studies were conducted based on specific technology (e.g. UMTS) (ECC, 2004). However, nowadays, different available technologies are taken into account (e.g. WiMAX, LTE) (ECC, 2012b).

Thirdly, WAPECS promotes BEM to be chosen for introducing flexibility in Europe although other approaches exist. In particular, while the UK developed a concept called SUR which specifies the maximum level of interference that can be caused, rather than the power that can be transmitted (Ofcom, 2008). Eventually, the UK abandoned SUR in most of the spectrum bands and adopted BEM just like the rest of Europe. Fourthly, WAPECS has allowed neutrality between the different generations of mobile (2G, 3G, 4G) for operators and as a result it has simplified the process of trading spectrum blocks between the different mobile operators “*WAPECS is just a word to say that you do not tie your license to a specific technology*”. Finally, one interviewees from the industry indicated that WAPECS is useful in determining OOB as it clarifies the conditions for adjacent channel interference with neighbouring operators.

Several interviewees expressed their opinions that the influence of WAPECS could be significant in the future when technologies would be capable of

accommodating such flexibility. In particular, there is a relationship between the applicability of WAPECS and technologies such as Cognitive Radio System (CRS) and Software Defined Radio (SDR). However, these technologies which can make WAPECS more feasible are costly and complicated and the industry does not want to be in charge of that “*flexibility is fine, but somebody has to pay for it*”. It should be noted that WAPECS is already perceived by many as a friendly concept to CRS technologies and opportunistic access (Forde and Doyle, 2013, Veenstra and Leonhard, 2008). In addition, one opinion that was expressed during the interviews is that WAPECS could be introduced for systems such as short range devices where flexibility in use of unlicensed bands could benefit spectrum users.

VI. Influence of International Spectrum Regulations on WAPECS

While the previous section shows the practical limitations of the WAPECS implementation, it is useful to examine the influence of the international spectrum regulations on the implementation of WAPECS. This is due that one of the main constraints on the application of WAPECS as identified by RSPG is the lack of flexibility in some existing licenses, particularly arising from international agreements (RSPG, 2005). In addition, it is argued that the international rules on spectrum management can restrict trading services other than those intended by the ITU (WIK, 2006). Moreover, it is argued that international co-ordination is a constraint on the ability of a single country to introduce more flexibility into its spectrum use (Cave, 2002). However, this varies according to the geographical characteristics of such country in terms of area, coastal line length, and number of neighbouring countries.

Therefore, this section aims to address the influence of the international spectrum regulations on WAPECS. To achieve that, a brief overview on the RR is needed. Firstly, allocating spectrum to the different radiocommunication services is the main responsibility of the ITU-R (ITU-R, 2001). The main rationale behind spectrum allocation is the management of interference between radio stations (Louis and Mallalieu, 2007). More specifically, it is argued that the level of protection required by one type of service, may not be suitable for another type of service (ITU-R, 1995). Moreover, Louis (2011) argues that the evolution of the ITU-R RR have always aligned with service harmonisation.

Secondly, a general rule is that if national service allocation is in conformity with the ITU-R table of spectrum allocation, this allocation is protected against interference from services allocated in the same band. Otherwise, it cannot claim protection from other services in the same band. In addition, it should not collide with neighbouring countries’ spectrum allocation (Indepen, 2001). Thirdly, there are several benefits of international harmonisation such as achieving global roaming, economies of scales for users’ equipment, and seamless movement of international services such as maritime and aeronautical (Lie, 2004).

Regarding the relationship between the service definitions in WAPECS and in the RR, the concept of service neutrality within the WAPECS concept is different than neutrality within the ITU-R radiocommunication services. The former is based on replacing traditional service and technology combination by what is called “electronic communications services (ECS)” where mobile, portable, or fixed access could be provided under one or more radiocommunication service allocations (e.g.

mobile, broadcasting, fixed) (Chaduc and Pogorel, 2008) as shown in figure (1)². On the other hand, the ITU-R radiocommunication service is defined as a service that involves the transmission, emission and/or reception of radio waves for specific telecommunication purposes (ITU-R, 2008).

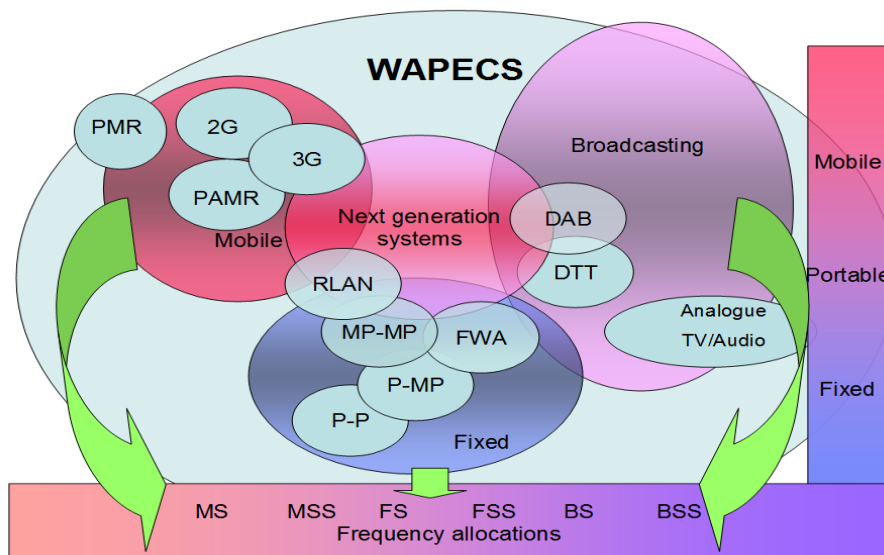


Figure (1): Radiocommunication Service Allocation Covered by WAPECS (RSPG, 2005)

As shown from the figure above, it seems that there is intersection between ECS and the ITU-R radiocommunication services as WAPECS was based on the convergence between three main radiocommunication services namely, fixed, mobile, and broadcasting (Grad, 2011). As exemplified by RSPG (2005) “*Particularly for converged applications, WAPECS may cover frequencies from various allocations (using the term “allocation” in the sense of the ITU Radio Regulations). For instance, spectrum under a broadcasting allocation can support a down-link of a mobile network (either without a return channel, or with a return channel in another frequency band allocated to mobile) and vice-versa (e.g. data casting, multimedia, interactive broadcasting within the mobile allocation)*”.

The interviews show also that there is confusion over whether services in WAPECS are the radiocommunication services in the sense of ITU-R RR or electronic services in the sense of ECS. While one group believes that they are the same, the other explains that ECS is related more to applications delivered to the user (e.g. telephony, pictures, video, music or data), and that the different electronic services or applications working under WAPECS are not necessarily linked to a given radiocommunication services. In addition, it was pointed out during the interviews that at the early days of WAPECS, there were concerns that WAPECS may contradict with the service concept of the ITU RR, and that the intention of WAPECS was to provide technology neutrality and to have elements of radiocommunication service neutrality.

² MS: Mobile Service, MSS: Mobile Satellite Service, FS: Fixed Service, FSS: Fixed Satellite Service, BS: Broadcasting Service, BSS: Broadcasting Satellite Service.

Regarding the service neutrality element of WAPECS, one interviewee points out that beside not being technology neutral as BEM is specified to particular technology (e.g. LTE), it is also limited to specific radiocommunication services (e.g. mobile) as these technical conditions favour some services over the others. More specifically, it is argued that BEM derivation within the WAPECS framework is based on different network scenarios (e.g. high/low power, point to point/multipoint) (Forde et al., 2010). However, service neutrality is also related to the different network architecture (Frullone, 2007). In other words, the scenarios utilised in the BEM calculations are related to a specific radiocommunication service. On the other hand, one other interviewee argues that service and technology are tied together and that the ITU-R RR determine specific radiocommunication service while allowing technology neutrality. However, determining particular technology parameters where you can operate (e.g. BEM) allows service neutrality which being technology specific.

In general, the collected data shows that the ITU-R RR can accommodate WAPECS to a certain extent except for some radiocommunication services such satellite. Firstly, it was explained that the frequency bands where WAPECS was deployed were chosen to cover several radiocommunication bands (e.g. fixed, mobile) in order not to contradict with the ITU-R RR. Therefore, even if WAPECS includes one or more radiocommunication services, they all have an allocation status in the RR which allows several co-primary services allocations in the same spectrum band. Moreover, WAPECS is mainly applied in mobile service bands where the ITU-R radiocommunication service definition gives enough flexibility to operators to use spectrum.

Secondly, most of the interviewees agree that the ITU-R RR should be involved only when countries are dealing with their neighbours. Furthermore, it was explained that WAPECS is a national policy and that ECS are subject to national laws regarding the content of the information (e.g. audio, video). Besides, one interviewee points out that WAPECS does not contradict with the ITU-R RR because BEM are defined according to the protection criteria within the RR. In addition, it was pointed out during the interviews that the ITU-R is targeting harmonisation but is not constraining administrations' flexibility, and that the ITU-R harmonisation adds value to the spectrum property rights. Otherwise, spectrum would have much less value.

One interesting case of potential conflict between international regulations and national policies on spectrum management which was mentioned by one of the interviewees is about a case in the German court. In particular, fixed wireless broadband access operators claimed that international regulators should not be followed by the German administration as it does not allow utilising spectrum in the best possible way. More specifically, these operators argued that they are not allowed to use fixed service in the 2.6 GHz as the government decided to strike out the fixed service allocation from the national frequency allocation table which was in line with the ITU-R service allocation table.

Eventually, the court decided that there is no legally relevant provisions conflict with international law or WAPECS and that there is no legal constrains resulting from international service allocation by the ITU. More specifically, the court explained that identifying the band 2.6 GHz for use by IMT does not exclude other use. Moreover, the court pointed out that there is no international obligation to continue using the spectrum for the fixed service and that WAPECS does not conflict

with national regulations (Higher Administrative Court of North Rhine-Westphalia, 2008).

VII. European Attempts to Introduce Flexibility to the International Service Allocation Framework

While WAPECS is concerned with introducing flexibility to spectrum use on the European level, this has been also associated with some European efforts at the international level “*the idea was to carry over the same spirit into the ITU*”. In particular, there have been several European attempts to enhance the international service allocation framework via different measures in the last World Radiocommunication Conferences (WRCs). However, all these attempts were opposed from several countries which called for retaining the current practice.

One of these attempts was at the WRC-03 where the European countries called for measures to be developed to facilitate the use of common, worldwide, frequency bands for implementing terrestrial wireless interactive multimedia applications (CEPT, 2003). The issue was motivated by the convergence of radiocommunication services in which radio systems could operate within the same or different radiocommunication services (ITU-R, 2003a). On the contrary, several countries opposed that arguing that no regulatory impediments to terrestrial wireless interactive multimedia applications have been identified and, therefore, there is no need to study the issue in future WRCs (USA, 2003, ASMG, 2003). Eventually, WRC-03 decided that the existing regulatory framework contained sufficient flexibility to minimise any regulatory constraints resulting from the existing definitions of services (Gavrilov, 2003). It was also decided to continue studying the effectiveness, appropriateness and impact of the radio regulations with regard to the advances in radio technologies and to identify options for improvements in radio regulations until WRC-07 (ITU-R, 2003b).

The issue was not resolved at WRC-07, which decided to continue to study the issue until WRC-12 under agenda item 1.2 (ITU-R, 2007). Following WRC-07, the ITU-R studies approached the issue from two perspectives. The first focused only on convergence between fixed and mobile services, while the second addressed spectrum allocation issues more generally (ITU-R, 2011). Moreover, studies prior to WRC-12 showed that, in most cases, there is joint allocation of spectrum across fixed and mobile services (ITU-R, 2011).

During WRC-12 several regional organisations called for retaining the current practice with regard to spectrum allocation principles as there is sufficient flexibility within the existing regulatory framework and the WRC process does not impede the introduction of new technologies (APT, 2011, ASMG, 2011, RCC, 2011, CITEL, 2012). In contrast, the European countries proposed to upgrade recommendation 34 with regard to spectrum allocation principles so that it would become a resolution (CEPT, 2011). WRC resolutions have a higher degree of obligation and are more binding on ITU countries than WRC recommendations. With regard to the convergence between fixed and mobile services, the European countries and few other countries proposed to change some of the definitions within the RR with regard to these services (CITEL, 2012, CEPT, 2011).

Eventually, WRC-12 decided not to change current spectrum allocation practices with regard to the two issues (ITU-R, 2012f), and to end the general studies of enhancing the international spectrum regulatory framework under resolution 951 as it has been considered by two successive conferences without being resolved (ITU-R, 2012c). Furthermore, WRC-12 decided to continue the studies on revising the definitions of fixed service, fixed station and mobile station until WRC-15 (ITU-R, 2012d). The revision should make clear that radio applications involving stations that only operate at specified fixed points would fall under the fixed service category, while radio applications involving stations that operate in motion or at unspecified locations would fall under the mobile service category (ITU-R, 2011).

Following WRC-12 and prior to the next WRC-15, the positions of the regional organization groups regarding changing radiocommunication service definitions have not changed. For instance, ASMG supports no change to the definitions since it would affect the national regulatory instruments (ASMG, 2013). Moreover, RCC considers that current definitions in the RR do not prevent from using the existing applications in the fixed and mobile services (RCC, 2014). Canada which is one of the main promoters of changing the definitions is of the view that this issue needs to be resolved at WRC-15 (CITEL, 2013). Moreover, APT is of the view that there is no need to modify the existing definitions of fixed service, fixed station and mobile station (APT, 2013).

Surprisingly, while CEPT was the main promoter of changing some of the radiocommunication service definitions to accommodate convergence prior to WRC-12; this has changed prior to WRC-15 to align with the other regional organizations' positions "*CEPT is of the view that there is no need to modify the existing definitions of fixed service, fixed station and mobile station. Furthermore CEPT opposes any modification which may have any negative regulatory impact on existing allocations to radiocommunication services*" (CEPT, 2013). It was one of the targets of this paper to find an explanation of such change.

Firstly, the interviews show that the calls for introducing flexibility in the international service allocation framework were driven mainly by few European countries. In addition, it was pointed out that the result was that the ITU-R RR provide a general framework which accommodates sufficient flexibility for national administrations "*the radio regulation is flexible enough and it took some times for people to realize that*". Secondly, it was pointed out that there is indirect relation between WAPECS and the European calls during the last WRCs to introduce more flexibility in the international spectrum management framework "*The intention was to check whether the ITU-R RR accommodates WAPECS and the answer was yes*".

Thirdly, regarding changing the European positions after WRC-12, one interviewee explains that this is related to the continuous resistance from the other administrations since the beginning of the discussion "*We fought for change and we did not get it and we do not want this miserable debate again*". The issue is that flexibility discussions have been conducted in three consequence conferences (WRC-03, WRC-07, WRC-12) without any outputs. Hence, this is the reason why Europe has changed its position after WRC-12 to "no change".

It was also found that some European countries are more restrictive on the interpretation of the ITU-R RR and they wanted to make sure that fixed service definition accommodates point to multi-point in addition to point to point communication. Eventually, the European countries agreed that the current

radiocommunication services definitions are fine. “*The motivation was to somehow remove the distinction between fixed and mobile services but it turned out to be a lot more complicated than was expected*”. In addition, it was explained that making such distinction clear may cause some restriction as the intersection between the different radiocommunication services provides some sort of flexibility to national administrations.

The resistance from the other regional organisations was also explained during the interviews. For instance, there were concerns over the negative influences on changing these service definitions as they are included in several ITU-R recommendations and reports. Furthermore, changing fixed radiocommunication service may have implications on the national level in terms of the current deployment of this service as it may allow operators to provide different services than those agreed on (e.g. BWA in fixed service bands). In addition, it was also indicated during the interviews that the compromise reached on the WRC-12 agenda item 1.2 is related to the other agenda items of the conference. In other words, the decision of no change may have been linked to other decision on other issues during the conference. This is mainly due that in WRCs the different issues are discussed in parallel and sometimes by the same people.

Regarding the discussion on upgrading ITU-R Recommendation 34, which suggests allocating spectrum to the most broadly defined services, to ITU-R Resolution at the last WRC-12, the interviews revealed that the European move was motivated by attracting more attention from the other administrations to the recommendation by updating it into resolution. The reason why most of the other countries refused such upgrade is explained by one of the interviewees by that resolutions are part of the international laws and have more obligatory status especially for those countries which are heavily dependent on the ITU-R RR. In addition, it was explained that most of the countries are conservative in a way that they don't want to see changes. One other opinion was that any country may not follow an ITU-R resolution if they want.

The interviews revealed also that one of the implications of WAPECS on the international level is the introduction of the envelop concept by the European countries in the Geneva-06 agreement which plan digital terrestrial broadcasting service in the ITU-R region 1³ in addition to Iran. More specifically, any entry in the plan can be used for alternative applications as long as the implementation does not exceed the interference envelope derived from the characteristics of the digital plan entry (ITU, 2006). This was mainly driven by the European countries which wanted to introduce more flexibility to the plan.

VIII. Discussion

This paper has examined the interplay between the theory and empirical implementation of WAPECS and showed also the different limitations of the spectrum property rights concept in practice. More specifically, it is argued that while the original intention of WAPECS was to cover several spectrum bands that are

³ Region 1 comprises Europe, Africa, the Middle East west of the Persian Gulf including Iraq, the former Soviet Union and Mongolia. Region 2 covers the Americas, Greenland and some of the eastern Pacific Islands. Region 3 contains most of non-former-Soviet-Union Asia, east of and including Iran, and most of Oceania.

allocated to different radiocommunication services, however, the primary data collected through the interviews has shown that the practice of WAPECS is quite limited. The question now is what the reasons for the limited application of WAPECS are.

One possible explanation could be the different negative perceptions of the industry over WAPECS and that the concept was vague for them as exemplified in section four. One other explanation is that WAPECS was not the choice of the industry. More specifically, it was a theoretical approach embraced by the academia and promoted by the EC. However, the market has eventually made its final answer: harmonisation. This is also one of the main outcomes of section five of this paper which assesses the influence of WAPECS. Therefore, it is argued that the EC needs to further involve with the industry in order to understand their different perceptions on the flexibility issue as eventually they are the true decision makers.

One potential restriction on the applicability of WAPECS was assumed to be the international spectrum management regulations. However, this claim was also refuted in section six of the paper. In particular, it was pointed out that the ITU-RR can accommodate WAPECS. This could be exemplified by the different forms of spectrum property rights accommodated already within the RR. For example, stations operating in the band 3400-3600 MHz as primary mobile service have to meet some technical conditions in terms of power flux-density (pfd) at the border of the territory of any other administration as specified at the RR (ITU-R, 2012a).

One explanation to the resistance of the non-European countries to the introduction of more flexibility in the international service allocation framework is that these countries were not aligned with the European approach to flexibility in spectrum management. More specifically, the interviews show that the non-European countries do not perceive tangible benefits from introducing more flexibility in their national spectrum management. Maybe it would have been a good idea to involve them in the WAPECS discussion even if it was concerned with the European regional level.

It is worth mentioning that while most of the non-European countries have resisted the attempts by the European countries to introduce flexibility to the international service allocation framework, sometimes these same countries introduce flexibility in indirect way by allocating the spectrum to additional radiocommunication service. One famous example of that is the Arabian and African successful efforts in introducing flexibility in the UHF band by having additional allocation to the mobile service in the 698-790 MHz band in addition to the broadcasting service (ITU-R, 2012e). Such step provided more flexibility to national administrations in terms of choosing whether to deploy mobile or broadcasting service in the band. Interestingly, the CEPT countries opposed the 700 MHz proposal arguing that the band is heavily utilised by broadcasting service and that there are already long-term licensing arrangements (ITU, 2013). Therefore, it seems that these non-European countries are not against the concept of flexibility in spectrum use in general. However, it could be that they prefer a gradual change and not a radical one that may have negative consequences on the stable spectrum management framework that has been well established for years in their countries.

Finally, it is argued that regulators can resist ideas but they eventually cannot resist technologies. Therefore, technologies such as CRS which, in theory, can provide you with all the flexibility to implement any service via any technology

would impose the applicability of concepts such as WAPECS. And if these types of technologies are successful enough, they could enforce the regulators outside Europe to adapt to it and they could also call for changes at the international level.

Having said that, it could be argued that WAPECS was quite useful as an empirical implementation of Coase's idea in terms of understanding the impracticalities associated with WAPECS. As explained by Coase (2006): "*The theory suggests what empirical work might be fruitful, the subsequent empirical work suggests what modification in the theory or rethinking is needed, which in turn leads to new empirical work*". Therefore, the next step should be to re-examine the notion of spectrum property rights in the light of the different perceptions of the industry's stakeholders and considering the imperfection of today's technologies.

IX. Conclusions

Fifty five years ago, Coase argued that spectrum assignments should be treated in a similar way to property rights where market forces allocate these flexible tradable rights to users with the highest valuations for it. Coase's idea was brought back to life by a European concept named "Wireless access policy for electronic communication services (WAPECS)". WAPECS was the response to the different calls within the EU to reform traditional approach to spectrum management, Command and Control, towards "Spectrum Market" regime. This was mainly motivated by the calls by the 2G operators for more flexibility in their licenses in order to upgrade to 3G, the measures taken by other regulators outside Europe towards flexibility, and the convergence on the technological level.

It was found that there are different negative perceptions on WAPECS which varies between proofing a case of failure, being a vague concept, contradicting with spectrum use efficiency, associating with potential interference, and creating uncertainties to the market. Furthermore, it was also indicated that there was no agreement on adopting WAPECS at its early day within Europe and that it was promoted by few countries and the EC.

In order to assess the influence of WAPECS, the paper addresses the decisions related to frequency arrangements in the spectrum auctions in Europe in the 2.6 GHz and 3.5. Regarding the 2.6 GHz, the EC promotes flexible frequency arrangements for the 2500-2690 MHz band where operators can deploy TDD or FDD. What has happened in reality was that most of the 2.6 GHz auctions that were conducted in Europe have resulted in FDD networks and similar frequency arrangements. The examination of the flexibility accommodated in the 3.5 GHz shows also that flexibility may discourage operators to invest and incur additional costs for flexibility that is not needed for them. On the other hand, the interviews revealed several positive impacts of WAPECS including removing technology designation from CEPT decisions, influencing the sharing and compatibility studies in Europe, promoting BEM to be chosen for introducing flexibility in Europe, and simplifying spectrum trading.

Regarding the influence of international spectrum regulations on WAPECS, the paper shows that there is a difference between the definitions of services in WAPECS and ITU-R radiocommunication service. However, there is also intersection between them as WAPECS was based the convergence between three main radiocommunication services namely, fixed, mobile, and broadcasting. In

general, most of the interviewees agree that the ITU-R RR can accommodate WAPECS as while the ITU-R is targeting harmonisation, it is not constraining administrations' flexibility.

The paper shows also that there have been several attempts by the European countries to introduce more flexibility in the international service allocation framework via different measures in the last WRC-03, WRC-07, and WRC-12. However, all these attempts were opposed from several countries which called for retaining the current practice. In general, this paper has examined the interplay between the theory and empirical implementation of WAPECS and showed also the different limitations of the spectrum property rights concept in practice.

References

- AKALU, R. 2006. EU Spectrum Reform and the Wireless Access Policy for Electronic Communications Services (WAPECS) Concept. *Info*, 8.
- APT 2011. Common Proposals for the Work of the Conference. Agenda Item 1.2. *World Radiocommunication Conference (WRC-12)*. Geneva.
- APT 2013. APT Preparatory Process for WRC-15. *1st ITU Inter-Regional Workshop on WRC-15 Preparation*. Geneva.
- ASMG 2003. Arab States Common proposal. *World Radiocommunications Conference 2003*. Geneva.
- ASMG 2011. Arab States Common Proposals. Common Proposals for the Work of the Conference. Agenda Item 1.2. *World Radiocommunication Conference (WRC-12)*. Geneva.
- ASMG 2013. Agenda Items of the WRC-15. *1st ITU Inter-Regional Workshop on WRC-15 Preparation*. Geneva.
- BAZELEY, P. 2007. *Qualitative Data Analysis with NVivo (2nd edn.)*, London, Sage.
- BLUST, S. 2012. Global Deployments of Technologies Utilizing IMT Specifications and Standards. *WP5A-WP5B-WP5C Workshop on the Preparations for WRC-15*. Geneva.
- BRYMAN, A. & BELL, E. 2007. *Business research methods.*, New York, Oxford University Press.
- CAVE, M. 2002. Review of Radio Spectrum Management, An independent review for Department of Trade and Industry and HM Treasury.
- CAVE, M. 2010. Anti-competitive behaviour in spectrum markets: Analysis and response. *Telecommunications Policy*, 34, 251-261.
- CAVE, M. & WEBB, W. 2003. Designing Property Rights for the Operation of Spectrum Markets. *Papers in Spectrum Trading*.
- CAVE, M. & WEBB, W. 2012. The unfinished history of usage rights for spectrum. *Telecommunications Policy*, 36, 293-300.
- CEPT 2003. European Common Proposals for the Work of the Conference. *World Radiocommunication Conference (WRC-07)*. Geneva.
- CEPT 2006. CEPT Report 80: Enhancing Harmonisation and Introducing Flexibility in the Spectrum Regulatory Framework.
- CEPT 2007. CEPT Report 19: Report from CEPT to the European Commission in Response to the Mandate to Develop Least Restrictive Technical Conditions for Frequency Bands Addressed in the Context of WAPECS.
- CEPT 2009. CEPT Report 30: Report from CEPT to the European Commission in Response to the Identification of Common and Minimal (least restrictive

- Technical Conditions for 790 - 862 MHz for the Digital Dividend in the European Union”.
- CEPT 2010. CEPT Report 39: Report from CEPT to the European Commission in Response to the Mandate to Develop Least Restrictive Technical Conditions for 2 GHz bands.
- CEPT 2011. European Common Proposals for the Work of the Conference, Part 1, Agenda Item 1.2. *World Radiocommunication Conference (WRC-12)*. Geneva.
- CEPT 2013. Status of CEPT Preparations for WRC-15. *1st ITU Inter-Regional Workshop on WRC-15 Preparation*. Geneva.
- CHADUC, J. & POGOREL, G. 2008. *The Radio Spectrum. Managing a Strategic Resource*, London, ISTE Ltd.
- CITEL 2012. Inter-American Proposals for the Work of the Conference. Agenda Item 1.2. *World Radiocommunication Conference (WRC-12)*. Geneva.
- CITEL 2013. Preliminary Views and Proposals Regarding WRC-15 Agenda Items. *1st ITU Inter-Regional Workshop on WRC-15 Preparation*. Geneva.
- COASE, R. 2006. The Conduct of Economics: The Example of Fisher Body and General Motors. *Journal of Economics & Management Strategy*, 15.
- COASE, R. H. 1959. The Federal Communications Commission. *Journal of Law & Economics*, 2, 1-40.
- COASE, R. H. 1960. The Problem of Social Cost. *Journal of Law & Economics*, 3, 1-44.
- COMREG 2005. Summary of the Analysis of Responses to RSPG Consultation on WAPECS.
- CULLELL MARCH, C. 2011. Broadcasters and Radio Spectrum: The Emergence of a European Digital Dividend in the United Kingdom and Spain. *22nd European Regional ITS Conference*. Budapest.
- DELAERE, S. 2007. European Policy Trends Towards Flexible Spectrum Management. *The Southern African Journal of Information and Communication*.
- ECC 2004. ECC Report 45: Sharing and Adjacent Band Compatibility between UMTS/IMT-2000 in the Band 2500-2690 MHz and Other Services. *ECC Reports*.
- ECC 2005. ECC Decision of 18 March 2005 on Harmonised Utilisation of Spectrum for IMT-2000/UMTS Systems Operating within the Band 2500 – 2690 MHz. *ECC Decisions*.
- ECC 2007. ECC Decision of 30 March 2007 on availability of frequency bands between 3400-3800 MHz for the harmonised implementation of Broadband Wireless Access systems (BWA) *ECC Decisions*.
- ECC 2010. ECC Report 137: Introducing Greater Flexibility in the Current Regulatory Structure with a View to Taking Forward Convergence and Harmonisation in the ECC. *ECC Reports*.
- ECC 2012a. ECC Decision (01) 03: ECO Frequency Information System (EFIS). *ECC Decisions*.
- ECC 2012b. ECC Report 174: Compatibility between the Mobile Service in the Band 2500-2690 MHz and the Radiodetermination Service in the Band 2700-2900 MHz. *ECC Reports*.
- ECC 2012c. ECC Report 180: Guidance on the interpretation of the requirements of ECC/DEC/(01)03 on EFIS. *ECC Reports*.
- EUROPEAN COMMISSION 1998. COM (98) 596 Final: Green Paper on Radio Spectrum Policy.

- EUROPEAN COMMISSION 2008a. Commission Decision of 13 June 2008 on the Harmonisation of the 2 500-2 690 MHz Frequency Band for Terrestrial Systems Capable of Providing Electronic Communications Services in the Community. *Official Journal of the European Union*, L 163.
- EUROPEAN COMMISSION 2008b. Commission Decision of 21 May 2008 on the harmonisation of the 3 400-3 800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community. *Official Journal of the European Union*, L 144.
- EUROSTRATEGIES AND LS-TELECOM 2007. Study on Radio Interference Regulatory Models in the European Community.
- FORDE, T. & DOYLE, L. 2013. A TV Whitespace Ecosystem for licensed cognitive radio. *Telecommunications Policy*, 37.
- FORDE, T. K., DOYLE, L. E. & OZGUL, B. 2010. Dynamic Block-Edge Masks (BEMs) for Dynamic Spectrum Emission Masks (SEMs). *IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks*. Singapore.
- FORGE, S., HORVITZ, R. & BLACKMAN, C. 2012. Perspectives on the Value of Shared Spectrum Access: Final Report for the European Commission.
- FRULLONE, M. 2007. A Deeper Insight in Technology and Service Neutrality. *ITU Workshop on Market Mechanisms for Spectrum Management*. Geneva.
- GAVRILOV, T. 2003. Results of the WRC-03. *Regional Radiocommunication Seminar*. Lusaka.
- GRAD, J. 2011. WAPECS: A Method for Flexible Regulation of Radio accesses in the European Union. *22nd Regional European Conference of the International Telecommunication Society (ITS 2011)*. Budapest.
- GSMA 2010. The 2.6GHz Spectrum Band: An Opportunity for Global Mobile Broadband.
- GUIJARRO, L. & ALABAU, A. 2013. Radio Spectrum and Broadband European Union Policies: Towards a European Broadband Strategy. *CPREurope*. Brussels.
- HAZLETT, T. W. & MUÑOZ, R. E. 2006. Spectrum Allocation in Latin America: An Economic Analysis. *George Mason Law & Economics Research Paper*, 6.
- HIGHER ADMINISTRATIVE COURT OF NORTH RHINE-WESTPHALIA 2008. File Number 13 A 2394/07.
- INDEPEN, A. 2001. Implications of International Regulation and Technical Considerations on Market Mechanisms in Spectrum Management: Report to the Independent Spectrum Review.
- ITU-R 1995. ITU-R Recommendation SM.1133: Spectrum Utilization of Broadly Defined Services. *SM Series. Spectrum Management*.
- ITU-R 2001. ITU-R Recommendation SM.1265-1: National Alternative Allocation Methods. *SM Series. Spectrum Management*.
- ITU-R 2003a. CPM Report on Technical, Operational and Regulatory/Procedural Matters to be Considered by the 2003 World Radiocommunication Conference.
- ITU-R 2003b. Resolution 951: Options to Improve the International Spectrum Regulatory Framework. *Provisional Final Acts - World Radiocommunication Conference (WRC-03)*.
- ITU-R 2007. WRC-07 Resolution 951: Options to Improve the International Spectrum Regulatory Framework. *Provisional Final Acts - World Radiocommunication Conference (WRC-07)*.
- ITU-R 2008. Article 1: Terms and Definitions. *Radio Regulations*.

- ITU-R 2009. ITU-R Recommendation M.1457-8: Detailed Specifications of the Radio Interfaces of International Mobile Telecommunications-2000 (IMT-2000). *M Series. Mobile, Radiodetermination Amateur and Related Satellite Services*.
- ITU-R 2011. CPM Report on Technical, Operational and Regulatory/Procedural Matters to be Considered by the 2012 World Radiocommunication Conference.
- ITU-R 2012a. Article 5: Frequency Allocations. *Radio Regulations: 2012 Edition*.
- ITU-R 2012b. ITU-R Recommendation M.1036-4: Frequency Arrangements for Implementation of the Terrestrial Component of International Mobile Telecommunications (IMT) in the Bands Identified for IMT in the Radio Regulations (RR). *M Series. Mobile, Radiodetermination Amateur and Related Satellite Services*.
- ITU-R 2012c. WRC-12 Resolution 804: Principles for Establishing Agendas for World Radiocommunication Conferences. *Provisional Final Acts - World Radiocommunication Conference (WRC-12)*.
- ITU-R 2012d. WRC-12 Resolution 957: Studies Towards Review of the Definitions of Fixed service, Fixed Station and Mobile Station. *Provisional Final Acts - World Radiocommunication Conference (WRC-12)*.
- ITU-R 2012e. WRC-12 Resolution 232. Use of the Frequency 694-790 MHz by the Mobile, Except Aeronautical Mobile, Service in Region 1 and Related Studies. *Provisional Final Acts - World Radiocommunication Conference (WRC-12)*.
- ITU-R. 2012f. WRC-12 Weekly Highlights. [Accessed 19/3/2012].
- ITU 2006. Annex 2: Technical Elements and Criteria Used in the Development of the Plan and the Implementation of the Agreement. *Final Acts of the Regional Radiocommunication Conference for Planning of the Digital Terrestrial Broadcasting Service in Parts of Regions 1 and 3, in the Frequency Bands 174-230 MHz and 470-862 MHz (RRC-06)*.
- ITU. 2013. The second digital dividend: Another bite for mobile? *ITU News* [Online].
- LEGUTKO, C. 2008. Opinion: Changing the Regulatory Paradigm. *PolicyTracker.com* [Online]. [Accessed 30/9/2013].
- LOUIS, J. 2011. International Radio Spectrum Management Beyond Service Harmonisation. *Fourth International Conference on Emerging Trends in Engineering & Technology*.
- LOUIS, J. & MALLALIEU, K. 2007. Investigating the Impact of Convergence on the International Spectrum Regulatory Framework. *Proceedings of the Second International Conference on Systems and Networks Communications ICSNC '07* Washington D.C.
- MARSDEN, R., SEXTON, E. & SIONG, A. 2010. Fixed or Flexible? A Survey of 2.6GHz Spectrum Awards. *DotEcon Discussion Papers*.
- MEYER, C. B. 2001. A Case in Case Study Methodology. *Field Methods*, 13.
- OFCOM 2008. Spectrum Usage Rights: A Guide Describing SURs.
- RCC 2011. Common Proposals by the RCC Administrations on WRC-12 Agenda Item 1.2. *World Radiocommunication Conference (WRC-12)*. Geneva.
- RCC 2014. Preliminary position of the RCC CA's on WRC-15 Agenda Items.
- ROETTER, M. F. 2009. The European Commission's Illogical 2.6GHz Decision. *Responses to the Public consultation on the draft RSPG Work Programme 2010*.

- RSPG 2005. RSPG05-102 on Wireless Access Platform for Electronic Communication Services (WAPECS) (A More Flexible Spectrum Management Approach). *Radio Spectrum Policy Group Opinions*.
- SAUNDERS, M., LEWIS, P. & THORNHILL, A. 2009. *Research Methods for Business Students (5th edn.)*, Pearson Education Limited.
- TELLIS, W. 1997. Application of a Case Study Methodology. *The Qualitative Report*, 3.
- USA 2003. World Radiocommunications Conference 2003: Proposals for the Work of the Conference.
- VANY, A. S. D., ECKERT, R. D., MEYERS, C. J., O'HARA, D. J. & SCOTT, R. C. 1969. A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study. *Stanford Law Review*, 21.
- VEENSTRA, Y. & LEONHARD, H. 2008. Avoiding Harmful Interference – The Current Paradigm. *The Annual Conference on Competition and Regulation on Network Industries (CRNI)*.
- VRIES, P. D. & SIEH, K. A. 2012. Reception-Oriented Radio Rights: Increasing the Value of Wireless by Explicitly Defining and Delegating Radio Operating Rights. *Telecommunications Policy*, 36.
- WEISER, P. & HATFIELD, D. 2008. Spectrum Policy Reform and the Next Frontier of Property Rights. *George Mason Law Review*, 60.
- WIK 2006. Towards More Flexible Spectrum Regulation. *Study Commissioned by the German Federal Network Agency*.