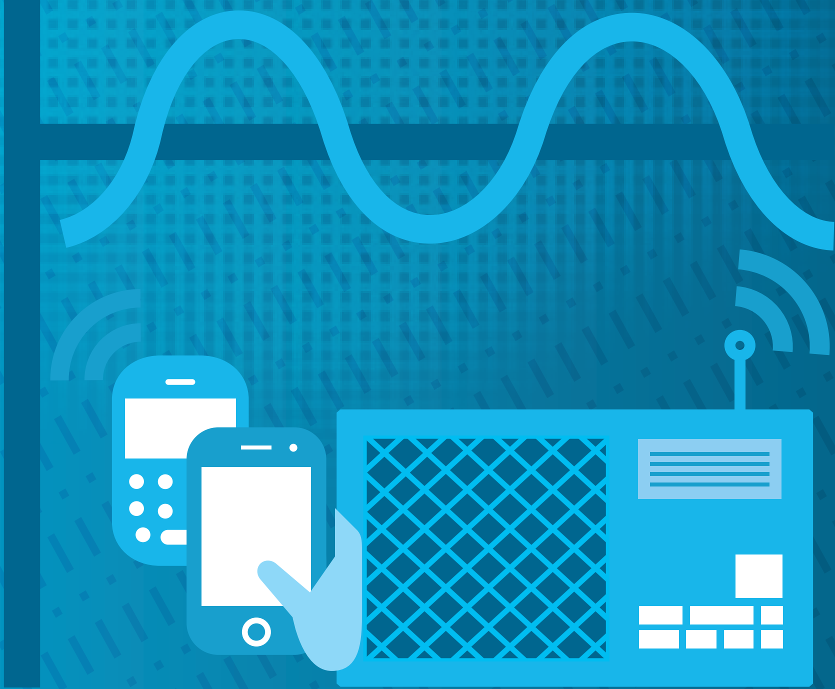
FINAL REPORT

ITU-D STUDY GROUP 2

RESOLUTION 9

PARTICIPATION OF COUNTRIES, PARTICULARLY DEVELOPING COUNTRIES, IN SPECTRUM MANAGEMENT

SPECTRUM MANAGEMENT



5TH STUDY PERIOD 2010-2014

Telecommunication Development Sector

CONTACT US

Website:	www.itu.int/ITU-D/study_groups
ITU Electronic Bookshop:	www.itu.int/pub/D-STG/
e-mail:	devsg@itu.int
Telephone:	+41 22 730 5999

RESOLUTION 9:

Participation of countries, particularly developing countries, in spectrum management

ITU-D Study Groups

In support of the knowledge sharing and capacity building agenda of the Telecommunication Development Bureau, ITU-D Study Groups support countries in achieving their development goals. By acting as a catalyst by creating, sharing and applying knowledge in ICTs to poverty reduction and economic and social development, ITU-D Study Groups contribute to stimulating the conditions for Member States to utilize knowledge for better achieving their development goals.

Knowledge Platform

Outputs agreed on in the ITU-D Study Groups and related reference material are used as input for the implementation of policies, strategies, projects and special initiatives in the 193 ITU Member States. These activities also serve to strengthen the shared knowledge base of the membership.

Information Exchange & Knowledge Sharing Hub

Sharing of topics of common interest is carried out through face-to-face meetings, e-Forum and remote participation in an atmosphere that encourages open debate and exchange of information.

Information Repository

Reports, Guidelines, Best Practices and Recommendations are developed based on input received for review by members of the Groups. Information is gathered through surveys, contributions and case studies and is made available for easy access by the membership using content management and web publication tools.

Study Group 2

Study Group 2 was entrusted by WTDC-10 with the study of nine Questions in the areas of information and communication infrastructure and technology development, emergency telecommunications and climate-change adaptation. The work focused on studying methods and approaches that are the most suitable and successful for service provision in planning, developing, implementing, operating, maintaining and sustaining telecommunication services which optimize their value to users. This work included specific emphasis on broadband networks, mobile radiocommunication and telecommunications/ICTs for rural and remote areas, the needs of developing countries in spectrum management, the use of ICTs in mitigating the impact of climate change on developing countries, telecommunications/ICTs for natural disaster mitigation and relief, conformance and interoperability testing and e-applications, with particular focus and emphasis on applications supported by telecommunications/ICTs. The work also looked at the implementation of information and communication technology, taking into account the results of the studies carried out by ITU-T and ITU-R, and the priorities of developing countries.

Study Group 2, together with ITU-R Study Group 1, also deals with Resolution 9 (Rev. WTDC-10) on the "Participation of countries, particularly developing countries, in spectrum management".

This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

Table of Contents

Page

Page

Page

Figures and Tables

RESOLUTION 9
Participation of countries, particularly developing countries, in spectrum management

Executive summary

This document is the final Report on WTDC Resolution 9 (Participation of countries, particularly developing countries, in spectrum management) (Rev. Hyderabad 2010). The document has been developed through close collaboration between the ITU Radiocommunication Sector (ITU-R) and the ITU Telecommunication Development Sector (ITU-D). Such joint collaboration has aimed to bridge the on-going radiocommunication-related activities and technical studies with the special and growing needs of the developing countries. In particular, this report takes into consideration the continuing growth in demand for spectrum, marketplace drivers, as well as new developments and technology trends in order to support the developing countries with regard to national technical and economic approaches to spectrum management while incorporating national experiences and case studies.

The report composes of four parts and eight annexes. The first part of this report (Part I) studies the market mechanisms used for frequency assignment. It aims in particular at developing a realistic and well-argued vision on spectrum management and its evolution, and promoting a logical approach that assesses the appropriateness of applying particular market mechanisms within the framework of spectrum management. It describes the different auction types and main recipes for an efficient auction design along with associated success and risk factors. Illustrative auctions case studies are provided in Annex 2. This part also addresses the secondary spectrum trading in terms of applicability as well as pros and cons.

Part II is devoted to the development of frequency allocation tables at national and regional levels and to spectrum refarming mechanisms. It addresses some principles of the frequency allocation table along with refarming challenges and illustrative case studies. Annex 3 provides an example of an allocation table.

Part III deals with the introduction of cost accounting tools in the field of radiocommunications. It provides guidelines for the introduction of cost accounting along with potential Implementation methods.

The fourth and last section (Part IV) analyses the evolution methods of calculating spectrum fees. Annexes 5 and 6 provide some case studies for calculating spectrum fees and help understand how to set a spectrum price.

0 Acknowledgements

0.1 ITU collaborators

- BDT
- BR
- TSB

0.2 Contributors

- Algeria
- Bangladesh
- Colombia
- Côte d'Ivoire/Ivory Coast
- Cuba
- Democratic Republic of the Congo (DRC)
- Egypt
- Eritrea
- France
- Gambia
- Hungary
- Maldives
- European Communication Office
- Thales Communications (France)
- Full list of contributions is provided in **Annex 7**.

0.3 Regional coordinators

- Mr Robin Haines (United States) for the Americas
- Ms Audrey Loridan-Baudrier (France) for Europe
- Mr Simon Koffi (Côte d'Ivoire) for Africa
- Mr Naser Al Rashedi (United Arab Emirates) for the Arab States
- Mr Kavouss Arasteh (Islamic Republic of Iran) for Asia-Pacific
- Mr Albert Nalbandian (Armenia) for the Commonwealth of Independent States (CIS)

0.4 Reminder of terms of reference of Resolution 9

This document comes as a contribution towards realization of the terms of reference of Resolution 9 (Rev. Hyderabad, 2010), which under the terms of resolves 1 include study of the following:

- Use of market mechanisms to allocate frequency bands (Part I of this contribution);
- National frequency allocation tables (NFATs) and spectrum refarming (Part II);
- Cost accounting for radiocommunications (Part III);

– Changing methods of calculating fees for spectrum use (Part IV).

The objectives are as follows:

– to update the database on spectrum utilization fees for the bands between 29.7 MHz and 30 GHz, taking account of new applications and the results of auctions and comparative selection processes;

– to develop guidelines for the establishment of national frequency allocation tables, with a view to establishing spectrum utilization fees related to new applications and procedures for the introduction of market mechanisms in spectrum management;

– to develop guidelines for spectrum refarming operations;

– to study cases regarding the experience of national administrations in the application of market mechanisms in spectrum management and regarding methods for calculating spectrum utilization fees.

0.5 Approach and structure of this document

This document is divided into four parts:

– Market mechanisms (Part I);

– Frequency allocation tables and spectrum refarming (Part II);

– Cost accounting for radiocommunications (Part III);

– Changes in methods for calculating spectrum utilization fees (Part IV).

Part I: Market mechanisms

The first part of this report studies the recourse to market mechanisms to assign frequencies.

It aims in particular to:

– Develop a realistic and well-argued vision on spectrum management and its evolution;

– Promote a logical approach that assesses the appropriateness of applying particular market mechanisms within the framework of spectrum management;

– Examine the dictates of competition, transparency, equitable spectrum access and public service.

1 Introduction

This part of the document commences with a reminder of the main definitions used within the framework of the Resolution 9 activities devoted to market mechanisms.

It goes on to provide a general overview of the problems encountered regarding the scarcity of radio resources in the light of the institutional, legal and economic challenges, based inter alia on the theory of property rights.

It then goes deeper into that analysis by developing guidelines on the use of auctions and secondary spectrum trading for radio frequencies.

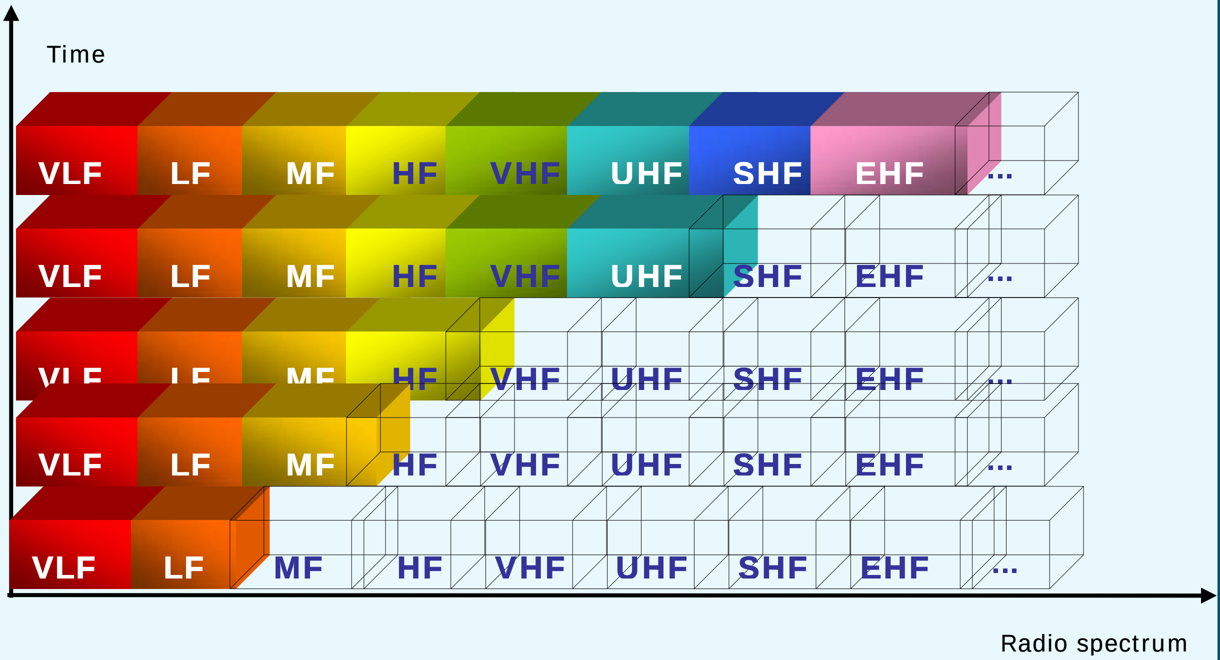
It concludes with recommendations for the introduction of market mechanisms as part of effective spectrum management.

1.1 An evolving context

Member States are endowed with a priceless intangible heritage. The first elements that come to mind are patents and licenses. Other elements nevertheless include the radio spectrum, software, brands, know-how, databases, access rights, rights of way, maps, images, etc. It is difficult to enter such assets into the public accounts, as they have been formed over time through the accumulation of different, evolving elements (APIE, 2011).

The radio-frequency spectrum constitutes the raw material of any radiocommunication system, and is an intangible asset linked to the sovereignty of each Member State and the exercise of regal powers. This particular asset may be relatively scarce in some instances. The cause of its scarcity is to be found not only in institutional mechanisms, but also in a growing demand for uses resulting from technical progress. This demand comes up against the fact that there is an increasingly narrow bottleneck in the availability of the resource as well as in the allocation and access mechanisms.

Figure 1: Scarcity of radio frequencies



The following factors contribute to the scarcity of frequencies and increased spectrum access costs:

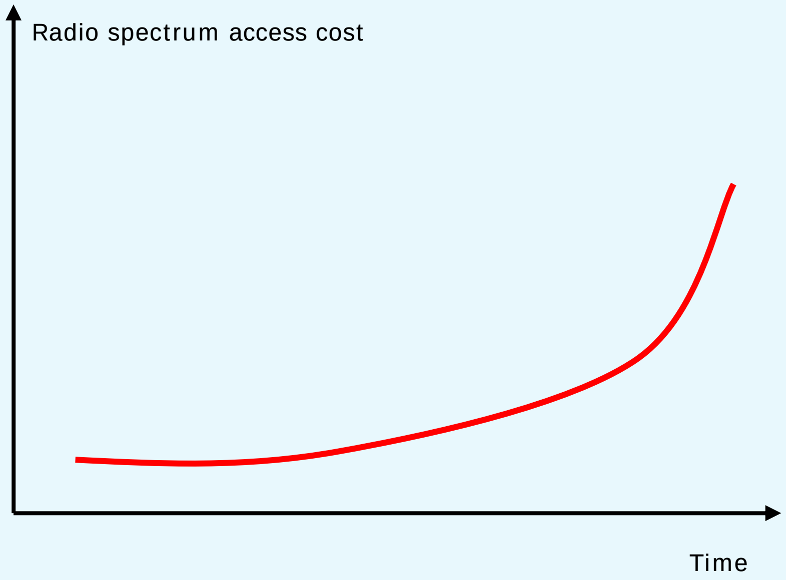
– The deregulation and liberalization of electronic communication markets

– The privatization and "merchandizing" of the public domain

– Awareness of the value of the spectrum

– Worldwide competition between multinational operators.

Figure 2: Increase in radio spectrum access costs

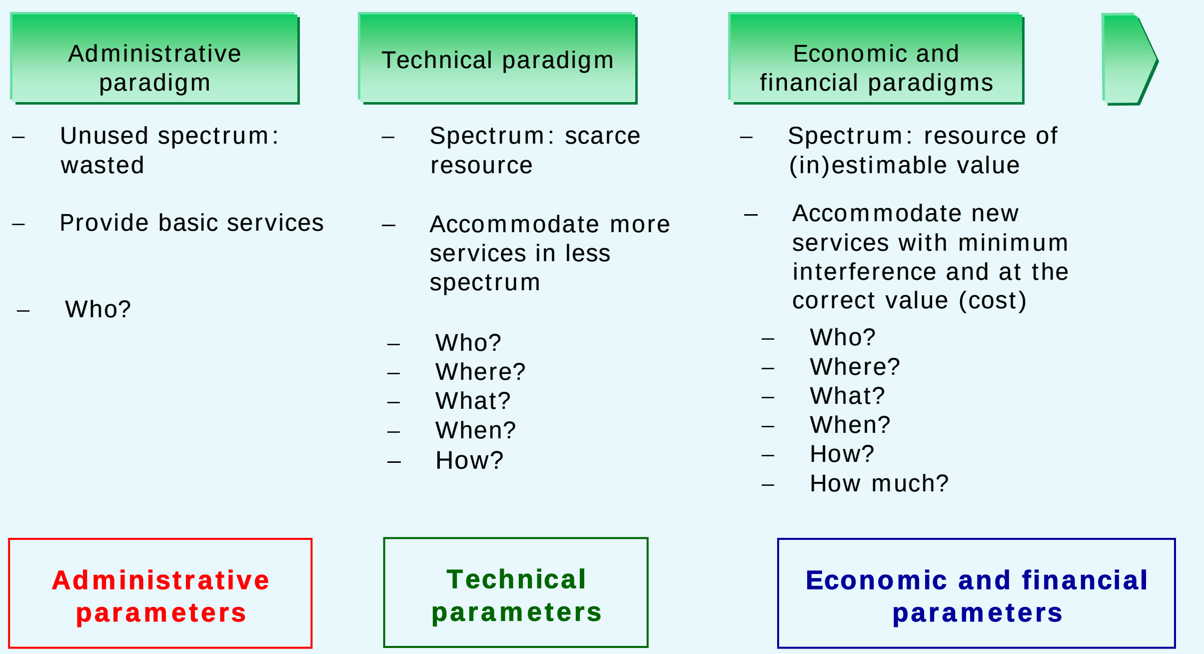


It must be noted that hitherto reflection concerning this natural resource has focused mainly on the case of the developed countries. The developing countries have long been left more or less on the fringe of the debates that took place in the technical, legal, economic and political fields.

This divergence of interest between developed and developing economies is explained by the very different structural and institutional contexts in which the uses of the spectrum resource have evolved.

Debates are nevertheless now beginning to run along much the same lines in all countries of the world, regardless of the legal or institutional regimes in place. They proceed from the same premise, that the challenges in frequency management are no longer simply technical and administrative, but also economic and financial. The financial approach and market strategies are steadily imposing themselves on all players in the radiocommunication sector, especially regulators and operators, who are finding themselves obliged to move from an administrative approach to economic and financial approaches.

Figure 3: Paradigm shift



1.2 Increasing recourse to market mechanisms

This profound paradigm shift is increasingly encouraging the adoption of new frequency allocation mechanisms. Different methods exist in cases where demand for frequencies exceeds supply. Traditionally, public authorities have often allocated frequencies for specific applications, and then assigned parts of the spectrum to entities responsible for using them for specific purposes based on the "first come, first served" principle. This approach is fast, practical and less costly, but has its limits in today's competitive environment.

Indeed, the limited resources required to operate a telecommunication service (radio spectrum, numbers, rights of way) should be divided up among operators in a manner that is equitable, effective, and serves the public interest.

To meet this concern, the WTO reference document on basic telecommunications (1997) promoted the emergence of new allocation methods. Any procedures for the allocation and use of scarce resources, including frequencies, will be carried out in an objective, timely, transparent and non-discriminatory manner (paragraph 6).

Players in the radiocommunication sector are thus making increasing use of market mechanisms, such as auctions and secondary spectrum trading, in order to optimize the value of the radio spectrum. Such optimization is now becoming both necessary and sought after by public authorities for several reasons:

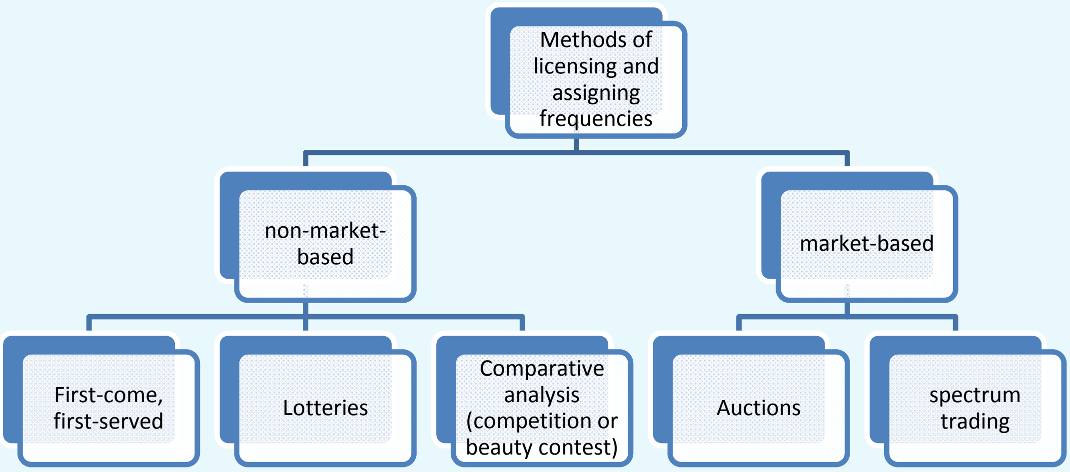
– to encourage an effective use of this resource which is not produced, is limited, and is in some cases scarce;

- the frequency spectrum has become an important means to develop countries' telecommunications;
- the budgetary income generated by the spectrum can contribute to countries' economic development;
- income from frequencies must contribute to improving the means used for spectrum management (monitoring, spectrum management information system, …) and make it possible to fund refarming operations.

2 Main definitions used

The increase in the number of competitors and requests for frequencies has led to the development of new competitive methods for allocating or re-allocating frequencies. These include lotteries, comparative evaluation methods, auctions and secondary spectrum trading. Several combinations of these methods have also been used. For example, candidates may be preselected based on a "comparative evaluation", and then participate in an auction or lottery for the definitive allocation of frequencies.

Figure 4: Methods of licensing and assigning frequencies



2.1 Lotteries

Lotteries represent a fast, relatively inexpensive and transparent means of choosing between candidates with very similar or equivalent qualifications. Lotteries should usually be preceded by an official qualification process to select candidates to participate in it, otherwise recourse to such a method could act as a brake on development of the sector. For example, participants in lotteries may not always intend to operate the telecommunication services, but may wish simply to resell the frequency licenses obtained for a profit. Moreover, some lottery winners may not have the financial resources to bring a service into operation.

2.2 Comparative evaluation methods

In using this method, the regulatory body (or other government body) decides to which entity a given frequency band is to be allocated. The method makes it possible to choose between multiple requests which are basically equivalent. It also allows the regulatory bodies to adapt specific sector objectives to the operators responsible for their realization.

Comparative evaluations come in numerous forms. In some cases, frequency licenses are issued to candidates who in principle are required to make optimum use of the spectrum in order to satisfy the requirements of the public. Comparative evaluation methods can involve various qualification and selection criteria. In most cases such criteria are published in advance, and candidates endeavour to demonstrate that their requests best satisfy those criteria.

The following minimum qualification requirements generally apply:

– justification of financial resources;

– technical capacity and commercial feasibility of the frequency request in question.

The following selection criteria deserve mention: the tariffs proposed, coverage (geographical and in terms of users), network implementation objectives, commitments regarding quality and service range and, lastly, the efficient use of the frequencies.

Some of the above-mentioned criteria are applied as qualification criteria in some cases, and selection criteria in others, depending on the country and even on the categories of service within a given country.

The comparative evaluation method has come under considerable criticism, usually with regard to lack of transparency. Even if the evaluation criteria are strict, most comparative evaluation methods have a subjective element. For this reason, they are sometimes referred to as "beauty contests".

As a result of this subjective element, regulatory bodies or other decision makers are often suspected of not being impartial in their judgments. In some cases, such suspicions have led to disputes. In others, they have had no tangible repercussions, but have nevertheless undermined the credibility of the licensing process on one hand, and of the public authorities or regulatory body on the other.

Other criticisms directed at the comparative evaluation method include the amount of time it takes to implement, due often to the fact that the painstaking evaluations of financial capacity, technical plans, etc., can take time. Lastly, they are often criticized because the selection of candidates (winners and losers) sometimes involves inappropriate or questionable regulatory intervention.

2.3 Auctions

This ancient sales and purchasing technique is linked to the history of humankind. It has been known to us since Antiquity. Indeed, the profession of "auctionator" was exercised in the Roman Empire.

In auctions, it is ultimately the market that determines the spectrum license holder. In many auctions, however, bidders pre-qualify based on criteria similar to those applied in the comparative evaluation methods. Thus, participation in some auctions is restricted to those bidders with proven technical and financial resources.

Auctions organized to allocate frequencies show that it is important to apply strict criteria at the technical, financial and commercial levels in order to determine the eligibility of bidders. Indeed, some successful bidders may subsequently find themselves unable to finance their overly ambitious bids. Other bidders may have neither the technical means nor the intention to operate the telecommunication services using the frequencies for which they made a bid which was ultimately successful.

Various types of spectrum auction exist, the most common being:

– single round or simple (open or closed) auctions; and

– multiple round (successive or simultaneous) auctions.

The first spectrum auctions (UHF TV) were organized in New Zealand in December 1989. A distinction is usually drawn between four standard auction formats. In reality, however, numerous combinations are possible (see below).

Note: according to the OECD report DSTI/ICCP/TISP(2000)12/FINAL of 17 January 2001, it is important to stress that the difference between auctions and comparative selection procedures is not as marked as it may seem at first sight. Auctions may still require participants to satisfy a certain set of technical and service parameters. Similarly, one of the criteria in a comparative selection procedure can be a monetary one. When using a precise set of measurable and enforceable criteria with weighted valuation to each criterion, comparative selection procedures can deliver the right incentives to disclose private information and as such are very close to an auction. The main difference between the two allocation methods arises from the emphasis they give to the price mechanism. In an auction, competitive bidding is pivotal, in a comparative selection procedure it is not. A report on the theory of auctions is contained in Annex 1.

2.4 Secondary spectrum trading

Secondary spectrum trading is a market-based mechanism whereby the purchase and sale of equipment licenses or spectrum utilization (with associated rights and obligations) previously allocated by the spectrum manager can take place between different parties for a given fee. This operation may be effected directly between parties or via an intermediary. Spectrum trading was firstly proposed in 1959 by Ronald Coase where he suggested that spectrum assignments should be treated in a way similar to property rights.

3 Institutional, legal and economic challenges

3.1 Taking account of the institutional context

In most countries, the radio-frequency spectrum is the property of the State. Thus any spectrum occupancy for non-governmental activities is considered to be private occupancy.

Belonging as it does to the public domain of the State, the spectrum must be managed in the interests of the national community as a whole.

In a number of countries, for political reasons, the radio-frequency spectrum was, or is still, managed by different regulators. In the 1990s a strong consensus arose between politicians, discussion groups and manufacturers on plans to establish a single regulator. There was convergence of media and technologies, and regulators had serious difficulties on a number of issues in terms of coordinating their approaches without encroaching on the activities of other bodies. This led to a broad discussion on the law concerning regulation and the institutional framework that could promote a dynamic and competitive market while guaranteeing public policies based on broader objectives. It was in that context that most countries established a single regulator with authority covering the entire radio-frequency spectrum irrespective of the user.

Case of the United States: the former foray of American economists into debates on the radio-frequency spectrum may be explained historically by the specific characteristics of the institutional environment in the United States. In that country, the spectrum became a public resource in 1927. Nevertheless, with the exception of a few users responsible for the State's regalian functions (defense, police and various public services), spectrum users have always been private entities (radio, television companies, telecommunication operators, electricity companies, etc.) (BENZONI, 1990).

Case of Cote d'Ivoire: "Enjeux des réformes du secteur des télécoms", ITU Telecom World (Dubai,17 December 2012).

3.2 Definition of utilization rights and property rights

Over the past 20 years, the increase and acceleration in the regulatory reform of telecommunications has served but to aggravate the scarcity of the radio-frequency spectrum. New opportunities emerge. Demand for frequencies multiply to such an extent that States find themselves obliged to change the rules of allocation.

Faced with the escalating demand, new allocation procedures have been tried out as much in order to avoid arbitrary discretionary decisions as to avoid saturation of the administrative services responsible for examining the files or interviewing candidates.

The methods used include drawing of lots by lottery, auctioning to the highest bidder and, lastly, the allocation of frequencies without first deciding how they are to be used by those who acquire the utilization rights. These mechanisms partly echo the reflection that has taken place since the early 1950s.

3.3 Economic valuation of the spectrum

The radio-frequency spectrum is a resource that is limited and scarce in some cases. The main objective of the manager is to achieve both optimum spectrum occupancy and effective use of frequencies. The initial problem of allocation of the resource thus involves rivalries between private players working in a market environment to obtain access to a public resource.

The government decisions taken on the supply of the radio-frequency resource involve stakes made all the higher by the fact that those decisions have a considerable bearing on the structure of competition in user sectors.

This spectrum saturation provoked by demand from markets for uses that are increasingly liberalized is not as pronounced in the developing countries. Indeed, the liberalization of uses on the spectrum market is recent in the developing countries, and is taking place in a steady and controlled fashion.

Historically, arbitrations concerning this resource have almost exclusively involved public bodies with no a priori market vocation. The challenges related to this resource have therefore not been tackled as market-related issues. Assessment of the quantity of frequencies available and optimization of the management of this resource have therefore always been dealt with from the technical viewpoint. Determination of the nature of the resource, its classification, and structuring of the bodies responsible for its allocation fell within the legal domain. Decisions concerning the uses and users of the resource were the fruit of political debate.

Thus regarding these three areas – technical, legal and political –, technical literature on the spectrum is abundant, whereas economic studies remain relatively few. Economic analyses have only recently entered into the debates on frequency allocation.

Significantly, certain Anglo-Saxon countries like the United Kingdom, New Zealand or the United States that have been the most precocious in introducing privatization and competition for audiovisual and telecommunications are countries with the greatest volume of economic literature on radio-frequency resources.

Moreover, economic literature has particularly recognized the importance of a famous article written by Ronald Coase in 1959. According to him, spectrum should be allocated by market mechanisms like any other resource, by creating rights for the use of spectrum and selling those rights by auction or secondary spectrum trading.

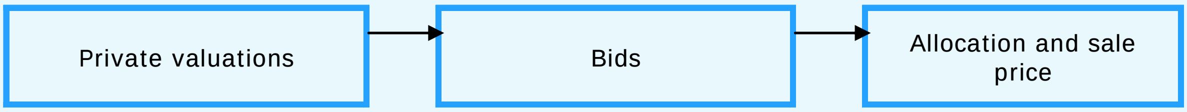
Coase considered that if the initial division of property rights did not result in the optimum allocation of frequencies, transactions would take place on the market until all viable services were implemented under acceptable conditions. He maintained that auctions ensure that spectrum falls to those who maximize its value. The positive theoretical effects are twofold: the more efficient use of frequencies through revelation of the private valuation of its price, and maximum optimization of spectrum access.

4 Guidelines for organizing spectrum auctions

Auctions are a form of spectrum pricing (associated with a frequency assignment mechanism) in which equipment licenses or spectrum rights are assigned to the winner(s) on the basis of price. In some countries, other factors are taken into consideration: quality of service, speed of roll-out and financial viability may be taken into account, either in the assessment of the bids or as pre-selection criteria.

Figure 5 below illustrates the operating principle of an auction. In a world of perfect information, the higher the number of participants, the higher the sales price. The sale price is equal to the expectation of the highest private valuation.

Figure 5: Operating principle of an auction



During the auction, participants indicate the amount they commit to pay to acquire the object for which the auction is organized. The amount may be indicated in a sealed envelope, orally in public, by fax, by Internet, etc.

4.1 Applicability of auctions: advantages and disadvantages

The objective of most spectrum auctions is two-fold: (1) economic efficiency/revenue maximization; and (2) spectral efficiency/social value – awarding spectrum to those who are best able to use it and impact the society positively. To allocate frequencies by auction offers several potential advantages. It gives rights to those users that accord them the greatest value.

Nevertheless, different countries will also have a certain number of spectrum management objectives, which auctions by themselves will not adequately address. Realization of those objectives often calls for recourse to other measures such as regulation, the determination of licensing conditions, standard-setting, etc.

Each administration will have to consider its priorities and decide whether auctions are suitable in the light of their different objectives. If the administration opts for auctions, it must not overlook the fact that in general, the greater the number of regulations, conditions or restrictions applicable to use of the spectrum auctioned, the lower the revenue from such auctions.

The administration would therefore be well advised to examine the advantages and disadvantages of auctions in the light of its priorities. It may for example decide to limit the supply of frequencies in order to increase revenue from the auctions. There is nevertheless a choice involved, in that to restrict the supply will limit the range of services offered to consumers and result in higher consumer prices, and consequently an overall loss of economic efficiency.

Auctions are applicable only when the demand for spectrum exceeds the available supply. Depending on a country's level of economic development, modernization of its communication infrastructure, the level of its investments, and the restrictions which may be imposed on foreign shareholdings or foreign trade for the provision of services involving the use of the spectrum (and other factors), it may not be in an administration's interest to put a portion of the spectrum up for auction.

In general, the higher the level of development of the economic and communication infrastructure, the more favorable the conditions for investment. In addition, the fewer the barriers to foreign shareholdings and foreign trade, the greater the demand for spectrum access, which will act as an incentive to competition at the auctions and boost the State's revenue.

Auctions nevertheless encourage the most profitable uses of spectrum, but discourage uses – which may be just as valid - that do not satisfy profit-making criteria, as each player pursues only those opportunities that are the most profitable and are the only ones exploited even if they do not correspond to the specific requirements of users (SM Report, 2005, page 24).

In addition, when some bidders overestimate the value of the lot, the winner may well be the most optimistic but not necessarily the most skillful in assessing the value of the lot. In a sealed-bid auction, auction proceeds may be reduced as bidders attempt to minimize the effects of this type of auction. These distortions can be reduced or eliminated by organizing multiple-round auctions.

Auctions are commonly considered to have the advantages of economic efficiency, transparency and speed compared to alternative assignment methods and also to capture the market value of spectrum rights for the administration holding the auction. They can nevertheless give rise to anti-competitive outcomes, for example if they result in large operators acquiring an undue concentration of part of the available spectrum. Various safeguards against this can be introduced, such as restrictions on the amount of spectrum a bidder may win or the prevention of hoarding, by obliging the winning bidder to use the frequency awarded.

By determining the eligibility of bidders in advance, it is possible to ensure that they have the technical and financial capacity required for the swift and efficient introduction of the services. The steep investments required in order to win an auction may be regarded as providing the equivalent in terms of incentive to introduce the infrastructure and services swiftly, as the sole means available to the successful bidder to recover the investment made in the license rights. A further argument in favour of auctions is that they provide the public with the highest "rent" for use of the public resource. Governments can use the revenue from the auctions to offset deficits and respond to other public priorities.

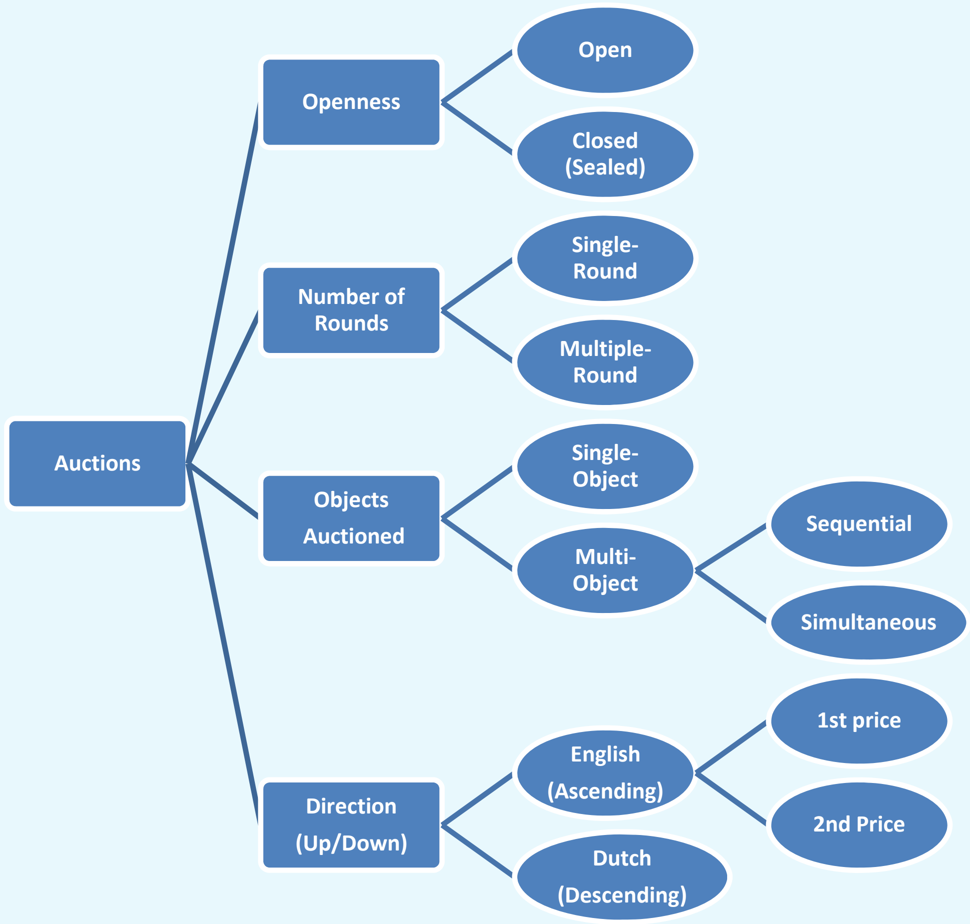
Advantages	Disadvantages
Relative maximization of revenue for the government Optimization of spectrum (economic efficiency) Opening up to competition Relative speed of process Transparency	Limited technical requirements Does not necessarily achieve the highest social value. A poorly qualified candidate may win the license Successful candidate may overbid (the so called "Winner's curse"): uncertainty regarding the demand, tariffs, etc. Possibility of collusion during the bidding

4.2 The different types of auction

An auction generally means the sale of a product, service, or commodity to the highest bidder. The term also refers to any form of sale involving a competition to determine the future owner of the item for sale through successive bidding.

There are several factors that should be taken into account to help identify/design a specific auction. Figure 6 illustrates such key factors in a tree representation format. A combination of the terminating nodes/leaves in each branch in this tree could constitute a valid auction type that will be elaborated on hereafter.

Figure 6: Main factors identifying the auction type



Auctions may consist of numerous combinations. In the following we describe the basic auction types along with the most common ones.

4.2.1 Open auction (public bids)/Closed auction (sealed bids)

In an open auction, the highest bidder always wins. This makes lower bidders reluctant to spend money in order to participate if higher bidders are likely to be present. In a closed (sealed bid) auction, the higher bidders have an incentive to minimize the amount, which favours lower bidders.

An essential advantage of open bidding is that the bidding process reveals information about valuations. The advantage of a sealed-bid design is that it is less susceptible to collusion; open bidding allows bidders to signal through their bids and establish tacit agreements.

4.2.2 Single-round/multiple-round auction

In a single-round auction, bids are called once and the auction is executed in one stage. Multiple rounds imply having a series/sequence of bids until the auction stops.

4.2.3 Single-object/multi-object auction

Bids can be made for one (single-object) or more (multi-object) lot(s) or license(s). For the latter case, the auction can be conducted sequentially (bidding for one license at a time) or simultaneously (bidding for multiple licenses at the same time).

4.2.4 Sequential/simultaneous open auction

– In order to calculate their bids, prospective buyers in sequential auctions have to guess the outcome of later bidding, which considerably complicates their task. In simultaneous auctions, more information is circulated and this enables bidders to pass from one license to another. They thus have a wider margin for maneuver and more information.

– Simultaneous auctions tend to encourage collusion, since bidders can raise their bids for some licenses in order to penalize those who fail to respect the agreement or to indicate which license they want. Simultaneous auctions are more difficult to organize. Sequential auctions have been widely used in practice and their success is thus more assured.

– Sequential auctions of identical items have resulted in the well-known "declining price anomaly" (cf. McAfee and Vincent, 1993). Prices of identical items follow a declining curve. During simultaneous bidding, it has generally been noted that similar licenses attain (more or less) the same price, which is what is expected. Sequential auctions thus have certain drawbacks that are not associated with simultaneous bidding.

4.2.5 English (ascending) auction

Potential buyers or bidders are convened by the seller who conducts the sale. The seller announces the starting or "reserve" price, and interested bidders call a price which must be higher than the preceding one and involve not less than an established minimum price increment. The process of elimination ends when only one bidder is left.

However, there are two possible prices payable by the bidder:

– First price – the highest bidder pays the highest price offered during bidding; or

– Second price – the highest bidder pays a price equal to the highest bid among the bidders eliminated.

4.2.6 Dutch (descending) auction

The seller announces a price higher than the likely maximum offer and reduces it progressively until a potential buyer accepts. That bidder pays the price reached at the moment when the descending bidding process stops (first price). Two things distinguish the "Dutch" auction: 1) bids from other bidders are not disclosed; 2) this type of auction can be completed very quickly.

Combinations of the above basic auctions are commonly used as follows:

4.2.7 Single-round/ sealed bid/ first price auction

Each bidder makes an offer to the seller independently, in an envelope or electronically, and the seller considers all offers. The item goes to the highest bidder, who pays the proposed amount. The process is "static" because there is only one round. A feature of this system is the fact that the bidder gets no indication of the bids made by other bidders. This is the classic bidding procedure for public markets.

4.2.8 Single-round/ sealed bid/ second price auction

Based on the procedure described in the preceding paragraph, the item for sale goes to the highest bidder, who pays the amount offered by the second highest bidder. This is also a static procedure of one round, with no signals given by bidders ("Vickrey Paradigm").

A variant of the single-round (second price) auction system is proxy bidding, in which the winning bidder pays the amount of the second highest bid plus a defined supplement, but in this case the bids are not sealed.

4.2.9 Simultaneous/ multiple-round/ ascending auction

Launched for the first time by the Federal Communications Commission (FCC) in the United States, this type of auction involves several rounds of bidding for a number of lots simultaneously. The simultaneous multiple-round auction has become the most widespread method. Even though different variants may exist in different countries, this method generally involves a simultaneous call for bids. The call remains open for as long as acceptable bids are made for any of the licenses. "Rounds", i.e. a series of consecutive bids, are organized for each license. The results of each round are announced to bidders before the commencement of the following round.

In the course of the rounds, the bids continue to increase until the highest bidder is determined for each license. At the beginning of each round, bidders receive information on the eligibility of the bidder to submit bids and on the highest bid for each license. In general, new bids on a given license must top the last highest bid by at least the minimum increment set. In some cases, bidders have the possibility of withdrawing bids made in a previous round, but this is usually subject to a penalty. "Activity rules" may penalize inactive bidders, by reducing their "eligibility points". The rounds continue until there are no more bids for a license.

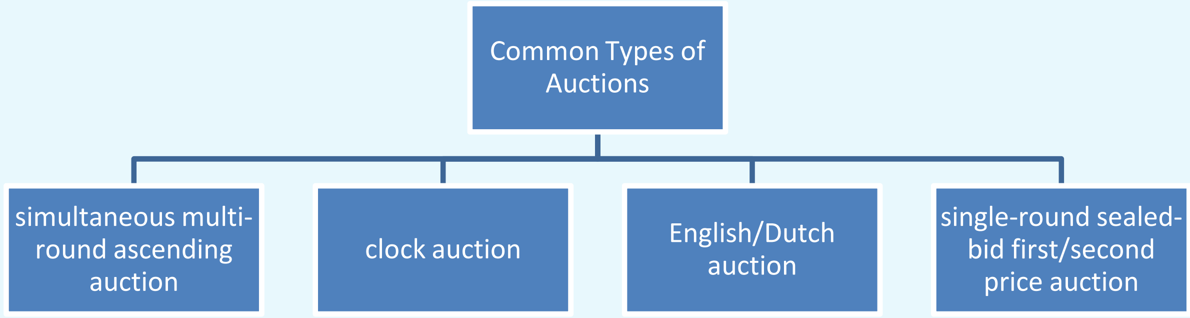
In principle, the simultaneous multiple-round auction is computerized, allowing the bids and other information on the auction to be displayed and calculations to be effected rapidly. Bids are usually encoded for security purposes and submitted electronically. Auctions may be held over the Internet, using public key infrastructure encrypting and digital signature techniques to protect the integrity of the bids.

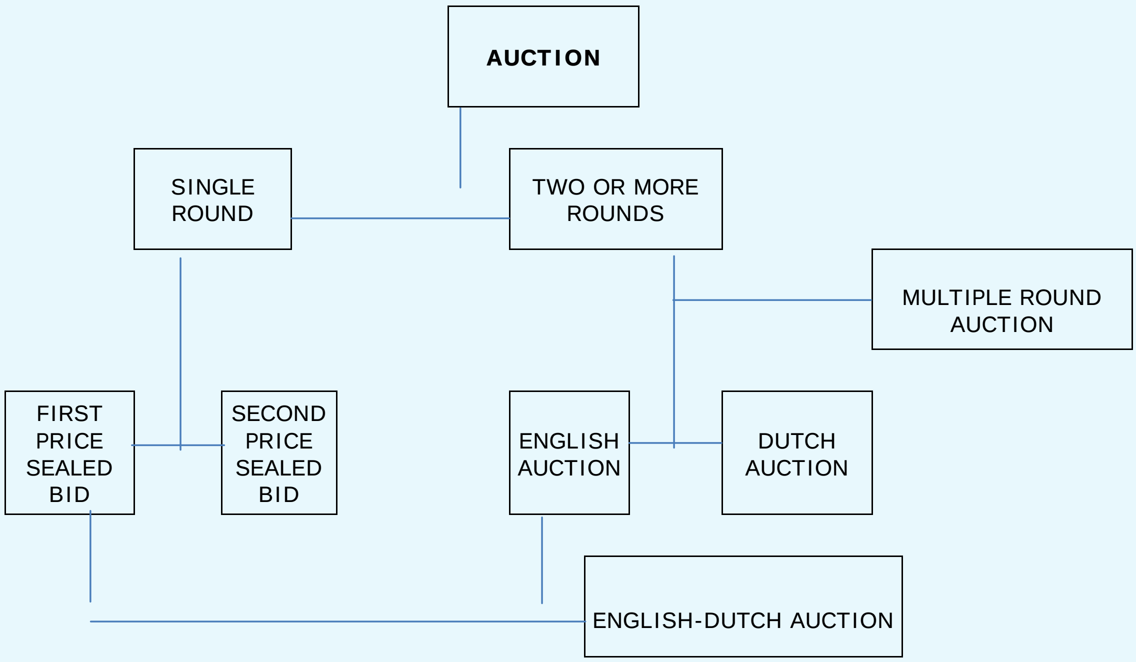
4.2.10 Clock auction

Clock auctions, which can be used for ascending bid or descending bid systems, is the most widely used method in sales of multiple homogenous units. For each category of lot a clock price is fixed for a set period, and ascending or descending bids in multiple rounds stop when the bid matches the price sought. In a variation of this method, bidders pay the same amount for all categories of lot. Other variations are also possible. Australia's ACMA in November 2011 announced that a "combinatorial clock auction" (CCA) would be used to allocate radio spectrum in the 700 MHz band. The CCA applies an optimized algorithm to determine the winners and the prices[1].

[1] www.acma.gov.au/Industry/Spectrum/Digital-Dividend-700MHz-and-25Gz-Auction/Reallocation/combinatorial-clock-auctions-reallocation-acma

Figure 7: Common types of auction





Remarks:

- The most widely used auctions for spectrum sales are simultaneous multi-round ascending auctions. They involve several rounds. At each round, each buyer can bid for one or more items. A ceiling can be set for the number and type of items for which bids can be made (rule of admissibility), the usual reason for this being the wish to avoid excessive concentration. There may also be a threshold (activity rule) with a view to ensuring that the auction proceeds as quickly as possible. A bidder contravening this rule is eliminated. Once bids have been submitted, the seller ascertains the winners on the basis of the highest bid for each item. The auction ends when no valid new bid is made. In that case, the bidder making the highest bid for each item gets the item and must pay the amount of his or her bid.

- Where there are m identical licenses and n potential buyers who can purchase not more than one license each, English auctions can be held to eliminate all buyers except m+1, sealed first price bidding then being conducted with the m+1 remaining potential buyers. This system combines the advantages of the ascending bids method, i.e. mitigating the "winner's curse" (excessive price estimates in bidding), with those of a single-round system (prevents collusion).
- "All pay" auctions: The authority may decide that each bidder has to pay an amount determined in advance for the right to submit an offer. This condition may be applied to all the types of auction described above.

4.3 Pre-auction requirements

All the rights and responsibilities related to the spectrum auctioned should be defined in advance so that bidders are not faced with uncertainties that may significantly compromise their ability to bid rationally and considerably increase the risk that the auction is unsuccessful. This obviously means that administrations intending to organize auctions must be in a position, both legally and politically, to develop the license definitions, terms, conditions and policies before they know to which users the licenses will be awarded.

Similarly, the rules and procedures governing the auction must be known to and clearly understood by all participants before the auction commences. Any administration planning to organize spectrum auctions should consult the relevant documentation and review the experiences of other countries, drawing both inspiration from that experiences as well as lessons based on the problems faced in organizing auctions.

Depending on the complexity of the auction, it may be best to opt for an automated auction system. This will require a technical infrastructure to organize the auction. It may also require a certain level of education and training for spectrum managers and potential bidders, to ensure that their knowledge of the matter is sufficient.

Depending on the policy followed by an administration regarding competition for the services using the spectrum, it may be important to take into account the possibility of dominant market position. The competition policy and license conditions, as well as the rules and procedures governing auctions, must be examined to ensure that they do not produce unacceptable results.

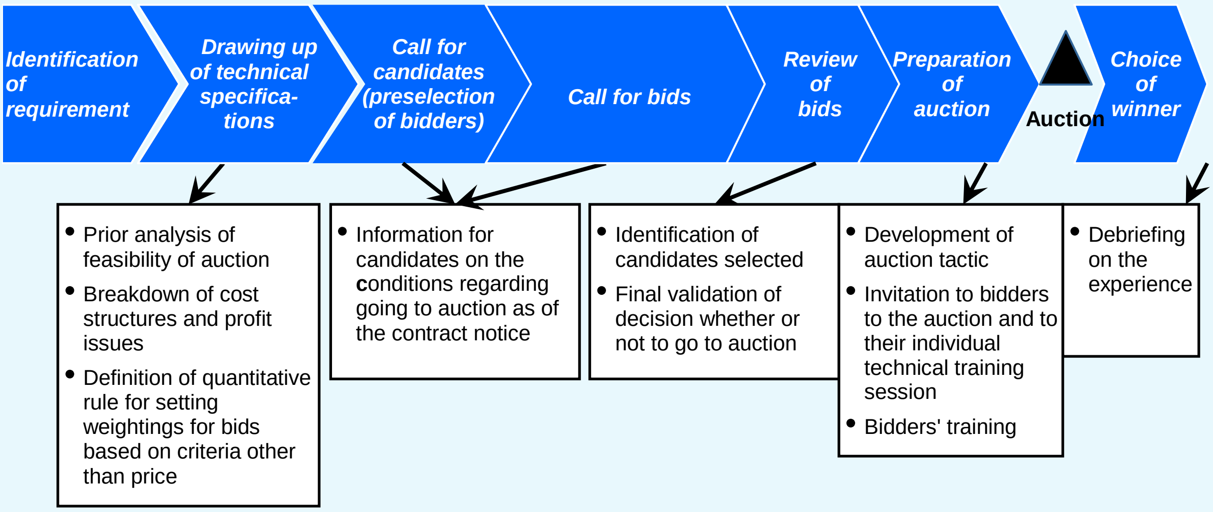
Before participating in a frequency auction, bidders will want to know the degree of protection against harmful interference they may expect with the spectrum that is auctioned, as well as the measures they are expected to take to avoid causing harmful interference to other users or suffering such interference. They will also want assurance that the State will ensure that this regime for protection against interference is properly enforced.

It is to be noted that the quality of an administration's database on licenses and their holders, as well as the administration's ability to monitor use of the spectrum on one hand and impose meaningful penalties on those causing harmful interference on the other, determine the administration's ability to protect the rights or privileges of spectrum users and consequently affect its ability to organize successful auctions.

4.4 The auction design

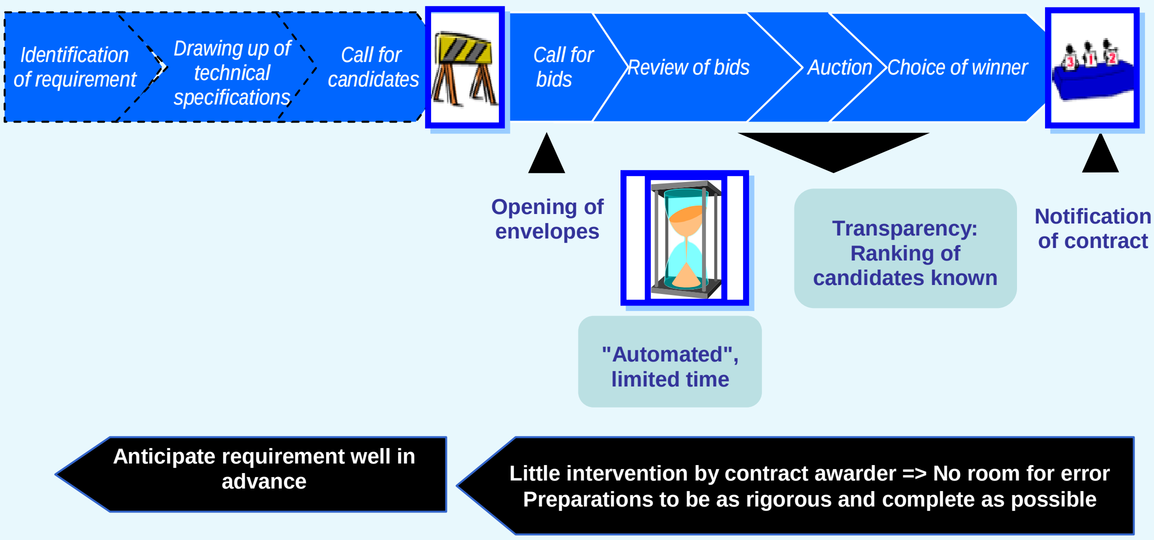
Auctions enable market forces to determine who will have access to spectrum resources and, indirectly, the purposes for which they are to be used. The authorities have to design auction procedures that provide an effective commercial means of awarding spectrum licenses based on a fair and transparent process that prevents collusion and corruption. The aim of the authorities is to choose the best formula for auctioning available frequency capacity in the light of the prevailing economic climate. As the theoretical and practical aspects of auction design are constantly evolving, the authorities should always be examining new concepts and adopting them where appropriate. The decision to hold an auction, and preparations for it, must be made well in advance.

Figure 8: Preparatory stages for auction



The success of the auction depends mainly on the performance levers activated prior to the call for bids.

Figure 9: Anticipation of requirements and award of contract



A number of strategic decisions have to be taken in designing auctions, including: the licenses to be auctioned (frequency bands, frequency blocks); license conditions (coverage areas, places of operation, license period); initial submission for each license; changes in auction rules; admissibility criteria (guarantees, auction fees); procedures for participating in the auction (setting a reserve price); and a timetable for license issue and payment).

In order to ensure that licensees can continue to adapt their services rapidly and efficiently to changing consumer demand, auctions must be as flexible as possible to ascertain the services proposed by bidders and the technologies they intend to use (technical specifications, set up, a posteriori supervision).

Designing an auction must take account of the following:

1) Publication of a consultation paper giving exact dates of the relevant stages and ALL obligations and constraints. Details of design, rules and characteristic of the auction must be reviewed in the public consultation exercise to be conducted before any actual frequency auction and all policy framework documents and license issue documents.

2) Deadline for submission of comments (including publication)

3) Possible second period for submission of comments

4) Formulation of general policy. Final decisions published after review of opinions expressed.

5) Submission of bids

6) Publication of list of applicants

7) Start of qualification evaluation process

8) Publication of list of qualified bidders

9) Start of the auction process

10) Completion of auction process (publication)

11) Issue of licenses

12) Payment for licenses

Note:

a) If legislation allows (secondary spectrum trading), available licenses including those abandoned after the closure of bidding can be auctioned at a later date or sold by some other means.

b) A bidder obtaining a license and failing to comply with the payment schedule may lose the license and be liable to a fine.

4.4.1 Qualification criteria

In most of the cases, auctions are preceded by a qualification process wherein applicants are pre-screened versus specific criteria to assess their readiness and eligibility to enter the bidding process. This phase is similar to the "beauty contest" mechanism. Some common qualification criteria include:

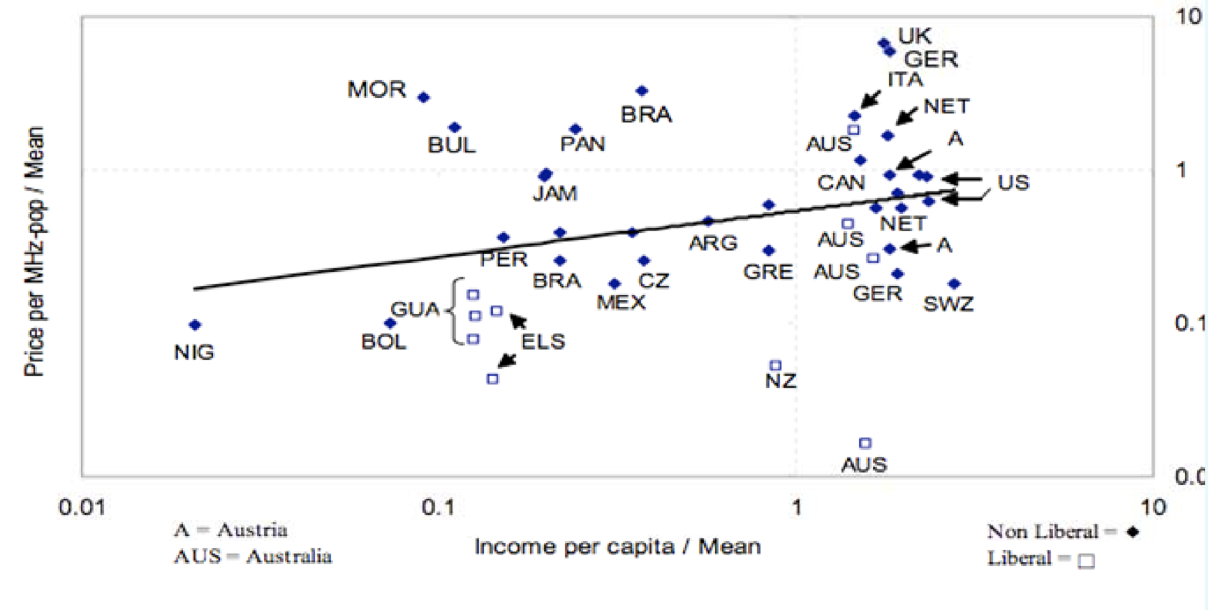
- Applicant experience/expertise: Experience in the country, years of experience, relation with other stake holders, customer care.
- Service characteristics: Type of service, quality of service, pricing model.
- Economic impact: Competition, new entrants, spectrum efficiency.
- Financial aspects: Business plan (solidity and credibility), performance guarantees.
- Technical aspects: Project technical quality, coverage plan, roaming plans, network capacity, MVNO access, site sharing.
- Others: Environment issues, impact on employment, project management, clarity of proposal.

4.4.2 Price determinants

There are numerous price determinants:

- Allocation mechanism: auctions, comparative submission, etc.
- Quality of institutions: transparency, integrity, etc.
- Number of licenses
- Situation of financial markets
- Business plan, demand outlook
- Frequencies (availability and fees)
- International access and long-distance infrastructure
- National roaming
- Interconnection (tariff framework)
- Universal service (obligations and contribution)
- Rights of way
- Exchange regime/taxation
- Country risk.

Figure 10: Correlation between sale price and income per capita



Source: *Thomas Hazlett, Property Rights and Wireless License Values, 2004.*

Figure 11: Examples of 3G spectrum prices

Country	3G Holders	Price per licence (EUR)	Spectrum FDD + TDD	Method
Denmark	TDC	0.127 billion	2x15MHz + 5MHz	Sealed bid process
	Telia Denmark	0.127 billion	2x15MHz + 5MHz	
	Orange	0.127 billion	2x15MHz + 5MHz	
	H3G	0.127 billion	2x15MHz + 5MHz	
France	Orange France	619 million, plus a 1% tax on UMTS revenues	2x15MHz + 5MHz	Beauty contest
	SFR		2x15MHz + 5MHz	
	Bouygues Telecom		2x15MHz + 5MHz	
Germany	Vodafone D2	8.4 billion	2x5MHz + 5MHz	Auction
	T-Mobile Deutschland	8.5 billion	2x5MHz + 5MHz	
	E-Plus	8.4 billion	2x5MHz + 5MHz	
	O_2 Germany	8.4 billion	2x5MHz + 5MHz	
	Mobilcom*	8.4 billion	2x5MHz + 5MHz	
	Quam (3G Group)	8.4 billion	2x5MHz + 5MHz	
Italy	TIM	2.417 billion	2x10MHz + 5MHz	Hybrid: auction and beauty contest
	Vodafone Omnitel	2.448 billion	2x10MHz + 5MHz	
	Wind	2.427 billion	2x10MHz + 5MHz	
	ISPE2000	2.442 billion	2x15MHz + 5MHz	
	Andala (H3G)	2.427 billion	2x15MHz + 5MHz	
The Netherlands	KPN Mobile	0.7 billion	2x15 MHz +5MHz	Auction
	Vodafone (Libertel)	0.7 billion	2x15 MHz +5MHz	
	Orange (Dutchtone)	0.4 billion	2x10 MHz	
	Telfort	0.4 billion	2x10 MHz	
	T-Mobile Netherlands	0.4 billion	2x10 MHz	
Spain	Telef–nica Moviles	0.13 billion	2x15MHz + 5MHz	Beauty cont est
	Vodafone Spain (Airtel)	0.13 billion	2x15MHz + 5MHz	
	Amena	0.13 billion	2x15MHz + 5MHz	
	Xfera	0.13 billion	2x15MHz + 5MHz	
The UK	Vodafone UK	9.85 billion	2x15MHz + 5MHz	Auction
	O_2 UK	6.65 billion	2x10MHz + 5MHz	
	Orange UK	6.75 billion	2x10MHz + 5MHz	
	T-Mobile UK	6.61 billion	2x10MHz + 5MHz	
	Hutchison 3G UK	7.23 billion	2x15MHz	

Average value: 23 euros/MHz/pop

Average value: 10 euros/MHz/pop

Maximum value: 106 euros/MHz/pop

Average value: 3.2 euros/MHz/pop

Maximum value: 164 euros/MHz/pop

Source: IDATE

3G auction: evident over-estimation in the case of the United Kingdom and Germany, the BT license lost 75 per cent of its value between 2000 and 2005 (FRENCH 2009)

In 2003, the O2 license lost 47 per cent of its value in relation to its initial sale price.

4.5 The risks: strategic tricks

These include:

– exploitation of information asymmetries or positions of strength

– signals sent over the bidding mechanism in order to lower the sale price

– English bidding (open ascending) can encourage anticompetitive practices, such as:

Entry deterrence (predation):

E.g.: Los Angeles, 1995, award of mobile license, with Pacific Bell dominant.

Collusion (signalling strategy) in order to share a contract:

E.g.: Germany, 1999, award of 10 regional licenses. Collusion between Mannesmann and T-Mobil.

E.g.: United States, 1997, the last three digits of the bids were used to signal the geographical codes of the regions sought after, producing revenue of USD 14 million versus an expected USD 1.8 billion!

E.g.: Sweden, 2009, suspicion of a "gentlemen's" agreement.

The collusion equilibrium is supported by threats of reprisal, which become void in a sealed bid auction.

The repetition of auctions involving the same participants facilitates collusion.

The OECD Recommendation on Fighting Bid Rigging in Public Procurement C(2012)115 Cor. 1 of 17 July 2012, recommends "that Members assess the various features of their public procurement laws and practices and their impact on the likelihood of collusion between bidders. Members should strive for public procurement tenders at all levels of government that are designed to promote more effective competition and to reduce the risk of bid rigging while ensuring overall value for money."

4.6 Key success factors

There are two sets of critical success factors to be considered in successful auction design. One set of factors is economic the other set is more technology related.

Economic critical success factors

- Discouraging collusion where bidders implicitly through signals or through explicit agreement fail to bid up prices. This can occur in several types including multi-unit ascending and uniform price sealed bid auctions
- Encouraging Entrants to participate encourages better prices and better efficiency in the conduct of the auction. Ascending auctions can prevent bids from occurring where potential bidders anticipate an eventual winner. Weak bidders can be excluded and strong bidders essentially joined in bidding.
- Deterring Predatory Behavior can result in weak bidders being excluded and strong bidders essentially joined in bidding. Aggressive bidding behavior can be communicated in advance, essentially disrupting the bid process in advance.
- The allocation rules must be motivating for each candidate.
- Competitiveness/free competition
- Transparency: each candidate should be able to assess in real time the efforts required (margin reduction) vis-à-vis potential profit (increased turnover).

The auction tactic must take account of competition on the market of offer and supply.

For example:

– Demand market dropping => strong competition => favour the auction approach to the security of profits (since the auction dynamic is ensured by the context)

– Reduced margins => competition less strong => favour the security of profits over the auction dynamic.

Technical critical success factors

Online capability is being used to conduct spectrum auctions. The following critical success factors for automated auction web sites have been identified.

- Site Design, Content and Support - must be clear, comfortable and easy to use, with good use of colour, typography and white space. It is important to have online support and education.
- User Services and Support - Interactive customer services and support: feedback systems, email communications and toll free support calls are basic and critical interactive customer services.
- Security - an effective encryption mechanism must be adopted by an online auction web site for exchanging information, such as login information, between the auction sites and users, in order to prevent security problems

4.7 Alternatives to auctions

The first thing to note is that it is difficult to test the main predictions of the different auction models empirically. In addition, the information elements that explain the positions taken by the bidders during an auction are multiple and asymmetric, so that spectrum auctions call rather for a "multi-criteria" approach. On the one hand, production and consumption externalities, resource characteristics, and the links between outcomes of procedures, and on the other, the technological and competitive dynamics of the markets in which the bidders are operating, market structures, stakeholders' strategies in these markets (externalities), and their performance, show that auction rules are not determined solely by information relating to the auction process itself. If we take these aspects into account, the economic effectiveness of auctions may appear low.

In this context it may be possible to suggest alternatives to the auction system. In practice the rules for awarding licenses may give importance to criteria other than selection by price and become multidimensional. For example, the EU's regulations on public markets require contracts to be awarded either to the firm offering the lowest prices, or to the company whose bid is economically more advantageous. In this case, potential suppliers are required to comply with a certain level of quality and with established technical specifications. The regulator thus has to apply a selection criterion that weights the respective advantages of the bids in terms of price and quality (value for money). This process shows that the procedures for optimizing attainment of the buyer's objectives are complex and require the buyer to dissimulate his real preferences or discriminate against suppliers offering high-quality products. As with auctions, we encounter the same difficulties arising from the multidimensionality, the role of strategic interactions, and the links between frequency allocations, the structure of the operators' market and the regulator's objectives.

Another alterative, the so-called "liberal" approach, is to assume that spectrum management may be a matter for private initiative which alone should prevail in the area of economic choices. The solution in this case is to separate the resource, i.e. the frequencies, from uses and services (i.e. production and consumption externalities). The function of the courts and of individual contracts would then be to deal with issues of interference and jamming, which would be sure to arise. Such a solution has already been partially introduced in Australia, with the Standard Trading Unit (STU). This tridimensional unit incorporates a standardized coverage area and the minimum bandwidth (spectrum map grid). Licenses are expressed in terms of STUs, without any reference to any specific technology, system or service. The Australian approach (Trading Rules for Spectrum Licenses /ACMA) shows that is possible to separate frequency management from operations and services.

Annex 2 lists some auction case studies (France, Unites States of America, Sweden, Egypt)

4.8 The lessons of international comparisons

If design of an auction mechanism is more a question of "tailor-made" than "off the peg", this is not an indictment of auctions per se, but an indication of the need for certain precautions to be taken in adapting the mechanism to suit the context.

Several failures could therefore have been avoided by taking better account of theories and through better preparation/organization.

Thus, any administration intending to carry out a spectrum auction would be well advised to consult the literature devoted to the subject and review other countries' experiences in the matter, so as to learn from their successes and difficulties in designing and holding the auctions.

Auctions are one of several mechanisms that have to be parameterized based closely on the institutional, socio-economic and financial environment!

"Clever new designs are only very occasionally among the main keys to an auction's success. Much more often, the keys are to keep the costs of bidding low, encourage the right bidders to participate, ensure the integrity of the process, and take care that the winning bidder is someone who will pay or deliver as promised." (P. MILGROM, 2004)

4.8.1 Limiting uncertainty

Before participating in an auction, bidders will want to know, for example, the degree of protection against harmful interference they may expect with the spectrum that is auctioned, as well as the measures they are supposed to take in order to avoid causing harmful interference to other users. They will also want assurance that the public administration will ensure that this regime for protection against interference is enforced.

All the rights and responsibilities related to the spectrum auctioned should be defined in advance so that bidders are not confronted with significant uncertainties that may seriously compromise their ability to bid rationally and considerably increase the risk that the auction fails. This means that administrations must be in a position, both legally and politically, to develop the definitions, terms, conditions and policies related to the licenses before they know their future license holders.

Similarly, the rules and procedures governing an auction must be known to and clearly understood by all participants before the auction commences. This means providing as much information as possible in order to limit uncertainty, ensuring that the auction rules and documentation made available to candidates are clear, and encouraging payment in stages rather than in a single amount. This gives operators more flexibility, if demand is low.

4.8.2 Simplifying the auction design

This is of particular benefit to developing countries, which can count only on their own, limited resources, have no particular experience in organizing auctions or managing scarce resources (timber, water, oil, gas, etc.), and do not have the means to take on financial experts or consultants.

Indeed, such countries generally do not have:

– a dedicated auction room;

– specialized computer hardware and software for holding multiple-round or combined auctions;

while respecting the basic principle of competition-based prices.

4.8.3 Careful regulatory preparation

Each administration should take account of its priorities and assess the overall appropriateness of an auction in the light of its various objectives.

To ensure a successful auction, it is necessary to define the legal framework as precisely as possible. This means, first, that the legal authority must specify the nature of the right auctioned (geographical coverage, available bandwidth, license duration, etc.) as well as the responsibilities attached to it (license conditions, service restrictions, equipment standards, etc.). In addition, there must be certainty that the State is both willing and able to take the necessary measures to ensure that licensees are able to exercise the rights or privileges they are awarded while also assuming the related responsibilities. Any uncertainty related to factors such as the duration of the license auctioned will create confusion and may bring bids down. The quality of the database of an administration's licenses and their holders, as well as the administration's ability to monitor the spectrum and impose meaningful penalties on those causing harmful interference on the other, all determine the public administration's ability to protect the rights or privileges of spectrum users and consequently affect its ability to organize successful spectrum auctions.

– Allow sufficient time to prepare in advance the regulatory texts governing the auction process

– Amend laws and regulations so as to define the spectrum property rights (utilization rights) as clearly and precisely as possible.

The property rights should foresee certain emission limits in the border areas covered by the license so as to allow for the management of interference problems and provide guidelines to deal with disputes.

The property rights should allow some flexibility, implying that spectrum could be exchanged, regrouped or split.

4.8.4 Introduce conditions for fair, non-discriminatory competition

The auction system is based on relatively simple and transparent rules that apply equally to all participants. To that extent they are fair and transparent. In the auction process it is the competition between operators, in accordance with absolutely clear rules, that determines endogenously which enterprises are to acquire licenses. Those rules must encompass the workings of the auction as such, as well as defining the resource to be allocated. A set of specific obligations requiring enterprises to meet certain minimum criteria, with prior and *post facto* monitoring of enterprise behaviour using competition policy mechanisms, strongly discourages strategies that are not consistent with the public interest (such as attempts to establish "niches") and limits opportunities for setting non-competitive charges.

Given that bids can be scrutinized by courts or other third parties, the final award is less likely to be subject to legal challenge than is the case of with awards following a comparative selection process. In the case of third-generation (3G) licenses, auctions have sometimes been completed very quickly, and there has been concern about possible collusion between bidders, although investigations by competition authorities have ruled this out.

5 Guidelines for the establishment of secondary spectrum trading

5.1 Operating principles

The introduction of secondary spectrum trading finds its basis in R. Coase's approach, and its justification in the economic theory of property rights.

The following main objectives are put forward:

– greater flexibility;

– greater efficiency in spectrum utilization;

– incentive for innovation and investment;

– greater competition with the entry of new players.

Technical advance and market uncertainties make strict ex ante standardization particularly delicate (in Europe, the success of GSM shields a mass of failures: Ermès, Tetra, etc.).

The plethora of innovations incites operators to choose technologies that are not necessarily similar, above all in order to offer diverse services.

– Are specifications regarding the uses of frequency bands allocated not ultimately contradictory with the convergence of voice, data and image services?

– Is the distinction between fixed and mobile still relevant (nomadic services, etc.)?

– Is the dynamic of competition (appearance and disappearance of operators) addressed properly through licenses?

This increases uncertainty; frequencies remain unused; players request frequencies but are not given them.

The challenge is to introduce some degree of flexibility in the management of licenses.

5.2 Applicability of secondary spectrum trading: advantages and disadvantages

Applying secondary spectrum trading is complex in that it is difficult to grasp and master all the relevant mechanisms in one go, so a gradual approach is required. Most countries that have allowed secondary spectrum trading in frequencies have therefore opted to introduce this mechanism in stages. It is important, first of all, to identify portions of the spectrum that are suitable for secondary spectrum trading and pose no major risks of abuse, and to establish stringent regulations. Subsequently other frequency bands can be included in the secondary spectrum trading process once those involved, in particular the regulator, have mastered the relevant mechanisms.

There are a number of arguments in favor of secondary spectrum trading, and the regulator has to focus on aspects which help to improve spectrum efficiency. This means that whatever operator is chosen in the primary award process, any other operator placing a higher value on the frequencies in question may negotiate to win back the license. If the value of a frequency is higher for a given operator, the latter will apply the necessary means to make best use of the resource in the light of the expected returns on investment. That situation is also evident in the case of a technical innovation, which a more efficient operator may seek to acquire. That may encourage the entry of new operators into the market and the use of innovative technologies. The existence of a secondary spectrum trading market may also be an incentive to an operator to make efficient and intensive use of its frequencies in order to free up a portion for sale on the market. The result is efficient use of the spectrum.

Opening up a secondary spectrum trading market may considerably alter the behaviour of operators when the primary award is made, or even in the secondary spectrum trading markets. Stakeholder behaviour in the primary or secondary spectrum trading market may be influenced by their expectations of the secondary spectrum trading market. That behaviour may be risky and undermine the potential benefits of secondary spectrum trading. The regulator must therefore be vigilant to possible instances of concentration, hoarding and speculation.

Positive introduction in some parts of the spectrum, subject to putting in place the necessary safeguards and fostering a cautious, coordinated, step-by-step approach that is nevertheless not restrictive, with exchanges of experience between countries.

Some bands should be avoided (minimum benefits with maximum risks): bands used for government, security, broadcasting or scientific purposes.

Stress the importance of harmonizing spectrum uses for the development of radiocommunications. Hence, opposition to any change of use not covered by the license without prior agreement by the regulator, and only within the framework of harmonization.

5.3 Some cases of secondary spectrum trading

5.3.1 Case of France

Like all other European States, France has incorporated in its own legislation the Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorization of electronic communications networks and services.

Article 9 § 3 of Framework Directive

Member States may make provision for undertakings to transfer rights to use radio frequencies to other undertakings.

Article 9 § 4 of Framework Directive

"Member States shall ensure that an undertaking's intention to transfer rights to use radio frequencies is notified to the national regulatory authority responsible for spectrum assignment and that any transfer takes place in accordance with procedures laid down by the national regulatory authority and is made public. National regulatory authorities shall ensure that competition is not distorted as a result of any such transaction. Where radio-frequency use has been harmonized through the application of Decision No 676/2002/EC (Radio Spectrum Decision) or other Community measures, any such transfer shall not result in change of use of that radio frequency."

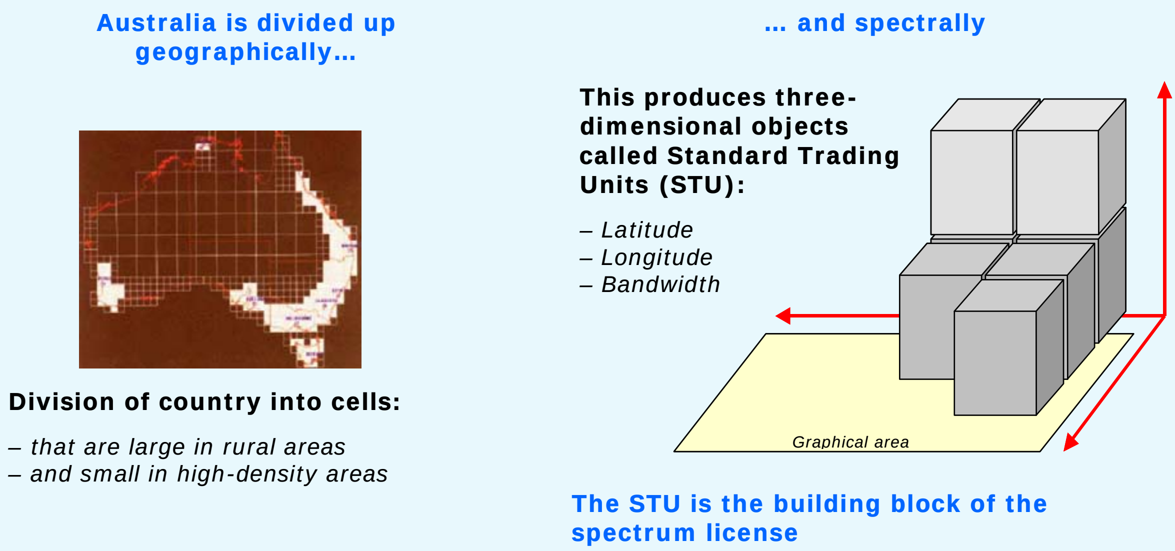
P&CE code (article L42-3): implementation of secondary spectrum trading in France

– Only frequency bands allocated to ARCEP concerned: includes radio local loop, certain professional mobile network bands, certain bands serving fixed radio-relay links, and certain bands in the fixed and mobile satellite service.
– A decree establishes the application arrangements. An order specifies the bands for which secondary spectrum trading is possible.
– The holder of the frequency utilization rights sells or leases all or part of those rights to a third party who can exploit them for the same utilization (or a different utilization in specified cases).
– Price set freely between the parties concerned
– The acquirer holds all the rights and obligations
– The acquirer is responsible for paying the fees and complying with the technical conditions for operating the frequencies up until the license expires.
– Commencement of secondary spectrum trading in France in January 2007. Transaction between the Regional Council of Alsace and the General Council of the Upper Rhine.

5.3.2 Case of Australia

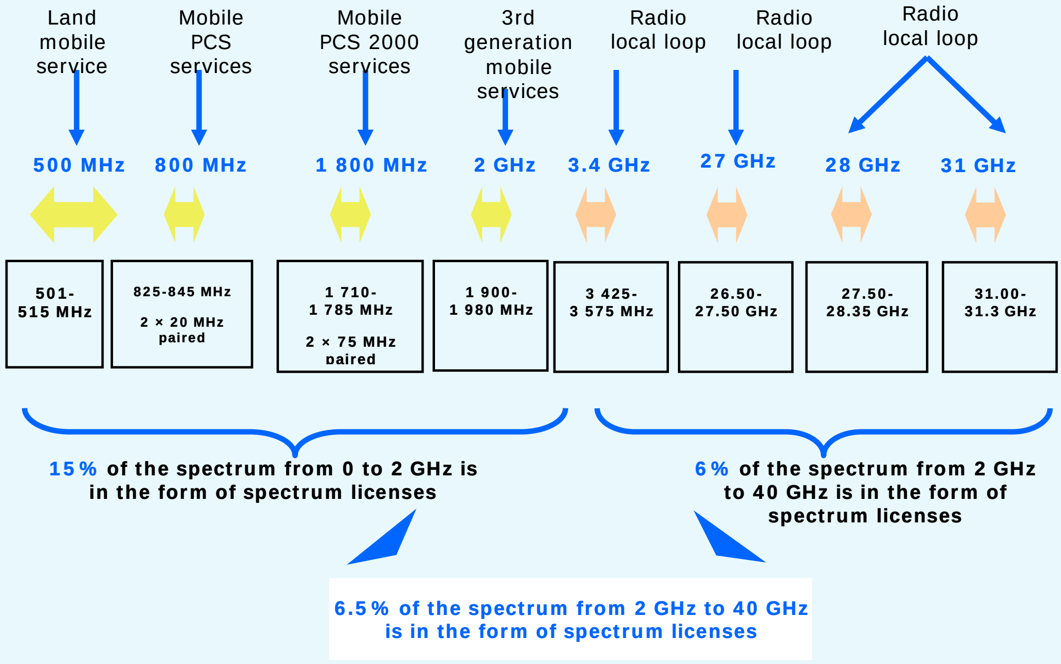
The regulator put up for auction spectrum licenses defined on the basis of the standard spectrum trading unit (STU) that may be the object of direct transactions between companies without having to go back through the allocation process centralized by the regulator.

Figure 12: Standard trading units: case of Australia

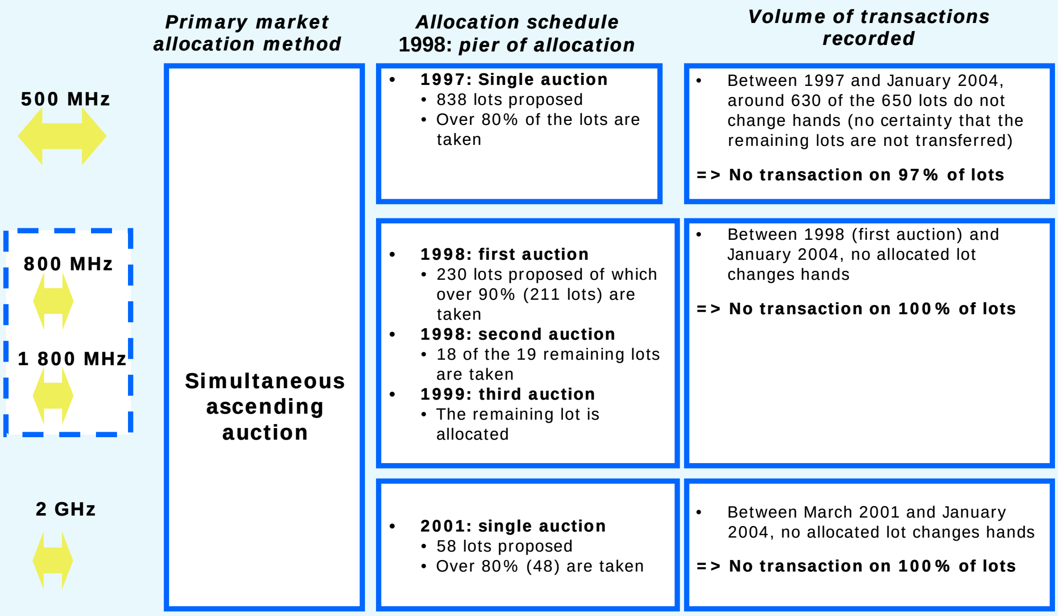


Source: ITU, 2004

Figure 13: Primary licenses and secondary transactions: case of Australia



Source: ACA, TERA



Source: ACA, TERA

5.4 The lessons of international comparisons

As with spectrum auctioning, the legal framework which underlies the ability of markets to function effectively, the clear specification by spectrum managers of rules and policies, and the legal and policy stance with respect to competition are all critical to how well a transferable spectrum property rights regime will work.

An administration considering the implementation of such a regime will wish to ensure that it has the wherewithal to continue to enforce applicable license conditions, standards and regulations once spectrum has been transferred from an original licensee to another party.

The ability of an administration to maintain an accurate license/licensee database is important in this regard, so a certain degree of administrative and/or technical infrastructure would appear necessary for a transferable property rights regime to be successfully implemented. This need is amplified if the administration intends to allow licensees to transfer their licenses not only in whole, but also in part, i.e. to allow license divisibility.

6 Synopsis of market mechanisms

6.1 Characteristics of market mechanisms

Table 1: Characteristics of different frequency assignment methods

	Lottery	Auction	Secondary spectrum trading
Applicability	Rapid dissemination of new technologies and services	Efficient dissemination of new technologies and services	– Transactions must be made in accordance with established procedures – Prior agreement of the competent authority is required
Advantages	Speed Transparency	– Price competition alone used to select licensees – Transparency and fairness – Avoids corruption and collusion – Maximization of revenues	– Spectrum efficiency: existence of a secondary spectrum trading market may encourage operators to use frequencies intensively and efficiently in order to be able to sell off part of their allotments on the market – Flexibility of frequency allocations, by establishing a direct re-allocation mechanism

	Lottery	Auction	Secondary spectrum trading
Disadvantages	Large number of applicants	– May involve high license costs, preventing rapid exploitation of spectrum, deployment of new networks and services, and inhibiting competition – Success of auction depends largely on its design	– New administrative arrangements required for resale of frequencies – Distortions in competition due to price differences between frequencies for competing services – Lack of coordination at borders
Risks	– Random selection of operators – Arbitrary prices obtained for frequencies if no reserve price set	Non-simultaneity of auctions may result in non-negligible distortions and in cross-subsidies	Speculation by licensees

7 Recommendations

7.1 Main feedback on experiences

7.1.1 Lotteries

The major advantage of this procedure is its speed. Its drawback is obvious: it attracts a large number of applicants, most of whom are motivated by pure speculation. For example, when cellular telephony licenses were awarded by the FCC in 1993 in a lottery, some 400 000 applications were received. A "minor" applicant obtained a license which was resold immediately to Southwestern Bell for USD 41 million. Following this, lotteries were abandoned and replaced with auctions. Lotteries are based on a random choice of operators, which aggravates the speculative character of the licensing process if the license can be resold or if there are no conditions regarding effective operation within an established period. For these reasons, this type of procedure has been dropped internationally in favour of auctions.

7.1.2 Auctions

The trend towards liberalization of the telecommunications sector throughout the world has only enhanced the potential benefits of a procedure allowing direct competition among operators. Auctions of cellular telephone networks have been held in most countries, involving: definition of frequency bands for specific uses; division of bands into blocks; and, in a third phase, award of operating licenses by block.

The success of the ascending simultaneous auction procedure that results from its ease of use has led to its use in many countries (United States, New Zealand, Canada Australia, Europe, Colombia). It enables the authorities to attain almost fully the following objectives:

– to encourage rapid development of new technologies and new services benefiting the entire population;

– to promote economic opportunities and competition, ensuring rapid dissemination of new and innovative technologies to the public;

– to recover some of the value of the spectrum;

– to avoid excessive concentration of licenses;

– to share out licenses among a range of diverse users.

7.1.3 Secondary spectrum trading

The objectives most often quoted in countries regarding the introduction of secondary spectrum trading are efficiency and flexibility in the use of frequencies and licenses.

In Australia and the United States, secondary spectrum trading was introduced mainly as a result of growing demand for spectrum, whereas in New Zealand and Guatemala the reason related more to the context of liberalization.

In Australia and New Zealand, secondary spectrum trading is not "liquid" (no sellers). In the United States, transactions have allowed transfers of licenses dissociated from transfers of tangible assets.

No behaviour found to involve speculation or spectrum set-aside.

The main advantage of the secondary spectrum trading procedure ultimately resides in the possibility of solely acquiring licenses, rather than license plus infrastructure => companies buy only what they require.

8 Conclusions

The technical uncertainties of the market no doubt call for the introduction of flexibility when defining future licenses: nature of the technologies used, of the services offered, and even of geographical coverage.

Faced with less stringent specifications, however, there will no doubt be a need to redefine the nature of operators' commitments:

– Lay more emphasis on controlling the means deployed (investments, OPEX, etc.)?

– Impose "review" clauses in licenses, making it possible to establish quantitative and qualitative assessments linked to possible revision of the license through dialogue or sanction?

9 References

APIE, 2011. La comptabilisation des actifs immatériels: enjeux et applications [Accounting for intangible assets: challenges and applications]. January 2011.

BENZONI, 1990

FRENCH, 2009

MILGROM P., 2004

ITU SM Report, 2005

Part II: Frequency allocation and spectrum refarming

Part II is devoted to the development of frequency allocation tables at national and regional level and to spectrum refarming mechanisms.

1 Introduction

Drawing up a national frequency allocation table is one of the first steps in the process of long- and medium-term planning. The national table has to be in conformity with ITU Radio Regulations (RR), Article 5 of which describes the Table of Frequency Allocations for the three ITU regions. The ITU Table of Frequency Allocations often contains more radiocommunication services than necessary or desirable in a national environment, and some aspects of these international regulations may not be applicable to a given country. Where a national table has been drawn up, other sub-allocations or designated uses are often made in order to group technologies or users within a given frequency band. It would be better to allow subsidiary allocations or designations for uses, rather than for users, as the latter may sometimes regard portions of the spectrum as "their" frequency bands. In general terms, use of the spectrum is more efficient when particular uses involving similar technical parameters share the same frequency band, for example, by grouping high-power applications with others of the same type.

2 Importance of allocation tables

A national frequency allocation table is the basis of efficient spectrum management. It takes the form of a general plan of spectrum use and a basic structure, ensuring efficient spectrum use and preventing interference between services at the national and international levels.

Maintaining a national frequency allocation table greatly facilitates notification of national frequency assignments for recording in the MIFR under Article 11 of the Radio Regulations.

3 Challenges of spectrum refarming

Refarming is a method whereby it becomes necessary to change the current use of spectrum including recovering spectrum from existing users for the purpose of re-assignments. Refarming is an additional tool that may assist to resolve collision with obsolete uses and make way for innovative radiocommunication services as well as for any fundamental change in conditions of use of frequencies in a given band of the spectrum. Those fundamental changes may involve:

1) changes in the technical conditions of frequency assignment;

2) changes in application (specific radiocommunication system using the band in question);

3) reallocation to a different radiocommunication service.

A major difficulty encountered by spectrum regulators arises from the reallocation of frequencies. When frequencies have been used for one purpose, sometimes for decades, it is often difficult to re-assign them to a different use. Major questions then arise as to who decides, and who is to pay the costs incurred by users in switching to new frequencies. One solution is for the regulator to set up a "refarming fund", setting aside for this purpose a portion of the revenues derived from use of frequencies.

The essential difference between administrative methods and market-based methods is the fact that with the former, the regulator takes decisions in the light of a number of competitive criteria and objectives including the logical structure of the market, financial and socio-economic criteria, and technical efficiency. The regulator's analysis must cover such factors as prices, costs, conditions for awarding licenses, withdrawals, and compensation. With a market-based approach, the criteria and analyses focus on financial and commercial factors and the decisions are the result of an agreement between two or more parties.

4 Guidelines for establishing frequency allocation tables

The radio-frequency spectrum is a limited resource and a public asset that comes under the authority of the ITU Member States; it must be managed efficiently to the maximum benefit of the community as a whole.

The spectrum must be shared in the best possible way between its different governmental, public and private users, in compliance with the international commitments agreed on by ITU Member States.

4.1 Principles of the frequency allocation table

4.1.1 Radio Regulations allocation table

Allocation of frequencies to radiocommunication services at the global level is the responsibility of ITU-R World Radiocommunication Conferences (WRC). This is codified by the Radio Regulations (RR), which is an international treaty and is revised at each WRC. ITU Member States undertake to comply with the RR Table of frequency allocation (Article 5) and other provisions of the RR when assigning frequencies to stations.

In the current ITU Table of Frequency Allocations, the spectrum from 8.3 kHz to 3000 GHz is segmented (up to 275 GHz) into smaller bands and allocated to about 40 radiocommunication services. This Table is organized into three Regions of the world and is supplemented by assignment and allotment plans for some bands and services. The radiocommunication services are identified as primary or secondary in the Table. Footnotes are used to alter, limit or change the relevant allocations.

The Radio Regulations provide the regulatory framework for spectrum use, are applicable to all ITU Member States, and form the binding basis of all national frequency allocation tables.

Note: RR Article 1 contains general and specific terms related to frequency management, radio services, stations and systems, operational terms, characteristics of emissions and radio equipment, frequency sharing terms and technical terms relating to the location.

RR Article 5 defines the ITU Regions and areas, categories of services (primary or secondary) and allocations, describes the Table of Frequency Allocations which is a part of this Article.

4.1.2 National frequency allocation table

The national frequency allocation table is a key tool in the management of the frequency resource. It identifies how frequencies are distributed among stakeholders, both government and non-government, and how they are used. In addition to honoring international agreements, the table reflects national policy on the use of frequencies in support of broader objectives for the telecommunication sector, and is the result of a planned process.

Over and above the allocations in the ITU Radio Regulations, the national table is based on:

– Final Acts of the Regional Radiocommunication Conferences

– signed international agreements or other decisions (decisions and recommendations of regional organizations);

– national agreements between the various ministries and administrations responsible for regulating the sector;

– further rules or procedures adopted by the organization responsible for frequency refarming.

4.2 Examples of frequency allocation tables

4.2.1 Case of Bangladesh

See **Annex 3**.

4.2.2 Case of Canada

See www.ic.gc.ca/spectre.

4.2.3 Case of Senegal

See www.artpsenegal.net/telecharger/document_TANAF_111.pdf.

4.2.4 Case of France

Simplified table available at: www.anfr.fr/index.php?cat=tnrbf&.

4.2.5 Case of Hungary

In 2011 in Hungary, a new project was launched called STIR (IT system supporting the frequency management activity) of which conception was first presented on the RES9 Meeting in 2012.The main goals of the system to be developed are the followings:

- to gather, organize, store and make accessible all frequency management information in the necessary form and structure in a relational database using different modern IT techniques and functions
- to conduct different analyses according to different criteria through processing the frequency management information available in the system
- to manage the legislation process such as, creation or edition of the legal documents regulating the frequency management in Hungary, furthermore, regulation of the work-flow
- to have a possibility to cooperate with other IT systems related to frequency management, especially with the ECO Frequency Information System (EFIS)
- to provide all internal (inside the Hungarian Authority (NMHH)) or external (WWW) users concerned with the necessary and structured frequency management information (bilingual data content and user interface)

It is worth mentioning that, the public procurement process has been lasting since the end of 2012, however, its successful closure is an inevitable condition in order to be able to launch the programming of the STIR. As NMHH already has the winner of the public procurement (presuming no further unforeseeable issues emerge), the programming is planned to start on 4 September 2013.

Earlier than the spring of 2014, new information on the status of the STIR project cannot be provided.

4.3 Regional harmonization

4.3.1 Importance of regional harmonization

The purpose of drawing up a "regional" frequency allocation table is to:

– help Members maintain and develop, through regional cooperation, the technological, legal and scientific bases required for optimal and secure use of the radio spectrum in all Member States and at borders;

– provide authoritative evaluations regarding the spectrum and identify areas of agreement on important issues that will help Member States in defining their spectrum policies and their national allocation table provisions.

For these and other, related activities, the regional organizations collaborate with ITU, mainly with the Radiocommunication Sector, and with other regional organizations under the terms of cooperation agreements.

4.3.2 Role of regional organizations

The goal of regional organizations is to ensure harmonized availability and rational use of the radio-frequency spectrum, where this is necessary to implement common regional policies in the field of telecommunications. They establish a framework that ensures an appropriate balance between spectrum requirements in order to implement regional community policies while taking account of institutional agreements in force concerning spectrum management and the defence of regional community interests at the international level. The need to harmonize allocation procedures at the regional level means adopting a "regional" frequency allocation table that combines the national tables.

The various regional organizations conclude cooperation agreements among themselves in order to facilitate collaboration on matters of common interest and to prevent disagreements and duplication of effort. It is noted that CITEL has concluded more than 20 cooperation agreements with organizations including ITU, the Caribbean Telecommunications Union (CTU), Caribbean/Latin American Action (C/LAA), ATU, CEPT, ETSI, Andean Community Telecommunications Enterprises Association (ASETA), and TIA.

Case of West Africa: The ECOWAS supplementary Act A/SA 5/01/07 is intended to harmonize procedures for spectrum management by Members of ECOWAS. Following its implementation, the West African Telecommunication Regulators' Assembly (WATRA) was officially set up in November 2002 to support ECOWAS in its initiatives to harmonize the policy and regulatory framework for telecommunications in West Africa (see the ITU/EU document: Harmonization of policies in the ICT market in WAEMU/ECOWAS, spectrum management, www.itu.int/ITU-D/treg/projects/ITU-ec/).

Case of Europe: Decision 243/2012/EU of 14 March 2012 established a multiannual spectrum policy programme (RSPP 2011-2015). This digital agenda confirms the wish of the Commission to pursue a policy of harmonization and greater flexibility in frequency management in the EU and maintains the ability of Member States to pursue an audiovisual policy based on the goals of diversity and pluralism.

Following Decision 243/2012/EU, the European Commission Implementing Decision 2013/195/EU defines the practical arrangements, uniform formats and a methodology in relation to the European spectrum inventory; in particular, that data should be made available by EU Member States through EFIS.

Example of simplified table:

The European Common Allocations Table (ECA Table) is integrated in the EFIS database (ECO Frequency Information System) and available at www.efis.dk .

The ECA Table contains all CEPT ECC harmonisation measures (ECC Decisions and Recommendations identifying spectrum) and the related ETSI harmonised European standards for radio services and applications. 42 CEPT countries (incl. all EU member states) are represented in EFIS and all information in the database is in the public domain and can also be exported.

A wide range of information is available in EFIS, mostly in the form of documents linked to the European Table of Frequency Allocations and Applications; among these, CEPT questionnaire summaries for dedicated spectrum inventory purposes, ECC Reports (e.g. compatibility studies) and other useful information about the actual present and future planned spectrum usage.

Figure 14: Query in the EFIS database (ECO Frequency Information System)

Frequency Range: 2900 to 3400 MHz Frequency Table: France Search

Results from the ERO Frequency Database:

FREQUENCY BAND	ALLOCATIONS	APPLICATIONS
2900.0 - 3100.0 MHz	RADIOLOCATION RADIONAVIGATION	Maritime navigation Primary radar
3100.0 - 3300.0 MHz	EARTH EXPLORATION-SATELLITE RADIO ASTRONOMY RADIOLOCATION SPACE RESEARCH (active)	Maritime radar
3300.0 - 3400.0 MHz	RADIO ASTRONOMY RADIOLOCATION	Defence systems

4.4 Recommendations

In order to ensure efficient spectrum use, minimize interference problems and avert problems of coexistence among different systems and services, spectrum management requires the maintenance and regular updating of a national frequency allocation table based on the ITU-R Radio Regulations and relevant publications of the regional organization concerned. The table sets out national use of the frequency spectrum and distinguishes between civil, non-civil and shared bands, and includes details of the frequency bands, associated radiocommunication services, and annexes containing rules for use of the frequency bands in question. It has to be approved by the national authorities.

Given the complexity of the spectrum management process and in particular of frequency assignments, automated systems are needed. These can support a number of spectrum management activities including frequency planning, allocations, assignments, and coordination.

Note: ITU Handbook on National Spectrum Management, Point 11 of Annex 2 "Best practices for national spectrum management": "Working in collaboration with regional and other international colleagues to develop coordinated regulatory practices, i.e., working in collaboration with regulatory authorities of other regions and countries to avoid harmful interference".

5 Guidelines for spectrum refarming

5.1 Principles of spectrum refarming

Recommendation ITU-R SM.1603 in recommends 1 gives the following definition: "Spectrum redeployment (spectrum refarming) is a combination of administrative, financial and technical measures aimed at removing users or equipment of the existing frequency assignments either completely or partially from a particular frequency band. The frequency band may then be allocated to the same or different service(s). These measures may be implemented in short, medium or long time-scales". Annex 1 of the Recommendation gives some guidance for national consideration of redeployment issues.

The Member States undertake continual spectrum adjustments in order to optimize spectrum occupation. More specifically, this situation is underpinned by decisions adopted:

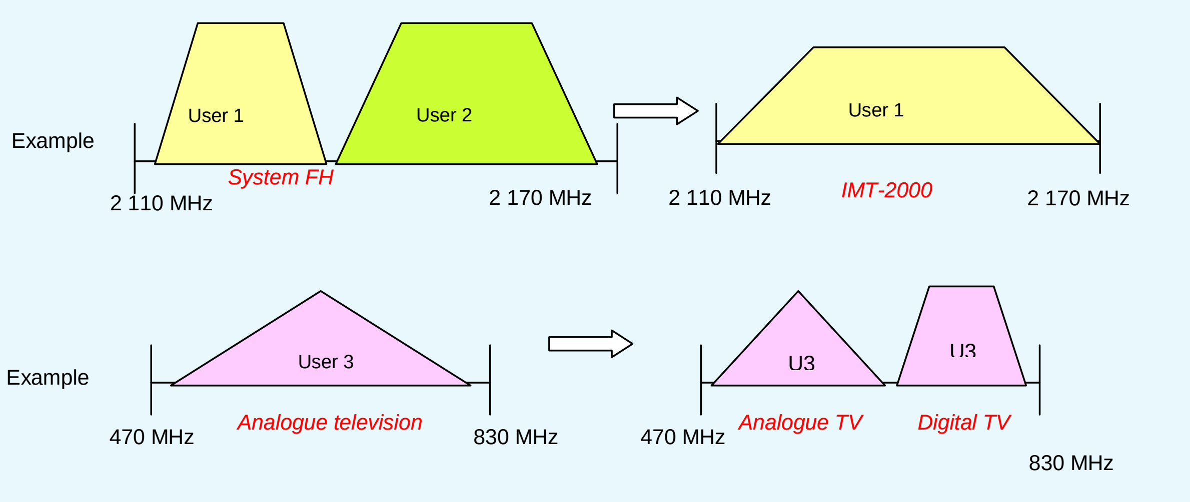
1) in connection with implementation of the ITU GE06 Plan: the transition from analogue to digital TV requires the freeing up and reallocation of certain frequency bands;

2) by WRC-12 as regards the "digital dividend": allocation for the mobile service of frequencies formerly allocated to audiovisual services. In addition, the agenda of WRC-15 includes the following items:

"1.1 to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 (WRC-12);

1.2 to examine the results of ITU-R studies, in accordance with Resolution 232 (WRC-12), on the use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and take the appropriate measures".

Figure 15: Spectrum refarming: case of France



There are basically two options available when a frequency band is to be redeployed. The choice is a matter for the public spectrum management authority, or for private bodies subject to approval by the regulator.

Table 2: Comparison of refarming processes management (ECC)

	Refarming managed by administration	Refarming by secondary spectrum trading*
Evaluation criteria	Legal Financial Political Socio-economic Technical aspects and efficiency All analyses conducted and decision taken by the public authority(ies)	Business Financial All analyses conducted and decisions taken solely by the frequency rights holder (licensee)**
Choice of refarming tool***	Incentive price for spectrum use License termination (before expiry) Voluntary license withdrawal Compensation for licensee Reassignment of equipment Other	Contract between parties**

Notes:
- * If secondary spectrum trading is authorized, conditions of use of frequencies can be changed within certain limits and according to rules established by the government.
- ** May be subject to approval by the administration
- *** Not in any order of preference.

5.1.1 Stages of refarming

– Preparatory work to assess different cost elements and establish the principles of refarming

– Estimate the costs of spectrum refarming

– Establish implementation programme

– Consultation with stakeholders

– Organize arrangements for supervision

– Monitor the implementation of refarming

– Manage the spectrum refarming fund (SRF)

5.1.2 Prospective studies of frequency values in the event of refarming

An assigning authority is responsible for allocating frequency bands at the national or international level and thus has a major asset, since a frequency band constitutes intangible capital for the assigning authority to which it is allocated. While of no value in itself, the use made of it gives it economic value.

Logically, if a frequency band is unused and no potential use can be assigned to it, its economic value is low. On the other hand, if a band is used, and if in addition there are many possible uses in the same band, its value is greatly increased.

In the context of frequency management and following a decision by a WRC or by the national frequency authority to redeploy/refarm frequency bands and/or include new services in existing frequency bands, it is essential that the assigning authority know the economic value of the frequencies in question.

Annex 3 sets out the methodology for evaluating frequency bands for redeployment.

5.1.3 Establishment of fund to finance refarming

A number of countries have put forward the idea of a redeployment/refarming fund to compensate spectrum users obliged to relinquish their frequency bands. This solution offers certain opportunities to implement redeployment more rapidly than is possible by waiting for an existing license to expire. However, creating a redeployment fund raises a number of issues that need to be considered carefully, in particular the possible assumption that the very existence of these funds guarantees compensation for any spectrum user obliged to make minor operational changes. It is therefore essential to define clearly the conditions under which compensation can be paid and to establish the appropriate practical arrangements.

The fund is managed by the spectrum management authority, which has a special budget distinct from its general budget and is able to draw on different sources. For example:

– new users might contribute to the fund collectively;

– all licensees could contribute to the fund through license fees;

– a sum could be levied on charges for spectrum use and credited to the fund;

– similarly, auctions of licenses or frequency bands are another potential source.

5.2 Cases

5.2.1 Case of France

5.2.1.1 A two-tiered process

Development and updates of the National Frequency Allocation Table (TNRBF) are proposed to the Board of ANFR by the Frequency Planning Committee (CPF).

Over and above the allocations in the ITU Radio Regulations, the national table is based on:

– The international agreements signed by France or other decisions (e.g. EU directives, CEPT decisions and recommendations)

– National agreements between the various ministries and independent administrative authorities

– Additional rules or procedures adopted by CPF.

5.2.1.2 Spectrum assigning authorities

Wholesale users: spectrum assigning authorities. The Prime Minister allocates spectrum to them based on their requirements by means of the National Frequency Allocation Table (TNRBF).

They manage the spectrum either to satisfy their own requirements (ministries), or to the benefit of operators (ARCEP) or audiovisual programme producers (CSA).

Spectrum cannot be managed by any single assigning authority.

ANFR provides a structure for dialogue (the "assigning authorities centre"), proposing the distribution of frequencies between assigning authorities, the pooling of elements common to frequency management, and intervention in cases involving conflicts of interest between assigning authorities.

Table 3: Spectrum allocation and assignment authorities: case of France

France	Frequencies used by ministries or administrations	Frequencies used for electronic communications and audiovisual transit	Frequencies used for audiovisual communication
Authority allocating frequencies (Service)	Prime Minister based on proposals by ANFR National Frequency Allocation Table (TNRBF)		
Authority assigning frequencies (Affectataires)	Ministries and administrations	ARCEP	CSA

Any assigning authority challenging a decision by the Board of ANFR can request arbitration by the Prime Minister. The Prime Minister approves the National Frequency Allocation Table by decree.

5.2.1.3 Status of frequency band allocation

Exclusive status (EXCL): an assigning authority with this status has exclusivity in the use of frequencies in this band.

Priority status (PRIO): when several assigning authorities share the same band, the one with this status has the recognized right to protect its interests in the band. It is the "coordinator" of the band.

Equality of rights (EQUAL): the assigning authority with this status shares the band concerned on an equal footing. The needs of each assigning authority must be coordinated with the others.

Table 4: Example of frequency band allocation

National footnotes (conditions of sharing)

RR				REGION 1				
REGION 1	REGION 2	REGION 3	MHz	France	Ser	Aff	Status	Notes
RADIOLOCATION RADIONAVIGATION 5.424A-5.425-5.426-5.427			2 900,000 3 100,000		LOC RNV	ARCEP DEF PNM AC ARCEP DEF PNM	EGAL	5.424A 5.425 5.426 5.427 F87
RADIOLOCATION Earth exploration-satellite (active) Space research 5.149-5.428			3 300,000		LOC asr ets res	DEF ARCEP PNM RST DEF ESP	→ PRIO	5.149 F88
RADIOLOCATION 5.149-5.429-5.430	RADIOLOCATION Amateur Fixed Mobile 5.149-5.430	RADIOLOCATION Amateur 5.149-5.429	3 400,000		LOC asr	DEF RST	EXCL	5.149

Services
LOC : Radiolocation service
RNV : Radionavigation service

Assignees
AC : Civil aviation
ARCEP
DEF : Defence

5.2.1.4 Refarming process

Refarming activities are financed by a spectrum refarming fund (FRS). The fund is managed by the National Frequency Agency (ANFR).

The fund can be fed by contributions by public authorities: annual finance law; private sector contributions to meet refarming requirements.

Newcomers to a frequency band make reimbursements in the form of refarming costs. Refarming activities are decided on a case-by-case basis: Files are proposed by the ministries and administrative authorities, and are considered by the FRS Committee, with a view to a proposal for decision by the DG of ANFR; agreements for approval by the ANFR Board.

5.2.2 Case of Japan

Refarming of the radio spectrum is the major spectrum management policy goal in Japan. In July 2003, the Radiocommunication Regulatory Council published a report "*Mid- and long-term outlook for radio spectrum use and the roles of the government – Radio Policy Vision*"). Starting in October 2003, the Ministry of Information and Communications, cognizant of new radiocommunication requirements, established a broad programme in order to develop a long-term response to these new requirements. This comprehensive frequency refarming project comprises a range of complementary measures which call for changes in legislation, major technical ground work and consultation and coordination.

This valuable experience may contribute to national discussions on frequency management and refarming[2].

6 Recommendations

In order to improve existing services or introduce new ones, it may be necessary for spectrum users to upgrade to more modern technologies or use new frequency bands. Refarming has to be planned: refarming operations should be part of any administration's national spectrum strategy, as should the means of implementation.

The main elements in designing a spectrum refarming plan are as follows:

1) Feasibility study to establish the volume of spectrum resources required and the deadlines envisaged (reasonable advance notification to allow existing and future users to anticipate and deal with the consequences).

2) Designing a traffic management and user management strategy consistent with the established objectives.

3) Designing a suitable frequency allocation strategy for the new technologies that will handle the initial traffic while freeing up the necessary spectrum resources.

4) Drawing up a new frequency plan including changes to network configurations vs. technologies and Allotment of channels in accordance with the frequency allocation strategy for the new technologies.

5) Costs of implementing refarming, which will have implications for administrations' or spectrum users' budgets.

6) Possible establishment of a spectrum refarming fund.

[2] www.rieti.go.jp/enevents/.

7 Conclusions

Spectrum redeployment is a spectrum management tool that can be used to meet new market requirements, improve spectrum efficiency or respond to changes in international RR Table of Frequency Allocations.

Spectrum planning and spectrum monitoring cannot solve all the problems of redeployment, but including the subject in any national spectrum management strategy can offer a simple way of mitigating problems arising from implementing redeployment. Frequency use plans and equipment parameters are among the important technical information which administrations and users must have in order to carry out spectrum redeployment within appropriate deadlines.

8 References

Recommendation ITU-R SM.1603-1;" Spectrum redeployment as a method of national spectrum management"*

Report ITU-R SM.2012-3: "Economic aspects of spectrum management"*

ITU-R Handbook on National Spectrum Management, Chapter 6 (2005).*

Decision 243/2012/EU.

ECC Report 16: Refarming and secondary spectrum trading in a changing radiocommunications world, 2002.

*Free copy of this document in six languages is available through ITU Publication site

Part III: Cost accounting in radiocommunications

Part III deals with the introduction of cost accounting tools in the field of radiocommunications.

1 Introduction

It is a legal obligation for businesses to maintain accounts. With the standardization of financial accounting rules, we are seeing a harmonization of the applicable laws and principles to provide a standardized picture of an enterprise's financial situation in time and space. There is also another form of operational accounting, so-call cost accounting. This is not compulsory and is an internal matter for the organization concerned. Cost accounting is understood to mean the analysis of the figures submitted in the general accounts in order to better understand the business results achieved and identify levers for growth, and is used as a management tool. While not compulsory, it is useful as an aid to decision making and can make use of a number of methods.

2 Challenges in the utilization of cost accounting for radiocommunications

Introducing cost accounting entails the development of an analytical plan based on the internal definition of structural analysis requirements. These have to be defined collectively with the involvement of project leaders, managers and financial departments.

The analytical plan must indeed not be the sole prerogative of financial departments. It is a comprehensive analysis tool for analysis over a period of years and must therefore be relatively stable to allow follow up and comparison of data. It is thus not fixed and may evolve in line with the evolution of business activities.

Recommendation ITU-D-3 (WTDC-10) in § 1 recommends that "In order gradually to introduce cost-orientated tariffs, developing country operators should be invited to develop analytical tools through the stage-by-stage implementation of a cost-accounting system."

This system enables us to record and classify different cost elements, to classify and analyse expenditure items and groups of items, to identify and classify cost and profit centres, and to attribute costs by network element or by service, thereby facilitating cost-oriented tariff setting.

3 Guidelines for the introduction of cost accounting for radiocommunications

3.1 Definitions of cost accounting

Cost accounting or management accounting is a tool derived from general accounting and comprises classification of expenditures in homogenous categories and analysis of total expenditure in terms of those categories. Some so-called "secondary" items (such as support function expenditure) are subsequently reclassified under sectoral "principal" headings (expenditure linked to production of goods and services) according to the appropriate allocation keys.

3.2 Implementation methods

A number of methods can be used to implement monitoring of costs. The choice depends on the analysis of requirements, the expected uses of the accounting tool, and the management approach adopted. The criteria of implementation cost and ease of development will also be crucial.

Standard costs method: this establishes a standard cost for a given activity based on past data and can also anticipate future credit payments. This can be used to highlight differences with previous results. This involves:

1) collecting past data;

2) establishing standard costs and unitary prices (average quantities and prices over a given period, for example);

3) adjusting these standards in line with anticipated or recorded quantities;

4) comparing findings with forecast or past results.

Variable cost method: this can be used to attribute the variable charges corresponding to each product or service and thus to determine the difference between the variable cost per product and the price charged to the user each time the service is used. This allows us to measure the user's contribution to covering fixed charges.

ABC (activity-based costing) method: this gives us a horizontal, rather than a merely hierarchical, picture of the entity, the principle being to shed light on processes and activities rather than on structure.

Full costs method: This allows us to attribute indirect expenditure in a linear manner to distribution cost centres in accordance with allocation keys (attribution of direct costs presents no difficulty), the allocation keys being determined by a financial controller in general. This variable is referred to as the allocation driver and models the behaviour of activity-related costs.

3.3 Example: France

ARCEP is able to impose obligations of transparency, non-discrimination, access, tariff controls, accounting separation and cost accounting on major operators, under the terms of the Code des Postes et CE (CPCE). Accounting separation and cost accounting (Decision 2008-0409, Articles 11 and 13) constitute two distinct requirements under European Directive 2002/21/EC and under the CPCE (Article L 38 and D 312). Furthermore the EC in its Recommendation 2005/698/EC has provided guidelines on accounting separation and cost accounting systems, and states for example that "*The purpose of imposing an obligation to implement a cost accounting system is to ensure that fair, objective and transparent criteria are followed by notified operators in allocating their costs to services in situations where they are subject to obligations for price controls or cost-oriented prices." It also recommends "the allocation of costs, capital employed and revenue be undertaken in accordance with the principle of cost causation (such as activity-based costing, "ABC")*." The European Regulators' Group (ERG) has, since the adoption in 2009 of ORECE/BREC (EC Regulation No. 1211/2009), supported this Recommendation through Opinion ERG (04) 15 Rev. 1.

The ABC ("activity based accounting") method adopted by ARCEP is based on the creation of an analytical grid of costs by activity and can be applied to establish a non-discriminatory causal relationship between costs and services/products. The regulatory system of accounting is designed and implemented so as to meet the following objectives:

1) legibility of the method so that results can be interpreted clearly;

2) reliability of results and information sources;

3) coherence of the regulatory accounting system with the operator's accounts;

4) production of financial statements in conformity with regulatory requirements;

5) auditability of system and its results.

Note: ARCEP decisions can be appealed before administrative judges (Conseil d'État) and the judiciary (Paris Court of Appeal).

4 Recommendations

Implementation in stages of a cost accounting system:

1) Allocation of direct costs to cost items:

– by applying analytical coding or

– by showing the associated production time expressed in terms of hourly labour cost and taking into account equipment used in terms of unit costs.

2) Grouping indirect costs under headings covering all the costs of providing a given service or carrying out a given function.

3) Definition of an allocation driver to measure the relationship between a given amount of service provided and the related costs.

4) Breakdown of indirect costs using the allocation drivers and allocation keys to ascertain a full cost.

5 Conclusions

Introducing a cost accounting system enables us to know more about costs and is thus a useful and durable tool for enhancing performance and decision making and thus optimizing implementation of public or business policy. The results obtained can provide global indicators of activity costs but also more specific indicators including management performance figures or service costs. In addition, powerful IT tools and financial management software can be used to establish a direct link with budget accounts.

6 References

James Brimson, Feature costing: Beyond ABC, Journal of Cost Management, 1998.

Part IV: Methods of calculating spectrum fees

The fourth and last section analyses the evolution methods of calculating spectrum fees.

1 Introduction

For any resource, including the radio-frequency spectrum, the main economic objective is to maximize the net benefits for society that can be derived from the resource, so as to ensure that the resources are allocated efficiently and bring the greatest benefit to society. Prices are an important means of ensuring that spectrum resources are used efficiently by users.

The major objectives of charging for spectrum use are to:

– cover the spectrum management costs incurred by the spectrum management authorities or regulators;

– ensure efficient use of spectrum management resources by providing adequate incentives;

– maximize the economic benefits for the country and free up spectrum capacity;

– ensure that users benefiting from the use of spectrum resources pay the cost of spectrum use;

– provide revenues for governments or regulators.

Setting spectrum charges involves a range of spectrum management activities and tools including administrative fees, measuring spectrum use, and setting prices through market mechanisms. Developing spectrum charging strategies invariably means alignment with the revenue objectives of governments and regulators, defining objectives, and consultations with the main interested parties including finance ministries and sectoral groups such as telecommunication service providers. Revenue objectives and strategies relate directly to the principal objectives: payment for use of the spectrum by users, reimbursement of management costs, spectrum efficiency and attainment of economic and social development goals.

2 Reminder of principles updated by the work under Resolution 9

During the work of previous periods and since 2003 (WTDC-02) a database has been established using an ITU-D questionnaire (Letter CA/12-CA/120) on a "**Spectrum Fees (SF Database)**" (see www.itu.int/ITU-D/study_groups/SGP_2002-2006/SF-Database/index.asp). A user's guide has also been made available to enable administrations alone to complete the questionnaire and modify their data in the light of changes in their legislation (JGRES9/043 Rev.1). WTDC-06 decided to continue development of the SF database, as did WTDC-10 in the revised version of Resolution 9, in § 2.

Administrations can use the database to obtain information for the purpose of establishing models for calculating fees in the light of national requirements.

3 Changes in fee calculation methods

Generally speaking, the licensing authority is paid an annual fee (management and license issue fee) for radiocommunication concessions/licenses. The amount is based on factors including: the frequency domain allocated; frequency class and frequency value; bandwidth allocated; territorial coverage; period of use; and the domestic price index. In general, a mathematical formula is published officially (transparency) by the national regulator for each type of radiocommunication service, drawing a distinction drawn between private and commercial users. These prices are set administratively, on a discretionary basis, and do not reflect opportunity costs. The main challenge is to achieve effective and rational regulation that takes account of economic factors and the following elements:

a) Opportunity cost

The opportunity cost of an economic decision is a measure of the value of all the other actions or decisions which have to be foregone as a result. In choosing between different options, the most rational is the one with the (subjectively) lowest opportunity cost. In macroeconomics it is useful to take into account positive and negative externalities in order to estimate a total opportunity cost:

1) Depending on the frequency band, estimates taking account of the opportunity cost can be made by estimating savings in access costs or savings in costs of access to supplementary frequencies (the "least costly solution" approach), or based on net revenue which that supplementary spectrum can generate.

2) Values based on cost savings rather than net revenues are much easier to apply, as they require less information on future development of services. Uncertainty as to the future of the market and likely changes poses a major problem when estimating the opportunity cost for many radiocommunication services.

b) Public assigning authorities

The radio-frequency spectrum belongs to the public domain, and the State should therefore expect from frequency users, whether public or private, some quid pro quo for the benefits they derive from frequency use so as to ensure optimal use of this limited resource. As regards public users, a financially neutral system of "budget rents" should be put in place, the advantage of this system being that it would reveal the value of the frequencies used. The idea would be to require payment by user ministries of a user fee provided for in the budgets of the bodies concerned and to increase their budget allocation by the corresponding amount. No new public charge would be created but there would be greater awareness of the value of the spectrum.

The bodies concerned could thus be encouraged to envisage innovative decisions as it becomes possible to acquire equipment based on innovative technologies thanks to savings achieved with fees and the more economical use of spectrum which newer equipment allows. Developing this argument further, potential benefits may also be obtained by encouraging public users to vacate portions of the spectrum. This could be done by providing incentives in the form of financial benefits of reallocation. This would encourage reallocations of frequency bands between different categories.

c) Public audiovisual services

The contribution to the public audiovisual sector (fees) payable by users now takes into account inflation or the value of the consumer price index. This new method would ensure that the public service mandate, devolved to public audiovisual bodies, would be fulfilled while limiting increases in revenue from the public license fees in order to maintain users' purchasing power.

Increasingly, public TV broadcasters, for which advertising used to be one source of funding, are prohibited from using advertising spots at certain times (as in France) or altogether (BBC in the United Kingdom). This enhances the value of the license fee.

Following the introduction of new services accessible through the increasingly widespread adoption of Connected (computer) TV:

1) Some countries plan to extend the TV license fee to computer screens. For example, in France, under the General Tax Code, the license fee is payable for possession of any "television receiver or equivalent device that can be used to receive TV signals for private purposes in the home".

2) Global license: this is a proposal intended to legalize non-commercial traffic in audiovisual content (other than software) through the Internet in return for payment of a fee for license holders that is based for each license on the volume of the license holder's content actually downloaded.

3.1 Taking account of new networks and new technologies

Efficient spectrum management is essential to allow new services and new technologies access to the spectrum, to develop existing services, and to prevent interference between users. It is very useful to assess the economic benefits of radio spectrum use when taking decisions on spectrum planning. In general the economic benefits are considered to result from the development of industrial capacity or the creation of new branches or new radiocommunication services.

Two methods of quantifying economic benefits have been defined in the report *The Economic impact of the use of radio in the UK*, published in 1995 and most recently updated in 2006. These methods can be used to calculate the contribution to the economy of using telecommunication systems, based on:

– Gross domestic product (GDP) and employment

– Consumption and production margins. The consumption margin is the difference between what the consumer is willing to pay and the actual product price; the production margin is the difference between what the producer actually earns and the amount that needs to be earned for the producer to be able to continue operating.

ITU has made a model for calculating license fees available to its Members on the site www.itu.int/ITU-D/tech/spectrum-management/MODEL_FULL.pdf.

3.2 Migration to new-generation networks (NGNs)

In view of the forces of convergence, the move towards digital systems, globalization, Internet use, and the growing demand for broadband and mobility, the Global Symposium for Regulators (GSR) in 2012 considered that it was essential to rethink spectrum management policy. Traditional economic models and regulatory concepts are also called into question by the rapid growth of mobile data traffic, the emergence of "machine to machine" communications and "over the top" (OTT) services (use of existing structures created by another stakeholder in order to provide a service). These developments have major implications, especially for the developing countries. Spectrum policies therefore need to be reviewed. Regulators should give more thought to other ways of using the spectrum, including spectrum re-use and refarming. As regulations are adopted for third- and fourth-generation systems, network and frequency sharing arrangements play a crucial role along with technological neutrality.

Annex 5 illustrates some case studies for calculating spectrum fees.

4 Recommendations

The radio-frequency spectrum belongs to the public domain and the State should therefore require users, be they public or private, to give something in return for the benefits they derive from the use of the spectrum so as to ensure optimal use of this limited natural resource. Another challenge is to develop effective and rational regulation that takes account of economic factors.

As regards public spectrum users, a financially neutral system of "budget rents" should be established; the advantage of such a system would be that it reveals the value of the frequencies used.

Setting up more than one national regulator may have the disadvantage of putting a brake on the development of an overall view of the different needs of each user, and could indeed encourage a tendency to protect vested interests.

5 Conclusions

A simple fee-based formula would not reveal the value of spectrum use owing to different evaluations of different parts of the spectrum and of the associated services, even in neighbouring frequencies:

The value varies according to geographical area.

The level of international harmonization is what facilitates or prevents the rollout of networks in a given frequency band, and which determines its commercial value at any given time. Certain bands are not available for telecommunication services, which means they have little or no value.

Some bands are of inestimable value, for meteorological services, space research or radio astronomy; the "5.340" bands correspond to immutable physical phenomena and all emissions in those bands are prohibited by the Radio Regulations, which means the bands have no value for any other application.

The value may depend on the size and characteristics of the existing receiver pool. For example, the pool of TV sets allows reception only of TNT services broadcast in the VHF III or UHF band.

Services authorized by the Radio Regulations are not all of equal usefulness for society and the associated bands cannot therefore be evaluated in the same way. Audiovisual frequency allocations, for example, are intended to preserve cultural diversity and pluralism in the media.

It is thus difficult or even impossible to come up with a simple, pragmatic and transparent formula that will apply to all frequency bands, reflect the value of those bands, and be applicable to assigning authorities, while remaining compatible with license fees.

6 References

Recommendation ITU-R SM.1603, Annex 1, Regulations of the United Arab Emirates concerning charges for spectrum use

Report ITU-R SM.2012 (Chapter 4)

RIC-42 – Guide for Calculating Radio License Fees (Canada.gc.ca)

Revue juridique de l'économie publique, Feb. 2012, No. 694, "Mode de calcul d'une redevance pour utilisation des fréquences radioélectriques"

Annex 6: Explanation of methods used for determining spectrum prices

Annexes

Annex 1: OCDE Appendix DSTI.ICCP/TISP 12 (2000) Final: Auctions Theory

Concepts and definitions

Private, affiliated and common values

A priori, the value of an object to a buyer can depend on:

– The information that the buyer possesses about the object. The word "information" has to be understood very broadly, as it can also refer to the buyer's personal tastes, or characteristics.

– The information other buyers possess about that object. (The same applies for the word "information".)

Additional variables that can affect the values of the object for each and everyone in the same way.

– In the case of licenses, the following are examples for each category:

– The operator's own cost and budget.

– Other operators' costs and budgets.

– Consumers' interest in using mobile telephones.

– Performance of the stock market.

Therefore, if we let VA denote the value of an object to buyer A, we have:

$$VA = V\,(IA,\, IB\,/\,A,\, X)$$

where, *IA* denotes the information to buyer *A, IB/A* denotes the information to any other buyer except A ,and X refers to any other variable that can affect the object's value.

Bidders have private values when *VA = IA*. Consider for instance an auction of paintings. Consider moreover that none of the buyers is interested in resale markets. Then all that matters to any buyer is how much he likes the painting. This would be a case of private values. In such cases, the bidders know exactly what the object is worth to them;

Bidders have common value when *VA= X*. The best example of common value is an auction for treasury bonds. The value of a Treasury bond never depends on the identity of the owner, and would be the same whoever holds it. In such cases, bidders do not know the value of the object. They form their bids using what we call "signals".

Any situation where VA is of the form indicated above, is neither a private nor a common value case.

Finally, bidders' values are affiliated when (very broadly) observing a large value for a buyer makes it more likely that other buyers also have large values.

Bidders for licenses have values that are neither private nor common. Furthermore, their values are likely to be affiliated as they rely heavily on future market conditions, which would affect them in the same way.

Risk aversion-risk neutrality

Bidders are risk averse when the expectation of a gamble has more value to them than the gamble itself. For instance, the value they assign to a bond with a fixed return of 10% is higher than the value they would assign to a bond that generates a return of 0% with probability ½ and 20% with probability ½.

A bidder is risk neutral if he values equally the gamble and its expectation.

Standard auctions

Open auctions: The English auction: Bidders announce their bids openly in an ascending order. The auction stops when no one proposes a higher bid than the last announced. The winner is the last person to announce a price; he pays the price that he announced.

Japanese version of the English auction: The price raises slowly while bidders only signal if they are still in or whether they want to drop out. The auction stops when there is only one bidder remaining. He pays the price at which his last competitor dropped out.

Dutch auction: The auctioneer announces prices in a descending order. The auction stops when one bidder accepts to buy at the price announced. The winner pays the price at which he stopped the auctioneer.

Sealed bid auctions:

First-price sealed bid: Each bidder submits a bid in an envelope. The auctioneer examines all offers. The object goes to the highest bidder and he pays the amount he suggested. In Greece this method was used for the 2G licensing in 1992. However the second highest bidder, if this bid came within 10% of the highest bid, could match the highest bid and win the second license. Otherwise there would be a second round of bidding by the participants.

Second-price sealed bid: Each bidder submits a bid in an envelope. The auctioneer examines all offers. The object goes to the highest bidder and he pays the second highest offer. New Zealand, in 1990, used this method to auction three cellular licences. One of the winners bid NZD 101 million, but only paid NZD 11 million.

Main results on the allocation of a single object

The literature on mechanism design has mainly focused on two objectives: revenue maximization and efficiency. This is mainly due to the fact that objectives other than profit maximization and efficient allocations are difficult to model.

Achieving efficiency

The second-price sealed bid auction (Vickrey auction) achieves efficiency, in the sense that the object goes to the buyer with the highest valuation. In a Vickrey auction, the best thing a buyer can do is to bid his valuation truthfully. This is true independently of what the other buyers are doing. Suppose that buyer i has valuation vi. He does not know what the other buyers will offer but he knows there are two cases: (a) someone offers more than vi, or (b) all the other buyers offer less that vi . In case (a), buyer i should not bid more than vi because he only risks getting the object at a price above his valuation. In case (b), buyer I pays the second-highest bid and, therefore, he has no reason to go below vi because this will not reduce the amount he pays but can jeopardize his chance of getting the object. As each buyer bids his valuation truthfully, the object goes to the buyer with the highest valuation and efficiency is achieved.

The principle behind the Vickrey auction is that the winner should compensate society for the “damage” that he does by getting the object, since this precludes the next-best alternative use of the same object. This is an extremely general principle that underlies all of auction theory.

The seller may have intrinsic preferences over who gets the object. For instance, the seller may prefer to give the object to a new entrant or to a national firm. Efficiency then needs to be redefined by taking these factors into account. The Vickrey auction as defined above does not guarantee efficiency anymore.

The other main goal, besides efficiency, that the seller may have is *revenue maximization*. A fundamental result in auction theory is the *Revenue Equivalence Theorem.*

The revenue equivalence theorem

If bidders are risk neutral, each has a privately known signal, and if signals are independent then all mechanisms such that:

1. The object always goes to the bidder with the highest signal.
2. The bidder with the lowest feasible signal expects zero surplus.

will yield the same revenue.

If signals are, in addition, identically distributed then, all the basic auctions cited above are equivalent in that they generate the same revenue for the seller. However, it should be noted that the theorem is true not only in a context of private values. It holds in more general common value models provided the signals are independent.

Revenue maximization

If we have independent private values, risk neutrality, and if the function according to which signals are distributed displays a regularity condition, all standard auctions, with an optimal reserve price, maximize the seller's revenue.

Note 1: Under the hypothesis given above, both the second price sealed-bid auction and the English auction (with an optimal reserve price) maximize the seller's revenue. These auctions have a dominant strategy equilibrium: for each of these, buyers maximize their expected revenue by bidding their true values*, whatever the other players do.*

The existence of a dominant strategy equilibrium is interesting in that it is robust. Players need not know anything about the others (not even the number of competitors) to calculate their optimal bid.

Note 2 : Discrepancy between efficiency and revenue maximization.

Because revenue maximization requires setting a reserve price, it may be inefficient. It is important to understand the source of inefficiency. If the object is sold, it will be to the one who values it the most (under the regularity condition). The outcome is inefficient only if the seller ends up keeping the object. Indeed, the optimal reserve price is such that there could be no sale agreement even though the object is of no value to the seller while all the buyers have positive values for it (basically, a reserve price allows the seller to get rid of reluctant buyers so as to get more revenue from eager buyers.)

Risk aversion

When bidders are risk averse, the revenue maximizing auction becomes quite complex. There are two sources of risk in an auction:

1. An auction is a gamble in that the bidders may win or lose. The difference between what they get in each of these events is one source of risk.
2. Conditional on winning (or even losing) the amount they must pay (or receive) can depend on their competitors' bids (as it does in a second price auction). Because they do not necessarily observe their opponent's bid their payment may be random. This is a second source of risk.

When bidders are risk averse, the following features can increase the seller's revenue:

3. Payments should never be random. (Using random payments only deters competition.)
4. Eager buyers (high bidders) should get compensated when losing by receiving a subsidy while reluctant buyers (low bidders) must be forced to pay a fee. The idea is that the seller provides insurance to high bidders by lowering their first source of risk. This induces them to bid higher. He pays for this via a punishment on low bidders. They face more risk, and are less competitive. What is won on high bidders more than compensates the loss on low bidders.

The complexity of the optimal auction with risk-averse bidders raises the issue of implementation. The features described above are never observed in practice for they would be difficult to implement and require too much information.

Non-private values auctions: Winner's curse

When the value of the object either does not depend on any of the bidder's characteristics (e.g. Treasury bond) or depends on his characteristics but also on other bidders' characteristics then the revenue equivalence theorem breaks down.

The English auction (even the Japanese version) releases information and performs better in terms of revenue maximization than other mechanisms. More precisely the standard auction can now be ranked according to the revenue they generate as follows: English, Second price sealed-bid, First price sealed bid and Dutch (where the last two generate the same revenue).

The winner's curse: To evaluate their bids, buyers have to calculate estimates of the value of the object. Other things being equal, the buyer with the largest estimate will make the highest bid. Therefore, even if all buyers make unbiased estimates, given their information (or signal), the winner is the one who has over-estimated the object's value (on average). In other words, winning also means having the most favorable information regarding the object's value. Therefore, in some instances, the true value of the object may end up being lower than the estimate. This general property of auctions is known as the winner's curse.

Bidders, because they are rational, will take the winner's curse into account when they bid. In effect this means that all bids are revised downwards. Therefore, to increase his revenue the seller should weaken the winner's curse. By providing more information to all buyers the seller can reduce information asymmetry, increasing competition, and the value of bids.

In general, common value auctions (and more generally auctions with statistically dependent values) have received less attention than private value auctions. The main reason being that common values often lead to complex, non-tractable mathematical expressions.

Multiple objects

In the case where there are multiple objects for sale, a set S of objects, then each buyer has a valuation for each possible subset of objects. Hence if $v_i(s)$ is the valuation of buyer i for subset s belonging to S. For instance, $v_i(1, 3) = 4$ says that buyer i has a valuation of 4 if he ends up with objects 1 and 3 (and *only* objects 1 and 3).

Valuations can display positive or negative complementarities. If $v_{in}(1, 3) > v_i(1) + v_i(3)$, there are positive complementarities. If $v_i(1, 3) < v_i(1) + v_i(3)$, there are negative complementarities. In spectrum auctions both cases are of practical relevance. An operator may need licenses in two neighboring regions (or in two neighboring frequency bands) or two licenses in the same region in order to have a viable business, in which case we expect positive complementarities. Alternatively, an operator may face decreasing marginal revenues in the number of customers in which case we expect negative complementarities. The existence and sign of complementarities play a large role in the choice of an auction mechanism.

Efficiency now means that the objects are allocated in a way to maximize the total surplus, which is given by the sum of the valuations of all the buyers. An allocation A is a subdivision of S among the n buyers of the form $A=(A_1,A_2, ..., A_n)$. The efficient allocation satisfies:

$$A^* = \max_A \sum_{i=1}^{n} v_i(A_i)$$

There exists an extension of the Vickrey auction to multiple objects that achieves efficiency in an independent private values contest and with no budget constraints or wealth effect. It is *called generalized Vickrey auction (or Groves-Clark mechanism, or combinatorial auction*). As in the simple Vickrey auction bids are secret and simultaneous, i.e. a one-shot sealed-bid auction. Each buyer places a bid on each subset of S. For instance, if there are objects a, b, and c, each buyer bids on {a}, {b}, {c}, {a, b}, {a, c}, {b, c}, and {a, b, c} a total of seven numbers. The seller chooses the allocation that maximizes the sum of bids for subsets belonging to that allocation. The amount that buyer i pays is determined by looking at the bids of other players. Let b-i(A) denote the total amount of bids from players different from i for allocation A. Then if A' is the winning allocation, the amount that i pays is:

pI = maxAb-i(A) - b-i(A').

Buyer i pays for the damage that he imposes on other buyers by changing – through his bid – the allocation. This is the same principle as paying the second highest bid. Indeed, if there is only one object, b-I (A')=0 and that maxA b-I (A) is equal to the second highest bid, and hence the generalized Vickrey auction is the same as the simple Vickrey auction.

It can be shown that in the generalized Vickrey auction it is a dominant strategy for buyers to bid their true valuation on every subset of objects. If every buyer bids truthfully, it is easy to see that the winning allocation will be the efficient allocation A*.

The generalized Vickrey auction can be extended further to accommodate social welfare considerations. As in the one-object case, the seller assigns a social benefit to each buyer (except that now he must assign a number for each possible allocation). It is also possible to extend the mechanism to take care of externalities among buyers.

Given this strong efficiency property, it may then be surprising that the generalized Vickrey auction has never been in used in practice to sell spectrum. One of the reasons is probably its complexity when the number of objects is high. The number of bids each buyer places is equal to the number of possible object combination. If the number of objects is m, the number of possible combinations is 2m- 1. This number becomes large very fast. With m = 20, it is over a million.

Auction designers have thus turned their attention away from one-shot mechanisms towards ascending mechanisms, with the idea that the latter are less computationally demanding because buyers only have to respond to the highest current bid rather than considering all possible combinations.

The most widespread design for spectrum sales is the *simultaneous ascending auction* (SAA), introduced by the FCC in 1994. The auction is structured in simultaneous rounds. In each round, each buyer can place a bid on one or more objects. There may be an upper limit on the number and type of object on which a buyer can place bids (the *eligibility rule*), which is usually motivated by the desire to avoid excessive concentration. There may also be a lower limit (the activity rule), which has the objective to guarantee that the auction proceeds speedily. A buyer who violates the activity rule is eliminated from the auction. After bids are placed, the seller determines the current winners by looking at the highest bidder for each of the objects. The auction stops if, at some round, no new valid bids are received. In that case, the current highest bidder of each object is allocated the object and must pay his bid.

Discrepancies between the SAA and the generalized Vickrey auction occur in the presence of *exposure problems* . There is an exposure problem when some buyers have positive complementarities and others have negative complementarities. The SAA is not always efficient because of the exposure problem.

Not only does the exposure problem generate inefficiency in the SAA, but it also reduces the expected revenue of the seller. An often cited example of how the exposure problem can hurt efficiency and revenues is the 1998 spectrum auction held in the Netherlands (DCS 1800MHz). Eighteen licenses were for sale. Six of them were grouped in lot A, six of them were grouped in lot B, and the remaining six were sold singularly but buyers could cumulate them. The outcome of the auction was that the prices per bandwidth on lot A and B were twice as high as on the small licenses. This suggests that buyers had positive complementarities, they were interested in collecting several of the small licenses but were deterred to do so by the risk of being left with only one or two small licenses. One operator resold its only and almost worthless small license after the auction. In this special case, the resale of the license indicates that the auction format had not achieved efficient allocations in the first place.

In response to the exposure problem, the FCC has considered alternative auction formats. Following the advice of several leading auction theorists, it decided to adopt a *dynamic combinatorial auction* (DCA). The new format will be used in a FCC 700MHz spectrum auction to be held in March 2001. The DCA is still an ascending bid auction. However, it differs from the SAA in that buyers are allowed package bidding, that is, they are allowed to make joint bids on more than one object. At each round a buyer can submit bids on single objects and on packages of objects. A bid on a package means that the bid is paid only if the buyer gets the whole package. A buyer can bid on many objects and many packages. After bids are placed, the seller computes the allocation that would generate the highest revenue, analogously to the generalized Vickrey auction. The bids that compose the winning allocation are considered the current winning bids. But also the other bids stand. In the next round bidders must offer more than the current winning allocation but can do so by using the other standing bids.

The main advantage of the DCA is that it eliminates the exposure problem. However, it has been pointed out that the DCA creates a problem that in some senses is the converse of the exposure problem, which has been called the threshold problem. This auction format can give rise to a free rider problem among bidders on the individual licenses. Small buyers who are interested in small lots may have an incentive to wait and see if other small buyers increase their offers, because that will help them beat the offers of large buyers interested in large lots. Thus, two buyers may be tempted to wait and see if the other buyer moves first. This strategic effect may induce inefficiency and lower revenues.

In conclusion, each of the three mechanisms that have been considered for multiple objects has a distinctive drawback. The "generalized" Vickrey auction may be too complicated, the SAA has the exposure problem, and the DCA has the threshold problem or free riding problem. The optimal choice will depend on the number of objects for sale, on the number of bidders and on the type of synergies (complementarities) that the seller expects to exist.

Collusion

Collusion among buyers may take many forms. It may entail explicit agreements before the auction (bidding rings) on how to bid during the auction. Perhaps more important in the case of spectrum auctions is tacit collusion. Buyers do not directly communicate but they have an implicit mutual understanding on how to keep prices down.

This type of tacit collusion goes away if the seller uses a one-shot format, such as the generalized Vickrey auction. It is the ascending nature of the SAA that allows for a credible threat of retaliation and hence for tacit collusion. Thus, the fear of tacit collusion goes in the opposite direction of common values, and tends to favor one-shot formats.

Under some assumptions, auctions may be perfect mechanisms to reach efficiency and maximize seller's revenues. The extensions of the basic framework go in different directions. If the goal is revenue maximization, common values militate in favor of the English auction, collusion makes the use of one-shot mechanisms more attractive, while risk aversion favors first-price mechanisms. If instead the goal is efficiency, common values do not, as a first approximation, matter, and the effects of risk aversion and collusion are unclear. The optimal design should try to balance these different forces.

Hybrid formats are possible too. In the case of m identical licenses and n buyers who can only acquire one license each, one suggestion has been made to use an English auction to screen out all buyers but m + 1, and then run a first-price sealed bid auction among the m + 1 remaining buyers. This auction – called Anglo-Dutch– should combine the benefits of the ascending format in reducing the winner's curse and the advantage of a one-shot format in avoiding collusion bandwidth on lot A and B were twice as high as on the small licenses. This suggests that buyers had positive complementarities, they were interested in collecting several of the small licenses but were deterred to do so by the risk of being left with only one or two small licenses. One operator resold its only and almost worthless small license after the auction. In this special case, the resale of the license indicates that the auction format had not achieved efficient allocations in the first place.

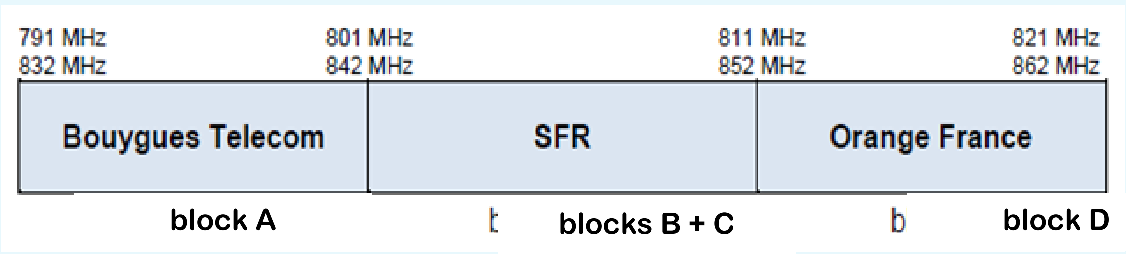
Annex 2: Auctions Case Studies

Average price/MHz/pop versus average income per capita => other variables?

2.1 Case of France: the 800 MHz band

In accordance with the call for bids issued on 15 June 2011 by ARCEP for allocation of frequencies in the 800 MHz band in connection with the rollout of new networks (4G/LTE), ARCEP on 22 December 2011 published the results of the procedure for awarding licences for frequencies in the 800 MHz band in metropolitan France in order to establish and operate a public mobile radio-frequency network (Decision 2011-2011). The selection was based on three criteria set out in the call for bids: an undertaking to develop the territory; commitment to admit mobile virtual network operators (MVNOs); and the sum proposed for the frequencies.

In the light of the bids submitted by the applicants, the following results were obtained:



The following table gives details of the winning bids.

Winning bidder	Frequency block acquired	Sum offered	Agreement to admit MVNOs	Undertaking to develop territory
Bouygues Telecom	Block A (10 MHz duplex)	683 087 000 €	Yes	Yes
SFR	Blocks B + C (10 MHz duplex)	1 065 000 000 €	Yes	Yes
Orange France	Block D (10 MHz duplex)	891 000 000 €	Yes	Yes

Awarding frequencies in the 800 MHz band has made it possible to capitalize on the public radio-frequency resource, to the tune of 2.639 billion euros (compared to the reserve price of 1.8 billion euros).

Note: ARCEP, in its decisions of 22 December 2011 and 17 January 2012, awarded roaming rights in the 800 MHz band to the operator Free Mobile in SFR's 4G network, since the ARCEP call for bids had agreed to this concession in awarding the operator a licence to use frequencies in the 2 600 MHz band, rather than the 800 MHz band.

On 11 October 2011, ARCEP published the results of the initial call for 4G/LTE bids for the 2.6 GHz frequency band (Decisions 2011 – 168-171):

Orange: 20 MHz duplex for 287 118 501 euros

Free Mobile: 20 MHz duplex for 271 000 000 euros

Bouygues Telecom: 15 MHz duplex for 228 011 012 euros

SFR: 15 MHz duplex for 150 000 000 euros.

2.2 Case of the United States

In 2006, the FCC decided to conduct auctions for the Advanced Wireless Service (AWS). As with all auctions, the FCC began by drawing up a specific plan of frequency bands to determine the bandwidths authorized at each site in order to establish lots. Each lot comprised a specific frequency band covering a specific geographical area. In this case the FCC decided that six paired frequency blocks (A to F) would be auctioned, with 1 710-1 755 MHz for the uplink and 2 210-2 155 MHz for the downlink.

Three blocks were of 20 MHz and another three of 10 MHz. As the United States is a large country, each frequency block was also divided geographically. In addition, the FCC was ready to admit all types of bidder, and divided the blocks using three different methods: for blocks D-F the country was divided into 12 large regions, with 176 medium-sized regions for blocks B and C and 734 small regions for block A.

It was notable that the divisions did not lead to a hierarchy, since a bidder could not formulate a bid for medium-sized zones by aggregating a number of smaller lots. This clearly limited the possibility of cross-bidding between blocks. The AWS auction for 90 MHz of bandwidth in 2006 involved 161 rounds and attained a total sum of USD 14 billion.

The next and most important auction was that of the 700 MHz band in 2008, in which the FCC adopted the same approach as with the AWS auction. Specific blocks were auctioned using a division of three categories on US territory. Once again this did not lead to development of a hierarchy. The final prices by bandwidth/population were as follows:

BLOCK	A	B	C
Bandwidth **Type** **Division of lots**	12 MHz Paired 176	12 MHz Paired 734	22 MHz Paired 12
Price USD/MHz-pop.	USD 1.16	USD 2.68	USD 0.76

2.3 Case of Sweden

Parameters

License duration: 20 years

National auction conducted by PTS

Open simultaneous multiple-round ascending

Duration: 16 days

Number of rounds: 112

Possibility of exchanging blocks

Cost of participation: 50 000 euros

Starting price: 15 000 euros/MHz

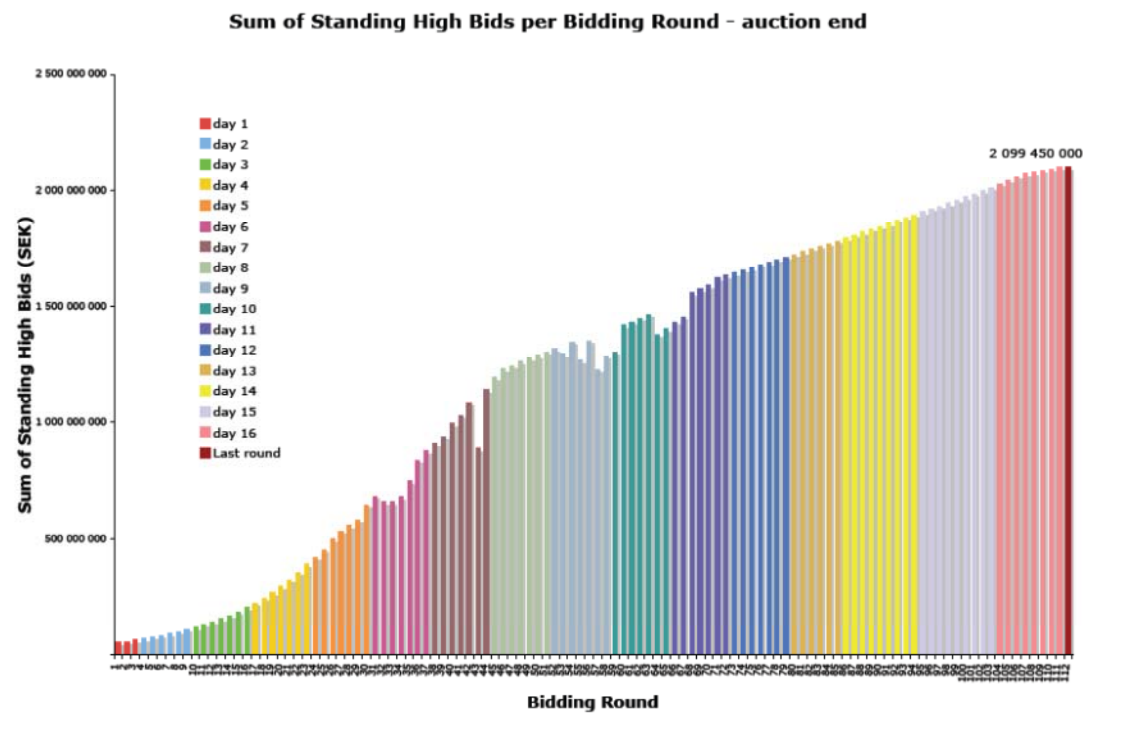
Minimum bid for each frequency block: 275 000 euros/MHz = 30 000 euros

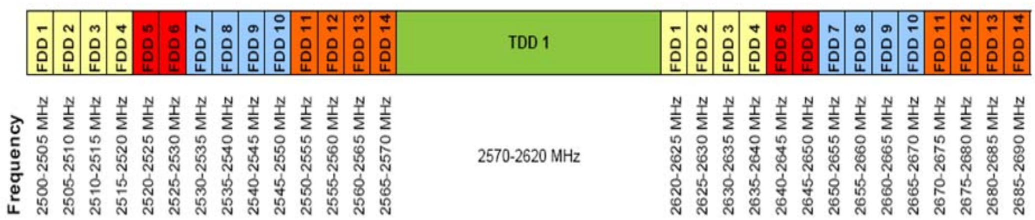
Final result: 226 million euros

Average price/MHz/pop.: 13.17 euros

Newcomer: Intel Capital Corporation (WiMAX mobile)

Cf. Qualcomm in May 2008: 10.7 million euros for 17 lots auctioned in the United Kingdom (1 452-1 492 MHz) to develop mobile TV technology (its subsidiary Nextwave sells wireless broadband and mobile TV equipment).





15 frequency blocks:

- 14 FDD blocks: 2 × 5 MHz
- 1 TDD block: 50 MHz

Company	Frequencies	Cost In Euros	Mobile market share (%)	Eurocents per MHz/pop
HI3G Access AB (trades as "Three")	2x10 MHz FDD	32,000,000	9.4	17.72
Tele2 Sverige AB	2x20 MHz FDD	59,000,000	24.5	16.33
Telenor Sverige AB	2x20 MHz FDD	57,000,000	22	15.78
TeliaSonera Mobile Networks AB	2x20 MHz FDD	61,000,000	41.3	16.89
Intel Capital Corporation	50 MHz TDD	17,000,000	n/a*	3.76

** Intel is not currently offering services in Sweden*

2.4 Case Study of Egypt: 3G Auction

In April 2006, The National Telecom Regulatory Authority (NTRA) oF Egypt announced a request for proposal (RFP) for the international auction for awarding a license to operate a 3rd mobile network in Egypt using 2G/3G technologies. In response to this RFP, the NTRA received 11 bids from national and international companies.

I. Fees

One Time Fee Upfront Royalty

The Licensee was required to pay an upfront royalty for the issuance of the License (2.5 Billion Egyptian Pounds[3]), referred to as the base upfront royalty. 20% of the upfront royalty represents the 3G component of the License, and the remaining 80% represents the 2G component. In consideration of the upfront royalty payment, the successful Bidder would be entitled to the following:

– Allocation of frequency bands

– Two million number assignments free of charge for the initial term of the License.

– Free access to available network code allocations, for the initial term of the License.

– The recurring fees payable by the Licensee are as follows:

- **Annual Royalty**

In addition to the upfront royalty referenced above, the successful bidder is required to pay, on an annual basis, a percentage of its gross revenues (3%), referred to as the base annual royalty, which rises by 0.2 per cent for each 100 million Egyptian Pounds increase in the bid value up to a cap of 6%. 40% of the annual royalty represents the 3G component of the License, and the remaining 60% represents the 2G component.

- **Annual License Fees**

An annual License fee of L.E. 22,000,000 (twenty two million Egyptian Pounds) (subject to the Egyptian Annual Inflation rate and prorated for the first year) is to be paid not later than 30 days after the effective date of the License and then annually on the first business day of each calendar year over the term of the License.

- **Radio Frequency Usage Fees**

– Annual fees of 200,000 L.E. /MHz for assignments in the 800 MHz band.

– Annual fees of 200,000 L.E. /MHz for assignments in the 900 MHz band.

– Annual fees of 100,000 L.E. /MHz for assignments in the 1800 MHz band.

– Annual fees of 100,000 L.E. /MHz for assignments in the 1.9 GHz/2.1 GHz band

[3] In 2006, one US dollar was approximately equivalent to 5.7 Egyptian Pounds (L.E.)

II. Frequency Bands

The Bidder should choose from the following mobile frequency bands assigned by the NTRA on a National basis in Egypt:

- **GSM Services**

2 x 5 MHz Bandwidth within the 900 MHz band (880-885 MHz / 925-930 MHz)

2 x 5 MHz Bandwidth within the 1800 MHz band (1710-1715 MHz/1805-1810 MHz)

- **CDMA2000_1x Services**

2 x 5 MHz Bandwidth within the 800 MHz band (835-840 MHz / 880-885 MHz)

- **IMT2000 (WCDMA OR CDMA 2000_1x EV-DO) Services**

2 x 10 MHz bandwidth within the 2 GHz band (1920-1930 MHz / 2110-2120 MHz)

- **Bidders shall be permitted to request and combine frequencies as follows:**

Option 1:

2 x 5 MHz in the 900 MHz bands plus an additional 2 X 5 MHz in the 1800 MHz band plus an additional 2 X 10 MHz in the 2 GHz band

Option 2:

2 x 5 MHz in the 800 MHz band plus an additional 2 X10 MHz in the 2 GHz band

- **Coverage and Rollout Plans**

The rollout plan shall address the following general requirements:

1) Ultimately, at least 85% of the populated areas in all Governorates of Egypt shall be covered with Class (1) services[4] by the end of the third year following the effective date of the License.

2) Coverage for Class (2) services[5] shall be in accordance with or exceeds the minimum rollout plan requirements described below. By the end of the fifth year following the effective date of the License, at least 85% of the populated areas in Egypt shall be covered with Class (2) services.

Launch of commercial services for both sets should not be later than six months from the effective date of the License.

[4] Services available over networks based on standards such as the GSM standard developed by CEPT and ETSI and now maintained by the Third Generation Partnership Project (3GPP) or the TIA/EIA/IS-2000 standard (known as CDMA2000_1X) developed by the Third Generation Partnership Project 2 (3GPP2) and published by the Telecommunications Industry Association (TIA); and also available over networks based on the IMT-2000 (3G) standards identified by the ITU (WCDMA or CDMA2000_1xEV-DO). Such services include voice and lower-speed data services such as text messaging and the ability to roam on existing NPMT networks.

[5] Services available over networks based on the IMT-2000 (3G) standards identified by the ITU (including WCDMA or CDMA2000_1x EV-DO). In addition to the services identified in Set 1, Set 2 includes services such as more efficient voice communications and a variety of services enabled by the higher data rates of IMT-2000 technologies, such as multimedia messaging, video calls, broadband Internet access, location-based services, application downloads and video downloads, and the ability to roam - to the maximum extent possible - on existing NPMT networks.

III. Evaluation of Bids

Technical Evaluation Process and Criteria (Phase 1)

A proposal is technically unqualified (failed) if its technical score is less than 85% of the technical score of the top ranked proposal and is considered rejected accordingly. Also for a proposal to be technically qualified, its score must be above 700/1000 points.

Criterion	Score
Consortium or Company Management, and past experience capabilities	225
Consortium or Company Commercial, Economic and Financial Capabilities	225
Quality of the Marketing Plan	50
Quality and Compliance of the Technical Plan, Network Launch and Coverage Commitment	250
Quality of Customer Care Plan	50
Quality of Management and Organizational Structure	50
Quality of Financial Plan	150

The evaluation method adopted by the Evaluation Committee for the technical proposals is a pass/fail basis. Qualified proposals are then eligible for the bidding process.

Financial Evaluation Process and criteria

The highest final bidder at the end of the open auction rounds will be declared successful winner for grant of License.

In case of the tie for the financial value, the Bidder with the higher technical score will be the declared winner.

IV. Illustrative Bidding Mechanism

For the purposes of ensuring that the Financial Proposal is structured correctly, an illustrative example of the bidding mechanism related to the minimum bid increment is presented below:

In this exercise:

1) The components of the 'base' price are:

   a) base Upfront Royalty of 2.5 Billion Egyptian pounds

   b) base Annual Royalty of 3%

2) The **minimum bid increment** (applied to the two components of the base price) is:

   a) 100,000,000 (one hundred million) Egyptian Pounds for the Upfront Royalty **and** 0.2 % for the Annual Royalty.

Accordingly, the lowest bid above the base price that is acceptable is:

a) 2.6 billion pounds for Upfront Royalty [computed as 100 million pounds above the 2.5 billion pound minimum]

   and

b) 3.2% for Annual Royalty [computed as 0.2% above the 3% minimum]

All subsequent bids are to be in integer multiples of the minimum increments identified.

V. Auction Mechanism and Results

- Nine technically qualified consortiums announced out of the 11 bidders while two consortiums are excluded. The nine consortiums went through an auctioning process, to choose the winner.
- The bidding process was an open auction format. Qualified bidders sat around a table and bid face-to-face, with the license ultimately going to the highest bidder.
- Starting from the second round, the highest bid in the previous round considered the minimum bidding value for the next round.
- A multi-round auction started with 2.5 billion Egyptian Pounds. After a competitive financial auction consisting of nine consortia, Etisalat Consortium won the bid for the 3rd telecom license in Egypt after bidding over 3 consecutive rounds.
- At the end of the auction, the auction Head (the NTRA President), announced the winning of the consortium, which was granted the license for 16.7 billion Egyptian pounds. The share of the NTRA in the operator’s annual revenues stands at 6%.

Annex 3: Example of allocations table: Bangladesh

As per the Bangladesh Telecommunication Act-2001, Bangladesh Telecommunication Regulatory Commission has a Spectrum Management Committee. The Committee consists of one commissioner of BTRC and a number of other members, as specified by the Commission from time to time. The functions of the Committee are as follows:

a. To make recommendations to the Commission on the principles of allocation of radio frequency and fixation of fees for such frequency

b. To make recommendations to the Commission for specifying the radio frequencies to be used for operating radio apparatus or for providing services by various licensees, broadcasting enterprises and other organizations

c. To make recommendations to the Commission on the methods and time-limits of allocation of radio frequencies and the revocation or modification thereof

d. To coordinate the international and multipurpose use of radio frequency and to frame policies thereon, to present such policy for approval of the Commission and to revise from time to time the policies approved by the Commission

e. To revise matters relating to radio-frequency band in order to ensure their proper use and receipt of better information by using such band

f. To determine the technical standards applicable to radio apparatus or interference causing apparatus; and to make recommendation on the issuance of technical acceptance certificates

g. To make recommendations on the issuance of licence for radio apparatus

h. To monitor the compliance of the provisions of this Act and regulations in respect of the use of the allocated radio frequency spectrum, and to make suggestions on the actions to be taken, if any.

The BTRC in consultation with the members of the SMC, have produced an NFAP for Bangladesh. The extent to which the full benefits of the radio spectrum are realized depends on the actual use that is made of it and how efficiently it is managed. The primary objectives to be achieved with the radio spectrum include the following:

- To allow the development of new services to meet customer and governmental demand for radio services;
- To manage the radio spectrum within Bangladesh taking account of governmental requirements and the needs of the various commercial sectors;
- To harmonise spectrum use with international developments (ITU, APT);
- To enable liberalisation of, and competition for, telecommunications (including radiocommunications) services and equipment;
- To enable the realisation of public policy objectives on safety (including emergency services), cultural (including broadcasting) and social issues;
- To stimulate technological innovation and competitiveness;
- To support economic growth, create employment and to promote general welfare;
- To support national security and governmental applications.

Annexe 4: La valorisation des bandes de fréquences en cas de réaménagement du spectre

La méthode de valorisation des bandes de fréquence peut être décomposée en trois parties distinctes :

– **Valorisation de l'existant**: étude de l'utilisation des bandes de fréquences et calcul du coût de déménagement,

– **Valorisation des utilisations potentielles**: étude des différentes applications possibles et valorisation du coût d'opportunité,

– **Correction de la valeur**: étude des différents paramètres (bande partagée/exclusive, usage primaire/secondaire, contraintes de déploiement…) qui viennent atténuer ou augmenter la valeur des bandes de fréquences.

Pour chaque bande de fréquences, on définit alors une valeur associée à chacune des parties précédentes:

– Coût de déménagement *Cd*,

Un nouvel usage de fréquences suppose des investissements importants qui s'étendent nécessairement sur plusieurs années pour être rentabilisés.

– Coût d'opportunité Co,

Le spectre n'a pas de valeur en soi, sa valorisation résulte de sa rareté relative en raison de la multiplicité des usages potentielles. En conséquence, sa valeur se mesure par son coût d'opportunité c'est-à-dire la valeur des usages alternatifs auxquels il faut renoncer lorsqu'un usage donné est choisi.

– Coût correctif Cc.

Certains paramètres importants peuvent altérer la valeur des bandes de fréquences calculée précédemment par exemple : partage, obligation de zone de couverture, marché secondaire.

En conséquence, la valeur d'une bande de fréquences est une fonction de ces trois paramètres. En première approximation, on peut considérer que cette fonction est une somme :

$$Valeur\ (Bande) = Cd + Co + Cc$$

2.1 Valorisation de l'existant/ Coût de déménagement

Cette première étape consiste à évaluer la valeur économique du patrimoine que possède l'affectataire. Ce patrimoine est constitué d'une série de bandes de fréquences qui doivent être évaluées une par une. La valeur totale du patrimoine est la somme des valeurs des bandes de fréquences prises séparément.

La liste des bandes de fréquences utilisées par l'affectataire constitue le premier jeu de données. Des informations collectées viennent compléter ces données d'entrée. Enfin, l'étude économique est alimentée par de nombreuses sources d'information au niveau national comme international. Les sources suivantes sont citées à titre d'exemple et ne constituent pas une liste exhaustive, il est possible d'avoir recours à d'autres sources non expressément citées :

– National : tableau des tarifs, frais de licences, redevances, prix équipements.

– Institut National de la Statistique (et des Études Économiques)

– Portail de la Statistique Publique

– CCI (Chambres de Commerce et d'Industrie)

– Base de données de l'UIT/UNESCO

– Banque Mondiale, OCDE

– United Nations Statistics Division

Pour chaque bande, il convient d’étudier l’utilisation qui en est faite à partir des données récoltées auprès de ces organismes nationaux et internationaux, et de calculer les coûts de déménagement liés à la transposition de cette utilisation sur une autre bande. Cette transposition peut, dans certains cas, nécessiter de lourds investissements suivant qu’il faille renouveler la totalité des équipements, du réseau ou des terminaux.

Le calcul dépend, en particulier, des différents paramètres suivants (liste non exhaustive):

- ◊ D_1: Type d'équipement,
- ◊ D_2: Nombre d'équipements,
- ◊ D_3: Coût unitaire d'équipement,
- ◊ D_4: Formation à l'utilisation,
- ◊ D_5: Coût de déploiement,
- ◊ D_6: Coût de maintenance…

$$C_d = fonction\ (D_1, D_2, D_3, D_4, D_5, D_6,...*)$$

* *d’autres paramètres peuvent être considérés lors de l’étude*

2.2 Valorisation des utilisations potentielles et futures/ Coût d’opportunité

La valorisation des bandes de fréquences fait en outre intervenir le coût d’opportunité des usages possibles de ces bandes de fréquences. En effet, c’est l’usage fait d’une bande de fréquences qui en détermine sa valeur et il faut donc étudier les usages potentiels associés à chaque bande de fréquences. Pour déterminer la valeur d’un usage potentiel d’une bande de fréquences, on adoptera l’une et/ou l’autre des deux méthodes suivantes :

– Méthode du surplus collectif,

– Méthode PIB/Emploi.

2.2.1 Méthode du surplus collectif

Dans le cas où une seule technologie est envisageable pour la bande de fréquences, déterminer la valeur économique de cette bande revient à déterminer la redevance qui maximise le surplus collectif associé à la cession de la bande de fréquences pour cette technologie.

Dans le cas où plusieurs technologies sont envisageables pour la même bande de fréquences, la valeur économique totale est le maximum des redevances associées aux différentes utilisations.

Lors de la cession d’une bande de fréquences, pour une technologie donnée, 3 parties prenantes sont à considérer :

– L’Affectataire,

– L’opérateur potentiel,

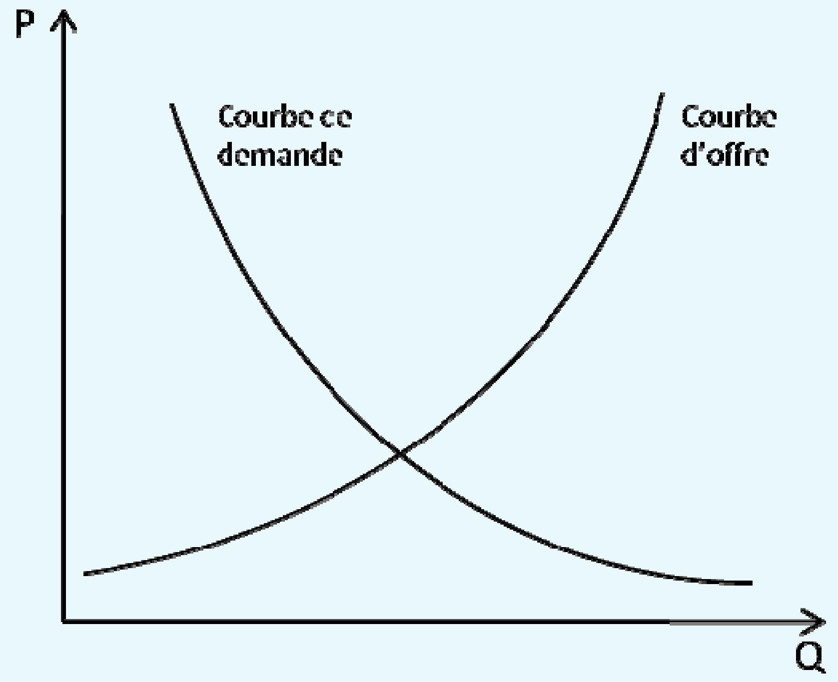
– Le consommateur final.

Le surplus social est alors la somme du surplus de l’affectataire, du surplus de l’opérateur et du surplus du consommateur.

Dans l’opération, le surplus de l’Affectataire est donné par la formule suivante où R est la redevance perçue par l’Affectataire de la part de l’opérateur et Cd le coût de déménagement supporté par l’Affectataire, c’est à dire les dépenses que devrait supporter l’Affectataire pour déménager ces équipements sur une autre bande de fréquence :

$$Surplus_{MinDef} = R - C_d$$

Lorsque l’on considère la courbe de demande ci-dessous, il est possible de déterminer les valeurs du surplus de l’opérateur ainsi que le surplus du consommateur final



- Q : quantité,
- *P*: prix,
- *R*: redevance,
- $C_{Variable}$: Coût de production,
- C_d: Coût de déménagement,
- *M*: marge de l'opérateur.

$$Surplus_{Opérateur} = P(Q) \times Q - (R + C_{Variable}(Q))$$

L'idée générale de maximiser le surplus social est alors exprimé de la manière suivante:

$$\underset{Q}{Max}(Surplus_{Social}) = \underset{Q}{Max}(Surplus_{MinDef} + Surplus_{Opérateur} + Surplus_{Consommateur})$$

Par la suite, l'objectif est de trouver la redevance maximum possible en ajoutant la contrainte de profit de l'opérateur qui s'exprime de la manière suivante M étant la marge en % souhaitée par l'opérateur :

$$P(Q) \times Q \geq (C_{Variable}(Q) + R) \times (1 + M)$$

En prenant la limite de cette contrainte (l'égalité), on peut déterminer pour une valeur de la redevance R donnée une valeur de Q. C'est à dire que l'on obtient Q en fonction de R.

Ensuite pour déterminer la redevance maximale il suffit de trouver la redevance R qui maximise le maximum sur Q du surplus social. C'est à dire déterminer R de :

$$\underset{R}{Max}\left[\underset{Q}{Max}\left[\int_{0}^{Q(R)} P(s)ds - C_{Variable}(Q) - C_d\right]\right]$$

Afin de comparer les valeurs des différentes utilisations possibles d'une même bande de fréquences, on compare leurs redevances associées. Pour être économiquement efficace, l'allocation de la bande de fréquences doit se faire à l'utilisation dont la redevance est maximale.

La valeur économique de la bande correspond alors à la redevance maximale sur l'éventail des utilisations possibles :

$$Valeur_{Bande} = \underset{Ensemble\_des\_utilisations\_possibles}{Max}(R)$$

2.2.2 Méthode PIB/Emploi

Cette méthode se concentre sur l'effet de l'utilisation d'une bande de fréquences sur l'économie à l'échelle du territoire national. Elle n'est pas systématiquement applicable pour chacune des bandes de fréquences de l'Affectataire. En effet, elle nécessite d'avoir une utilisation potentielle dont l'impact est mesurable à grande échelle.

Lorsque c'est le cas, il convient d'étudier les différents impacts apportés par l'apparition d'une technologie sur le PIB. On considère alors, dans un premier temps, l'effet direct sur le PIB lié à la consommation des ménages et aux investissements des opérateurs. Dans un second temps, on étudie l'effet indirect résultant de l'utilisation de nouveaux produits ou services sur le reste de l'économie. Enfin, on corrige la somme de ces effets directs et indirects par les effets de « déplacement » qui tiennent compte du fait qu'une partie des dépenses des ménages pourraient se tourner vers d'autres secteurs.

Empiriquement, on sait que les deux variables PIB et Emploi sont corrélées. Lorsqu'on a calculé un accroissement de PIB lié à l'utilisation d'une nouvelle application, on peut déterminer l'accroissement du niveau de l'Emploi associé.

Afin de comparer les valeurs des différentes utilisations possibles d'une même bande de fréquence, on compare leurs impacts respectifs sur l'emploi et sur le PIB. Pour être économiquement efficace, l'allocation de la bande de fréquences doit être effectuée au bénéfice de l'utilisation dont l'impact sur le PIB et l'emploi est le plus conséquent.

La valeur économique d'une bande de fréquences dépend donc de son impact mesuré sur le PIB et l'emploi :

$$Valeur(Bande) = fonction(PIB\ Emploi)$$

Conclusion:

On considère donc le coût d'opportunité de la bande de fréquences comme une fonction des valeurs économiques issues des deux méthodes décrites précédemment en 2.1 et 2.2 :

$$Co = fonction\ (R, PIB, Emploi)$$

Lorsqu'une seule méthode est mise en œuvre, on a seulement :

$Co = fonction\ (R)$ ou $Co = fonction\ (PIB\ Emploi)$

2.3 Correction de la valeur

Les méthodes précédentes permettent d'estimer la valeur des bandes de fréquences, cependant, certains paramètres importants peuvent altérer cette valeur. En effet, suivant les contraintes liées à l'utilisation d'une bande de fréquences, sa valeur peut en être modifiée par exemple, une utilisation partagée d'une même bande de fréquences. Suivant l'occupation spectrale de chacune des utilisations et des risques de brouillage, le coût d'opportunité de la bande peut être modifié à la baisse.

D'autre part, si l'Affectataire associe à la cession d'une bande de fréquences des contraintes en termes d'obligation de couverture géographique (80% d'un territoire par exemple), sa valeur économique peut être impactée car les opérateurs intéressés peuvent potentiellement subir des manques à gagner sur certaines zones.

Enfin, si l'on considère une bande de fréquences soumise au marché secondaire, le propriétaire de la bande peut céder tout ou partie de cette bande et tirer des bénéfices supplémentaires de l'acquisition de cette bande. Cet effet aura donc un impact non négligeable sur la valeur économique de la bande.

Les différents paramètres suivants, entre autres, influent sur la valeur économique des bandes de fréquences et doivent donc être considérés pour chacune de celles-ci :

◊ C_d: Coût de déménagement,

◊ C_O: Coût d'opportunité,

◊ C_1: Bande exclusive/partagée,

◊ C_2: Bande avec possibilité de marché secondaire,

◊ C_3: Contraintes liées à l'acquisition de la bande...

$$C_c = \text{fonction} \ (C_o, C_d, C_1, C_2, C_3, ...^*)$$

* *d'autres paramètres pourront être considérés lors de l'étude*

Remarque :

Suivant les bandes de fréquences, l'étude de leurs valorisations n'induit pas la même somme de travail : le calcul du coût d'opportunité d'une bande de fréquence sur laquelle plusieurs technologies sont susceptibles d'être implantées peut s'avérer lourd, tandis que la valeur d'une bande de fréquence sur laquelle aucune technologie n'est prévue sera réduite au coût de déménagement qui sera obtenu sur la base des données « Affectataire ». Une organisation rationnelle des études se doit de prendre en compte ces particularités en priorisant les différentes tâches pour chaque bande de fréquence considérée : une première segmentation des bandes de fréquences pourra être établie par exemple en fonction du nombre et du type d'usage envisagés.

On peut en effet considérer que le calcul de la valeur économique d'une bande de fréquences sera d'autant plus complexe et nécessitera d'autant plus de données que le nombre d'usages potentiels sera important et que les usages potentiels toucheront le public le plus large.

Annex 5: Case studies of methods of calculating spectrum fees

5.1 Case of Bangladesh

The spectrum charges shall be calculated using the following formula.

Spectrum Charges in Taka = STU × CF × BW × AF × BF

where:

i) STU = Spectrum Tariff Unit = Tk. 60.00 per MHz per 5 km^2

ii CF = Contribution Factor for Access Frequency has been fixed considering Assignment of frequency, use of assigned frequency and subscriber base:

Sl. #	Subscriber base related to use of frequency (lower limit inclusive and upper limit exclusive)	CF
1.	From 0 to 2 million	0.70
2.	From 2 to 5 million	1.20
3.	From 5 to 10 million	1.70
4.	From 10 to 15 million	2.20
5.	From 15 to 20 million	2.70
6.	From 20 to 25 million	3.20

iii) CF = Contribution Factor for microwave Frequency = 1

iv) BW = Bandwidth Assigned for Access Frequency in MHz

v) BW = Bandwidth occupied for Microwave Frequency in MHz

vi) AF = Area Factor for Access Frequency = 134 275 km2

vii) AF=Area Factor for Microwave Frequency point-to-point link = Link $Length^2 \times 0.273$ (Minimum distance for Link Length shall be considered from 10 km)

viii) BF = Band Factor:

Sl. #	Band	BF
1.	VLF/LF/MF (3-3 000 kHz)	1.00
2.	HF (3-30 MHz)	1.50
3.	VHF (30-300 MHz)	1.00
4.	UHF1 (300-746 MHz)	0.75
5.	UHF2 (746-2 690 MHz)	0.50
6.	SHF1 (2.69-16 GHz)	0.25
7.	SHF2 (16-31 GHz)	0.15
8.	EHF1 (31-65 GHz)	0.10
9.	EHF2 (65-275 GHz)	0.05

The operators will pay to the BTRC annually spectrum charges as fixed by the BTRC, as given at para-1 above, on a quarterly basis by the 10th day of the month following completion of every quarter. Any payment already made on this account as per previous rate list will be adjusted in the first payment.

The operators shall pay the spectrum charges to the BTRC in the manner and at the rate fixed by the BTRC from time to time. If the operator fails to pay the spectrum charges in time, it shall be liable to pay to the BTRC annually 15% compounded interest on the outstanding amount as compensation.

Short-term charges for new microwave links depending on date of Installation will be applicable as follows:

SL #	Date of installation	Percentage
1.	January-March	100%
2.	April-June	75%
3.	July-September	50%
4.	October-December	25%

The Bangladesh Telecommunication Regulatory Commission (BTRC) may review this spectrum charges after two and half years commencing from 1 July 2006.

The above spectrum charges shall remain in force until revised/modified by the BTRC.

A5.2 Case of Maldives

The fees payable for the long term usage of radio frequencies comprises of two main components, namely, the Application & Processing Fee and the Frequency Management Fee.

The details of the Application & Processing Fee, and the Frequency Management Fee are given as follows:

i) Application and Processing Fee – this is a one-time charge payable upon the approval of frequency(s) assignment. The application & processing fee covers the cost of the initial activities performed in assessing the suitability of the frequency to be used for the intended application. Any changes in the technical parameters shall be deemed as a new application.

ii) Annual Frequency Management Fee – this is a recurrent fee payable annually to cover the cost of the activities performed to safeguard the use of the frequency(s).

Frequency fees are separately payable for the allocation and management of frequencies, apart from the station licence fees.

Details of annual fees

	Radio-frequency spectrum	Fee payable per frequency per annum	
1.	Frequencies for networks and systems		
a)	exclusive use		
i)	bandwidth of less than 1 MHz	Rf 1 500 per 25 kHz of occupied bandwidth or part thereof	
ii)	bandwidth of 1 MHz or more	Rf 50 000 for the first MHz of occupied bandwidth, and Rf 10 000 per subsequent MHz of occupied bandwidth or part thereof	
b)	shared use		
i)	bandwidth of less than 300 kHz	Rf 1 500 per 25 kHz of occupied bandwidth or part thereof	
ii)	bandwidth of 300 kHz or more but less than 20 MHz	Rf 20 000	
iii)	bandwidth of 20 MHz or more	Rf 35 000	
2.	Terrestrial broadcasting frequencies		
a)	FM radio broadcasting channels		
i)	National use (one pair)	Rf 100 000	
ii)	Atoll Region	Rf 15 000	
iii)	Malé Region	Rf 30 000	
iv)	Community level	Rf 2 000	
(b)	TV Broadcasting channels		
i)	National use (one pair)	Rf 500 000	
ii)	Atoll Region	Rf 75 000	
iii)	Malé Region	Rf 150 000	
3.	Common frequencies for in-building or onsite wireless systems	*ISM band*	*Non-ISM band*
a)	bandwidth of 20 MHz or less	Rf 300	Rf 600
b)	bandwidth of more than 20 MHz but not exceeding 50 MHz	Rf 600	Rf 1 200
c)	bandwidth of more than 50 MHz	Rf 1 000	Rf 2 000

5.3 Case of Cuba

Spectrum valorization imposed in each scenario, the accounting implementation of its use with regard to the speed evolution and development of the up-to-date radiocommunications. By mean of the tridimensional evaluation (Required bandwidth, associated area, annual part of time) of each frequency assignment of national register, we can obtain a size proportional to the use of each assigned frequency and with additional ponderation index introduction; it is possible to modulate this size to take into account different aspects of the telecommunications policy for various uses and services in the framework of a determined scenario.

By applying this procedure to all assignments included in the national frequency register, it is possible to obtain a reasonable estimate of the value of the authorized and updated radio-frequency spectrum. By linking this result with the annual cost incurred by the administration in connection with national management of the spectrum, with a specified level of efficacy and efficiency, it is possible to calculate the value for the tridimensional weighted unit of authorized spectrum use, which makes it possible to put a value directly on each frequency assignment or group of assignments in a way that is proportional and automatic. Lastly, further readjustments of the values obtained, within acceptable limits, can be obtained in a practicable and simple manner.

Particular attention must be paid to the choice of weighting indicators applied to each frequency assignment. That choice determines the extent to which the model matches the particular conditions of each specific case.

5.4 Case of Democratic Republic of the Congo

In the Democratic Republic of the Congo, spectrum utilization fees are not set based on any market principle, but are often based on international benchmarking.

Their value is then dictated by budgetary considerations at the public authority's level. As its economic value is not known in advance, and is certainly not estimated using any scientific methodology, this resource can represent a profit loss and/or act as a brake to the sector's development should its value be overestimated for budgetary reasons.

For the Congolese regulator, the frequency utilization method retained must take account of the opportunity cost of spectrum occupancy, or "Fees conducive to administrative incentive pricing".

This approach aims to use the price to encourage the efficient use of the spectrum.

In calculating the conducive fees, the regulator plans to take several aspects of spectrum utilization into account, including:

– territory covered;
– possible degree of frequency sharing;
– demographic density;
– authorized power levels;
– bandwidth;
– scarcity of frequencies.

This method, known as the administrative method, essentially takes account of frequency-related criteria, the equipment used and socio-economic criteria.

5.5 Case of Gambia

The following fees should be applied:

1) Application fee for all category of services
2) License Fee
3) Annual Spectrum Fee

The fees recommended should be based on the following service categories:

– Broadcasting:
– Radio
– Television
– Satellite:
– V-SAT Terminal
– Internet service provider
– Wireless cellular operator
– Fixed line operator

- VHF/UHF communication
- Fixed and land mobile services
- Maritime services
- Aeronautical services
- Equipment dealer
- International gateway
- Internet gateway
- Value added network

Annex 6: Setting the price of spectrum

METHODES	SUBJETS	Part of Report
Simple fees	Simple fee to have the right to use the spectrum	IV
Fees based on costs	Based on all the kinds of cost systems	IV
Incitative prices of spectrum (Spectrum « Value »)	– “Economical Variables” to calculate the fees (Formulae) – Bandwidth – exclusivity – geographic location – coverage – etc. – Fees based on brut income – Fees on cost opportunity	IV IV & 3.1 IV & 3.A
Auctions	– Sealed bid (first price) auction – Single round sealed (second price) auction – English or ascending auction – Dutch (descending) auction – English/Dutch auction – Clock auction – Simultaneous multiple-round auction – Sequential/simultaneous open auction	I & 4.3.2 I & 4.3.3 I & 4.3.4 I & 4.3.5 I & 4.3.6 I & 4.3.7 I & 4.3.8 I & 4.3.9
Secondary Market	“Rights to Frequencies Uses”	I & 5

Annex 7: Developing a National Spectrum Handbook: Colombia case

National Spectrum Management (NSM) Handbook for Colombia

I. Introduction

The National Spectrum Agency (ANE) of Colombia has just recently finished the development of the National Spectrum Management (NSM) Handbook for Colombia which contains 8 titles that encompass the multiple activities that national administrations deal with when carrying out spectrum management activities. Taking into account the importance of such a tool for national regulatory agencies, the administration of Colombia decided to present the obtained results to regional and global organizations so that it could be used as a reference by other administrations.

Consequently, ANE proceeded to make the document public through the International Telecommunications Union (ITU) and presented it as a contribution to the ITU-R Working Party 1B meeting held in June 2013.

The document was also presented in the meeting of the Joint Group ITU-D/ITU-R Resolution 9 (Rev. Hyderabad, 2010) also during the meeting held on June 2013. A request from the Joint Group Chairman was received in order to share the Colombian experience in elaborating the Colombian NSM Handbook, how other ITU documents where used for this purpose and how the contents were adapted to the particularities of the Colombian spectrum management framework in order for this information to be included in the Final Report of the Joint Group .

In response to this request, this document describes the background for the development of the NSM Handbook of Colombia, the different stages carried out for the development and completion of the work presented in the Joint Group, a comparison between the Colombian NSM Handbook and the 2005 edition of ITU's NSM handbook and, finally, some useful lessons learned during this work.

Moreover, considering that Colombia is currently developing a proposal to adjust the spectrum fee regime taking into account some principles included in Title VI of the Colombian NSM Handbook, a brief description of the relevant features and elements of the proposal currently under internal discussion is presented at the end of this document.

Finally, it should be noted that the execution of this important document in Colombia, was possible due to the participation of a group of ITU and national experts which gave to this handbook an excellent theoretical and practical level. These experts also achieved the effective adaptation of the contents of the NSM Handbook to the national needs in compliance with current international best practices.

II. Background

Due to the rapid technological changes in the telecommunications industry over the last years, the radioelectric spectrum has played an increasing role on the operation of new telecommunications services and applications. Nevertheless, the rapid changes in technology usually do not allow for national administrations, including the Colombian, to react and to take appropriate actions for achieving the greatest benefits for the community.

Moreover, in relation to spectrum management, Colombia as any other country is immersed in an international environment. Hence, policies and initiatives for the spectrum management in the country must consider the guidelines that have been established by international organizations such as the ITU reflecting best practices for the harmonization in spectrum.

These reasons, in addition to other specific national circumstances, generated the need to adapt to new ways for managing this scarce resource, including providing information about this activities on a more democratic manner.

Therefore, based on the 2005 edition of ITU's NSM Handbook, the Colombian government, recognizing the importance of having a guide that contained legal, economic, scientific, administrative and technical issues that would lead the way for all those involved in spectrum management activities, in 2007 took the decision to develop the NSM Handbook for Colombia. There have been multiple stages that allowed the Colombian Handbook to adapt to the Colombian constitutional and regulatory frameworks.

Thus, the NSM Handbook for Colombia based on ITU's Handbook preserves the thematic structure of the latter in a different order. The contents are initially based on ITU's NSM Handbook with the addition of a deeper and broader scope in order to include latest spectrum management trends. Hence, the Colombian Handbook was enriched based on best international practices regarding new theories, trends and developments on radio spectrum management and expanded by including references from the latest versions of ITU-R Recommendations.

III. Description of Colombian NSM Handbook Development Process

The first stage (2007) determined the structure of the contents taking into account the guidelines of Spectrum Management Handbook developed by ITU. This proposal included the initial definition of an index or table of contents that allowed setting an organized plan on the main issues to be addressed in the preparation and development of the handbook. The result of this phase was a structure model for later developments in various subject areas that should be incorporated into the final document.

The second stage (2008) started by defining the structural aspects of the national spectrum management policy. On this stage recommendations and contents related to the fundamentals for the national spectrum management (Title I), spectrum planning and adjustment and updating of existing frequency plans (Title IV), Spectrum permits and Frequency Assignment Processes (Title III), Radio Spectrum Economics (Title VI) were developed. During this period all the requirements for the joint work with ITU were established in order to make sure the participation of international experts was guaranteed for the development of the next phases of the Handbook .

It is important to mention that, at this point, the work done during the first and second stages were important inputs for the identification and introduction of legal adjustments to the spectrum management framework in the country. Among these adjustments, the most important ones were related to the institutional structure and the economic obligations of operators using spectrum. As a result of this, the new legal framework of the ICT industry issued in 2009 included important elements for improving spectrum management activities such as the creation of the National Spectrum Agency (ANE), a new governmental organization in charge of advising the Ministry of ICTs in all aspects of radio electric spectrum management.

Between 2009 and 2010 the third stage was carried out. On this stage the Colombian government worked with ITU experts in structuring and developing the content of the remaining titles of the Handbook. The work focused on titles related to Radio Spectrum Engineering (Title II), Radio Spectrum Monitoring (Title V), Measurement and Spectrum Efficiency Factors (Title VIII) and Type Approval of Equipment and Devices (Title IX). The work done on this stage was characterized by a deep analysis and research of the aforementioned topics and its adjustment to the national legal framework.

In a fourth stage (2011-2012) modifications and adjustments which came from legal and institutional reforms that took place during the time the handbook was being developed were introduced. The changes brought to the handbook according to new realities, trends and rules that were introduced in the country.

Finally, translations and editing of the documents prepared by the ITU experts were translated to Spanish.

IV. Comparison of ITU´s and Colombia's NSM Handbooks

Features of the NSM Handbook for Colombia: Among the most important, we can highlight the following:

- It deals with topics such as the bases for spectrum management processes formulation and implementation, the latest trends and best practices in spectrum management and their integration into the national activities carried out by the administration.
- It recommends the administrative structure and the authorities directly or indirectly associated with spectrum organization and administration in the country, specifying their objectives, jurisdictions and how they harmonize on behalf of the definition of clear policies for Radio Spectrum management.
- It presents advantages and disadvantages of each one of the spectrum management models, so that administrations can choose the best combination between them, according to their policies and plans.
- It presents guidelines for the definition of spectrum policies to facilitate the adequate planning of the Radio spectrum as a scarce resource, seeking fair access for those who need it.
- It develops from a conceptual standpoint and framed in the international arena, the principles, criteria, and policies for the assignment of frequencies, the duties and powers of the administration.
- It gives the necessary information about how to carry out the radio spectrum planning activities, considering the economic, social and technical components.
- It shows how to define compensations for the use of the Radio Spectrum, based on the variables of the Colombian economy.
- It describes the different tools and establishes the mechanisms for the analysis of engineering and measurement of parameters such as interference, noise levels and radiation limits, among others.
- It presents the characteristics concerning verifications and technical inspections aimed at supervision and control over the use of the resource.

The following chart provides a graphic description of the comparison of contents of both Handbooks:

V. Lessons learned

The development of the NSM Handbook for Colombia has given the following lessons:

a) The handbook is an alive, dynamic and frequently changing tool. Consequently, there is a need for permanent revision and update addressing and introducing systematic and orderly changes and modifications. These reforms can be technical, economical and normative that usually occurs over time.

b) The handbook is an indispensable tool to make a more efficient, transparent and public management of the radio spectrum. At the same time, it constitutes an input for public officers training to perform such duties and also to generate knowledge to the public.

c) The handbook is a multifaceted and interdisciplinary instrument. The handbook covers the technical, economical, administrative, institutional, regulatory and policy aspects related to managing spectrum.

d) The handbook is a useful tool for formulating national policies and for identifying the policies that are in force.

e) The regulatory developments related to spectrum, the national technical plans, the procedures for allocation and assignment of frequencies, must be subsequent demonstrations and practical applications taken from the content of the handbook.

f) To have a national handbook for managing the spectrum allows identifying the policies and common objectives related to the spectrum management activities at a national level that can serve as a support for performing these activities in border regions.

VI. Financial obligations related to the use of spectrum in Colombia

This chapter provides an outline of the work carried out by the Colombian administration in relation to the adjustment and modification of the spectrum fees regime over the past three years. This proposal will be put on consideration of the industry and the public in the second half of 2013 and is expected to be approved and issued before the end of this year.

The analysis carried out for the constructions of this proposal allowed to conclude on the need to adjust the current spectrum management model applied in Colombia in order to develop a more flexible model in Colombia. In the short term the proposed model will introduce incentives to promote a more efficient use of the spectrum. Consequently, the Colombian administration is preparing the context for greater flexibility on the use of the spectrum and in the medium term a partial liberalization scenario is expected to be put in place.

This aspect is consistent with the recommendations contained in the ITU Spectrum Management Handbook which encourage policies for the flexible use of spectrum because it promotes the development of services and technologies.

Following there is a brief description of the general aspects of the current spectrum fees regime. Also, a brief review is made about the main characteristics of the proposal that the Colombian government has built to adapt and adjust this regime to the changing needs of the industry according to best international practices.

A) Overview of the current regime

The spectrum fees regime for Colombia considers two groups of rules associated with the type of frequency bands, differentiating whether they have been identified for IMT or not.

IMT Bands: The rules for the allocation of frequencies and the granting of permits for use of the spectrum in these bands are developed through "objective selection" mechanisms. Auctions are usually used as a market mechanism to fix the value to be paid for the rights to use these frequencies. In this sense, there is no specific fee determined for all IMT frequency bands as their valuation is determined whenever the conditions of the assignment process are established.

Other frequency bands: The second group corresponds to the bands that have not been identified as IMT bands. Its rules are contained in the current fee regime which it is under review. The main characteristics of this regime are:

a) Spectrum fees are determined through an algorithm that takes into account a number of variables that describe the characteristics of the services associated to the spectrum licence.

b) The calculation formulas have been defined based on different criteria such as: the frequency band, the type of link and/or the type of service. Therefore, the current rules have four different algorithms for the calculation of the spectrum fees:

    a) Spectrum in the **HF band**

    b) Algorithm for **Point to Point** (Microwave) links - Algorithm for **Point to Multipoint** services

    c) **Satellite segments**.

c) The current formulas for the calculation of the spectrum fees for these four categories take into account different technical variables like bandwidth, frequency and coverage. The calculation also includes as a monetary unit the minimum legal wage. This allows to annually update the values according to the behavior of the Colombian economy.

d) There is a special and separate regime for broadcasting services which contains its own algorithm for calculation and for different types of existing stations.

B) Description of the proposed regime

The following segment describes the principles and attributes for the proposed regime, its objectives and the different variables or parameters that are being considered in order to estimate the fees associated to the use of radio spectrum and the mathematical expressions for calculations of the spectrum fees for multiple types of services or applications.

1. Principles and attributes

- **Principles and general attributes:**
    - *Equity in access and use of spectrum*: Every interested party has an equal opportunity of having have access to spectrum.
    - *Predictability*: Allows users of the spectrum to identify in advance the obligations that entail the right to use the resource, especially the financial obligations, in order to ensure legal stability.
    - *Transparency*: Allows to all spectrum users (current and potential) to know information related to their rights, obligations, and conditions to have access to the resource. The transparency deals with the simplicity of the rules to establish the fees and of the processes for spectrum fee payment.
    - *Coherence*: An intrinsic relationship between the regime and the policy objectives established for the use of the spectrum must exist.
- **Economic, technical and practical principles and attributes:**
    - *Charging a fee for the use of the spectrum*: The fee must recognize not only the cost incurred by the regulator for its spectrum management activities, but also reflect the value given to the different frequency bands on which the operator will have the right of use..
    - *Technology neutrality***:** The objective is to ensure free technology adoption and to promote the efficiency in the use of spectrum and to ensure free and fair market competition.

- *Simplicity*: The State, as the administrator of spectrum, should ensure the definition of simple formulas for easy application and the settlement of the processes, verification and collection that allows a better understanding of the fees.
- *Visibility and the possibility of making an effective control*: This principle considers the need for incorporating and implementing mechanisms and tools that enable the effective control and monitoring of the regime.

2. Objectives

1) Efficient use of the radio spectrum. This is the main objective of the proposed regime. Therefore, the proposal has included various criteria in order to implement it. Among them the following are the most important guidelines used for the definition of conditions for establishing spectrum fees:
   - To promote efficiency of use and scale;
   - To promote return of underused frequencies by providing clear mechanisms to be used by users;
   - To encourage migration to frequencies which have less congestion, by introducing a congestion factor depending on variables such as the geographic location, and availability of frequencies among others;
2) Contributing to finance social plans in order to promote massive use of telecommunications services (broadband, mobile, etc.).
3) To compensate the costs of the spectrum management**.**

C) Algorithms of calculation in the proposal: It Includes only those algorithms that will change:

- Point to Point Links:

$$VAC = AB\ x\ Fv\ x\ Fc\ x\ SMMLV$$

Where:

AB: Bandwidth

Fv: Factor to evaluate the frequency

Fc: Congestion factor

SMMLV: Monthly Legal Minimum Wage

- Point – multipoint Links

$$VAC = AB\ x\ N\ x\ \%Pob\ x\ Fc\ x\ SMMLV$$

Where:

AB: Bandwidth

N: Factor to evaluate the frequency

%Pob: Population Percentage calculated as the potential population to cover with the permit compared to the total population

Fc: Congestion factor

SMMLV: Monthly Legal Minimum Wage

D) Congestion factor

The Colombian model currently lacks of significant variables which are capable of encouraging the efficient use of the spectrum. The objective of including this variable is to promote relocation of users to less occupied bands by increasing the fees for congested bands.

Therefore, incorporating a congestion factor has been considered consistent with the main objective of the spectrum fees regime. The purpose of the factor is to show the demand towards certain types of bands, and to make a difference depending on the use of the spectrum.

The congestion factor requires for the administration to determine the level of congestion. Consequently, a specific study will be carried out to analyze the geographic scope and intensity of the current use of the spectrum. The goal is to obtain a matrix determining congestion by frequency and geographic location, which should be updated periodically.

One of the main issues in developing this variable is determining the degree of substitution in the use of multiple bands for the same services, which needs to be aligned with all spectrum planning analysis and decisions. The analysis of the degree of substitution shall determine, apart from the technical issue, the economic cost which would be different depending on the band of frequency. This will be the input to define the incentives for the use of bands in non-congested areas.

Annex 8: Contributions list (2010-2014 Study Period)

I. Meeting of the Joint Group on Resolution 9 (16 September 2010)

1.1 Agenda

Web	Received	Source	Title	Questions
OJ 11	2010-08-06	Telecommunication Development Bureau	Draft Agenda of the Rapporteur's Group meeting on Resolution 9 Thursday 16 September 2010, 0930 – 1045 hours	RES9

1.2 Contributions

Web	Received	Source	Title	Questions
C 7	2010-08-24	Radiocommunication Study Group	Reply to Liaison Statement to ITU-D SG 2 Resolution 9 (Rev. Doha, 2006), Draft Guidelines for the Establishment of a System of Fees (Copy for information To WPs 1B and 1C)	RES. 9, LS
C 31	2010-09-02	BDT Focal Point for Resolution 9	New Study Period for Resolution 9	RES.9
C 59	2011-06-02	ITU-D Study Group 2	Participation of countries, particularly developing countries, in spectrum management	LS, RES.9
C 60	2011-06-02	Radiocommunication Bureau (BR)	Liaison Statement to ITU-D Study Group 2: Nomination of Co-Chairmen of the Joint Group on ITU-D Resolution 9 (Rev. Hyderabad, 2010)	LS, RES.9
C 61	2011-06-02	Co-Chairman of the Joint Group on Resolution 9	Programme de travail pour la Résolution 9 (Rev. Hyderabad, 2010)	WP, RES.9

1.3 Information documents

Web	Received	Source	Title	Questions
INF 5	2010-08-03	Eritrea	Resolution 9 (Rev. Doha, 2006)	RES. 9

1.4 Meeting Report

Web	Received	Source	Title	Questions
R0	2010-09-16	Co-Chairman of the Joint Group on Resolution 9	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), 16 September 2010	RES. 9

II. Meeting of Joint Group on Resolution 9 (6 and 7 June 2011)

2.1 Agenda

Web	Received	Source	Title	Questions
OJ 1	2011-03-16	ITU-D Co-Chairman, Joint Group on Resolution 9	Draft agenda of the meeting of the Joint Group on Resolution 9 (Geneva, Monday, 6 June 2011 - Tuesday, 7 June 2011)	RES9

2.2 Contributions

Web	Received	Source	Title	Questions
C 1	2011-03-16	ITU-D Co-Chairman of the Joint Group on Resolution 9	Draft agenda of the meeting of the Joint Group on Resolution 9, Monday, 6 June 2011, 0930 – 1230 hours and 1430 – 1730 hours, and Tuesday, 7 June 2011, 0930 – 1230 hours and 1430 – 1730 hours	RES.9
C 2	2011-04-21	Maldives	Spectrum Fees	RES.9
C 3	2011-05-27	Gambia	Proposed Fees Structure for the Gambia	RES.9
C 4	2011-05-30	Co-Présidente du Groupe de travail sur la Résolution 9	Projet de Rapport intermédiaire	RES.9
C 5	2022-06-01	BDT Focal Point for Resolution 9	Resolution 9 and BDT activities on spectrum management	RES.9
C 6	2011-06-01	Dem. Rep. of the Congo	Gestion du spectre et méthodes de calcul des redevances d'utilisation du spectre en RDC	RES.9
C 7	2011-06-03	BR Focal Point for Resolution 9	Preparations for RA-12 and WRC-12	RES.9

2.3 Information documents

Web	Received	Source	Title	Questions
INF 1	2011-05-05	Cuba	Resumen de la experiencia desarrollada en el Ministerio de la Informática y las Comunicaciones (MIC) para la "Evaluación del uso del espectro radioeléctrico" destinado a radiocomunicaciones	RES.9
INF 2	2011-05-19	Bangladesh	Spectrum assignment procedure and spectrum pricing formula in Bangladesh	RES.9
INF 3	2011-06-03	Telecommunication Development Bureau (BDT)	List of documents related to Resolution 9 (Rev. Hyderabad, 2010) for consideration during the September 2010 and June 2011 meetings	RES.9

2.4 Meeting Report

Web	Received	Source	Title	Questions
R1	2011-06-21	Co-Chairman of the Joint Group on Resolution 9	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), 6 June 2011	RES. 9

III. Meeting of Joint Group on Resolution 9 (12 September 2011)

3.1 Agenda

Web	Received	Source	Title	Questions
OJ 11	2011-08-31	ITU-D Co-Chairman, Joint Group on Resolution 9	Draft Agenda of the meeting of the Joint Group on Resolution 9 (Hyderabad, 2010) Monday, 12 September 2011, 1115-1230	RES9

3.2 Contributions

Web	Received	Source	Title	Questions
[C 126] +Ann.	2011-09-10	BDT Focal Point for Resolution 9	BDT Spectrum Management Assessments and Other Assistance	RES.9
[C 110] +Ann.1	2011-08-24	Côte d'Ivoire (Republic of)	Etablissement du tableau national de répartition du spectre de la Côte d'Ivoire	RES.9
[C 107]	2011-08-10	Eritrea	Eritrea's Input to the Work of Resolution 9	RES.9
[C 75] (Rev.1-2)	2011-06-27	ITU-D Co-Chairman, Joint Group on Resolution 9	Draft interim report	RES.9
[C 74]	2011-06-27	Democratic Republic of the Congo	Spectrum management and methods for calculating spectrum usage fees in DRC	RES.9
[C 73]	2011-06-27	Cuba	Summary of the experience acquired by the Ministry of Computer Science and Communications (MIC) in regard to "Evaluation of radio-frequency spectrum usage" for radiocommunications	RES.9
[C 72]	2011-06-20	ITU-R Co-Chairman, Joint Group on Resolution 9	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), Geneva, 6 June 2011	RES.9
[C 61] (Rev.1-2)	2011-06-02	ITU-D Co-Chairman, Joint Group on Resolution 9	Programme de travail pour la Résolution 9 (Rev. Hyderabad, 2010)	WP, RES.9

3.3 Documents for information

[INF 30]	2011-08-08	Cuba	Valoración del uso del espectro radioeléctrico destinado a radiocomunicaciones.	RES.9

3.4 Meeting Report

[R 12] (Rev.1)	2011-09-12	ITU-D Co-Chairman, Joint Group on Resolution 9	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), Geneva, 12 September 2011, 1115 - 1230	RES.9

IV. Meeting of Joint Group on Resolution 9 (21 September 2012)

4.1 Agenda

Web	Received	Source	Title	Questions
OJ 1	2012-08-06	Chairman, ITU-D Study Group 2	Draft Agenda for the ITU-D/ITU-R Joint Group Meeting for Resolution 9 (Rev. Hyderabad, 2010), Geneva, Geneva, Friday 21 September 2012.	RES9

4.2 Contributions

Web	Received	Source	Title	Questions
C 9	2012-07-19	BDT Focal Point for Resolution 9	BDT Spectrum Management Assessment and other Assistance	RES.9
C 10	2012-07-23	Eritrea	Eritrea's Input for the Work of Resolution 9	RES.9
C 11	2012-08-08	Chairman, ITU-D Study Group 2	Draft interim report	RES.9
C 12	2012-08-17	Hungary	Conception of the STIR Frequency Management IT System	RES.9
C 13	2012-09-05	Radiocommunication Bureau	Outcomes of the June 2012 meetings of ITU-R Study Group 1 and Report ITU-R SM.2012	RES.9
C 14	2012-09-17	Radiocommunication Bureau	Presentation on WRC-12 outcomes and preparation for RA-15 & WRC-15	RES.9

4.3 Meeting Report

Web	Received	Source	Title	Questions
R3	2012-09-21	Chairman, ITU-D Study Group 2	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), Friday 21 September 2012	RES. 9

V. Meeting of the Joint Group on Resolution 9 (6 June 2013)

5.1 Agenda

Web	Received	Source	Title	Questions
OJ 2 Rev 1	2013-05-23	ITU-D Co-Chairman, Joint Group on Resolution 9	Draft Agenda for the ITU-D/ITU-R Joint Group Meeting on Resolution 9 (Rev. Hyderabad, 2010) Geneva,	RES9

5.2 Contributions

Web	Received	Source	Title	Questions
C 16 + Add1	2013-05-06	Thales (Communications)	Draft interim report (French and English versions)	RES.9
C 17 +Add1	2013-05-23	BDT Focal Point for Resolution 9	ITU spectrum management training program	RES.9
C 18 + Add1	2013-05-23	BDT Focal Point for Resolution 9	Spectrum management trends towards 2020	RES.9
C 19 + Add1	2013-05-23	BDT Focal Point for Resolution 9	Digital dividend report - Insights for spectrum decisions	RES.9
C 20 + Add1	2013-05-27	Colombia (Republic of)	Presentation of the spectrum management handbook developed by the Administration of Colombia	RES.9
C 21	2013-05-28	European Communications Office	EFIS presentation	RES.9
C 22	2013-06-05	ITU-R Study Groups - Working Party 5A	Liaison Statement from ITU-R WP5A to ITU-D SG 2 on the Use of spectrum and radio technology low cost sustainable telecommunication infrastructure for rural communications in developing countries	RES.9 + Q 10-3/2 LS
C 23 + Add 1	2013-06-06	ITU-D Co-Chairman, Joint Group on Resolution 9	Input for revised version of draft interim report	RES.9

5.3 Meeting Report

Web	Received	Source	Title	Questions
R3	2013-06-18	ITU-D Co-Chairman of the Joint Group on Resolution 9	Report of the Meeting of the Joint Group on Resolution 9 (Rev. Hyderabad, 2010), Geneva, Thursday, 13 June 2013	RES. 9

VI. Meeting of the Joint Group on Resolution 9 (16 September 2013)

6.1 Agenda

Web	Received	Source	Title	Questions
OJ	2013-	ITU-D Co-Chairman, Joint Group on Resolution 9		RES9

6.2 Contributions

Web	Received	Source	Title	Questions
[C 326]	2013-08-29	Colombia (Republic of)	Manual de espectro colombiano y contraprestaciones a grupo	RES.9
[C 306]	2013-07-22	ITU-R Study Groups - Working Party 5D	Liaison Statement from ITU-R WP5D to ITU-D Study Group 2 on the use of spectrum and radio technology low cost sustainable telecommunication infrastructure for rural communications in developing countries	RES.9, Q10-3/2, Q09-3/2, LS
[C 294]	2013-07-12	Egypt (Arab Republic of)	Case Study: 3G Auction	RES.9
[C 279] +Ann.1	2013-07-12	ITU-D Co-Chairman, Joint Group on Resolution 9, THALES Communications	Draft Report on WTDC Resolution 9 (Participation of countries, particularly developing countries, in spectrum management) (Rev. Hyderabad 2010)	RES.9
[C 267]	2013-06-05	ITU-R Study Groups - Working Party 5A	Liaison Statement from ITU-R WP5A to ITU-D SG 2 on the Use of spectrum and radio technology low cost sustainable telecommunication infrastructure for rural communications in developing countries	RES.9, Q10-3/2, LS
[C 264]	2013-09-16	ITU-D Co-Chairman, Joint Group on Resolution 9	Report of the ITU-D/ITU-R Joint Group Meeting for Resolution 9 (Rev. Hyderabad, 2010), Geneva, 13 June 2013	RES.9

6.3 Meeting Report

Web	Received	Source	Title	Questions
[R 42]	2013-09-16	ITU-D Co-Chairman of the Joint Group on Resolution 9	Report of the ITU-D/ITU-R Joint Group Meeting for Resolution 9 (Rev. Hyderabad, 2010), (Geneva, Monday, 16 September 2013, 14:30-15:45 hours)	RES. 9

VII. Resolution 9 Reports from the previous Study Period (2006-2010)

Web	Finalized	Title
Report	2010	Report on Resolution 9 (Rev. Doha, 2006): Participation of countries, particularly developing countries in spectrum management
Guidelines	2010	Guidelines for the establishment of a coherent system of radio-frequency usage fees (separate publication to Resolution 9 report)

International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Office of the Director
Place des Nations
CH-1211 Geneva 20 – Switzerland
Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Deputy to the Director and Director，Administration and Operations Coordination Department (DDR)
Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5784
Fax: +41 22 730 5484

Infrastructure Enabling Environmnent and e-Applications Department (IEE)
Email: bdtiee@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Innovation and Partnership Department (IP)
Email: bdtip@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Project Support and Knowledge Management Department (PKM)
Email: bdtpkm@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia
International Telecommunication Union (ITU)
Regional Office
P.O. Box 60 005
Gambia Rd., Leghar ETC Building
3rd floor
Addis Ababa – Ethiopia
Email: itu-addis@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé – Cameroon
Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal
Union internationale des télécommunications (UIT)
Bureau de zone
19, Rue Parchappe x Amadou Assane Ndoye
Immeuble Fayçal, 4e étage
B.P. 50202 Dakar RP
Dakar – Senegal
Email: itu-dakar@itu.int
Tel.: +221 33 849 7720
Fax: +221 33 822 8013

Zimbabwe
International Telecommunication Union (ITU)
Area Office
TelOne Centre for Learning
Corner Samora Machel and Hampton Road
P.O. Box BE 792 Belvedere
Harare – Zimbabwe
Email: itu-harare@itu.int
Tel.: +263 4 77 5939
Tel.: +263 4 77 5941
Fax: +263 4 77 1257

Americas

Brazil
União Internacional de Telecomunicações (UIT)
Regional Office
SAUS Quadra 06, Bloco “E”
11º andar, Ala Sul
Ed. Luis Eduardo Magalhães (Anatel)
70070-940 Brasilia, DF – Brazil
Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados
International Telecommunication Union (ITU)
Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown – Barbados
Email: itubridgetown@itu.int
Tel.: +1 246 431 0343/4
Fax: +1 246 437 7403

Chile
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Casilla 50484, Plaza de Armas
Santiago de Chile – Chile
Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Palmira, Avenida Brasil
Ed. COMTELCA/UIT, 4.º piso
P.O. Box 976
Tegucigalpa – Honduras
Email: itutegucigalpa@itu.int
Tel.: +504 22 201 074
Fax: +504 22 201 075

Arab States

Egypt
International Telecommunication Union (ITU)
Regional Office
Smart Village, Building B 147, 3rd floor
Km 28 Cairo – Alexandria Desert Road
Giza Governorate
Cairo – Egypt
Email: itucairo@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia and the Pacific

Thailand
International Telecommunication Union (ITU)
Regional Office
Thailand Post Training Center, 5th floor,
111 Chaengwattana Road, Laksi
Bangkok 10210 – Thailand

Mailing address
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210 – Thailand
Email: itubangkok@itu.int
Tel.: +66 2 575 0055
Fax: +66 2 575 3507

Indonesia
International Telecommunication Union (ITU)
Area Office
Sapta Pesona Building, 13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10001 – Indonesia

Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta 10001 – Indonesia
Email: itujakarta@itu.int
Tel.: +62 21 381 3572
Tel.: +62 21 380 2322
Tel.: +62 21 380 2324
Fax: +62 21 389 05521

CIS countries

Russian Federation
International Telecommunication Union (ITU)
Area Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

Mailing address:
P.O. Box 25 – Moscow 105120
Russian Federation
Email: itumoskow@itu.int
Tel.: +7 495 926 6070
Fax: +7 495 926 6073

Europe

Switzerland
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Europe Unit (EUR)
Place des Nations
CH-1211 Geneva 20 – Switzerland
Switzerland
Email: euregion@itu.int
Tel.: +41 22 730 5111

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

Printed in Switzerland
Geneva, 2014

01/2014