International Telecommunication Union

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Economic aspects of spectrum management

SM Series

Spectrum management

International Telecommunication Union

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***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R SM.2012-3

Economic aspects of spectrum management

(1997-2000-2004-2010)

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PREFACE

The initial version of Report ITU-R SM.2012 – Economic aspects of spectrum management, was issued in 1998 and revised in 2001 and 2002 in order to include summaries of experiences obtained on this subject by a number of administrations.

As with the previous version, this new revision of the Report describes the different economic approaches for spectrum management activities based on new experiences of administrations. However, it now also includes the factors to be taken into account in an international comparison of fee levels, as well as guidelines on methodologies for the establishment of spectrum fees formula and system. It is the result of successful cooperation between ITU-R and ITU-D work on spectrum fees.

The Report is intended for the use by administrations of both developing and developed countries in formulating strategies on economic approaches to national spectrum management and financing this activity. In addition, the Report presents an analysis of the benefits of strategic development and the methods of technical support for national spectrum management. These approaches not only promote economic efficiency but can also promote technical and administrative efficiency.

François Rancy

Director Radiocommunication Bureau

FOREWORD

As we begin the second decade of the Twenty-first Century, many nations face significant economic challenges. The potential of information and communications technology (ICT) to stimulate national economic growth, along with the present worldwide demand for wireless services, makes this a fitting time for publication of a new revision of the ITU-R Report on the economic aspects of spectrum management.

ITU-R Study Group 1 was not alone in the development of this revision, as ITU-D Study Group 2 and the Joint Group on WTDC Resolution 9 also played a significant role. Study Group 1 is pleased to continue this cooperation on WTDC Resolution 9 and in other efforts providing spectrum management assistance to developing countries.

Though a number of administrations contributed to the development of this revision, I would like to specifically recognize Mr. Sergey Pastukh (Russian Federation), Vice-Chairman of Study Group 1 and Chairman of Working Party 1B, and Mr. Hasan Sharif (United Arab Emirates), Chairman of the Working Party 1B Correspondence Group, for their leadership in this effort.

Robin H. Haines

Chairman, Radiocommunication Study Group 1

Scope

The objective of this economic study is to respond to the following issues which are divided into three categories:

Category 1**:** Strategies for economic approaches to national spectrum management and their financing

1. What are the underlying principles that have been taken into consideration by various administrations in their approaches to financing the maintenance and development of national spectrum management?
2. What economic approaches have been, or are intended to be used to promote efficient national spectrum management in different frequency bands?
3. What are the advantages and disadvantages of these various economic approaches to national spectrum management?
4. What are the factors (e.g. geographical, topographical, infrastructural, social, legal) that could affect these approaches and how would they vary with the use of radio in a country and the level of that country's development?

Category 2**:** Assessment, for spectrum planning and strategic development purposes, of the benefits arising from the use of the radio spectrum

1. What are the benefits that accrue to an administration from the use of radio within its country and how can they be quantified, allowing them to be represented in an economic form so as to enable a comparison of the benefits and costs of particular spectrum management options (e.g. in terms of employment or Gross Domestic Product)?
2. What models can be used to represent these benefits in an economic form and how can they be validated?
3. What factors could affect the benefits accruing to an administration from the use of the radio-frequency spectrum, including by national safety services?
4. How would the factors in § 3 vary from country to country?

Category 3**:** Alternative methods of national spectrum management

1. What are alternative spectrum management approaches including the use of non-profit making user groups and private sector spectrum management organizations?
2. How can these approaches be categorized?
3. Which of these alternative spectrum management approaches would be responsive to the needs of the developing countries as well as for the least developed ones?
4. What measures, of a technical, operational and regulatory nature, would it be necessary for an administration to consider implementing when adopting one or more of these spectrum management approaches in the context of:
   - the country's infrastructure;
   - national spectrum management;
   - regional and international aspects (e.g. notification, coordination, monitoring)?

Further information is likely to be submitted that is relevant to this Report and that information will be included in future revisions as appropriate.

CHAPTER 1

Introduction to economic considerations

1.1 Need for spectrum economic approach

The increasing use of new technologies has produced tremendous opportunities for improving the communications infrastructure of a country and the country's economy. Further, the ongoing technological developments have opened the door to a variety of new spectrum applications. These developments, though often making spectrum use more efficient, have spurred greater interest and demand for the limited spectrum resource. Thus, the efficient and effective management of the spectrum, while crucial to making the most of the opportunities that the spectrum resource represents, grows more complex. Improved data handling capabilities and engineering analysis methods are key to accommodating the number and variety of users seeking access to the spectrum resource. If the spectrum resource is to be used efficiently and effectively, the sharing of the available spectrum has to be coordinated among users in accordance with national regulations within national boundaries and in accordance with the Radio Regulations (RR) of the International Telecommunication Union (ITU) for international use. The ability of each nation to take full advantage of the spectrum resource depends heavily on spectrum managers facilitating the implementation of radio systems, and ensuring their compatible operation. Furthermore, the imbalance between the demand for radio frequencies and the availability of spectrum keeps growing, especially in urban areas. According to economic theory, when demand exceeds supply, a price system should be implemented. As the frequency spectrum is a scarce resource, decisions concerning spectrum management should also consider the economic point of view. Therefore, to improve national spectrum management all available means including economic methods are needed.

This Report has been developed to assist administrations in the development of strategies on economic approaches to national spectrum management and their financing. In addition, the Report presents a discussion of the benefits of spectrum planning and strategic development and the methods of technical support for national spectrum management. These approaches not only promote economic efficiency but can also promote technical and administrative efficiency.

Before the economic approaches can be discussed it is first necessary to consider what is an effective spectrum management system and what areas of spectrum management can be appropriately supported by other means.

1.2 Requirements for national spectrum management

Effective management of the spectrum resource depends on a number of fundamental elements. Although no two administrations are likely to manage the spectrum in exactly the same manner, and the relative importance of these fundamental elements may be dependent on an administration's use of the spectrum, they are essential to all approaches. For further information on spectrum management functions see the ITU Handbook on National spectrum management.

1.3 Goals and objectives

In general, the goals and objectives of the spectrum management system are to facilitate the use of the radio spectrum within the ITU Radio Regulations and in the national interest. The spectrum management system must ensure that adequate spectrum is provided over both the short and long term for public service organizations to fulfil their missions for public correspondence, for private sector business communications, and for broadcasting information to the public. Many administrations also place high priorities on spectrum for research and amateur activities.

In order to accomplish these goals, the spectrum management system must provide an orderly method for allocating frequency bands, authorizing and recording frequency use, establishing regulations and standards to govern spectrum use, resolving spectrum conflicts, and representing national interests in international fora.

1.3.1 Radiocommunications law

The use and regulation of radiocommunications must be covered within each nation's laws. In areas where radiocommunications use is not extensive, and where the need for management of the spectrum may not yet be crucial, national governments must still anticipate the increase of radio use and ensure that an adequate legal structure is in place.

1.3.2 National allocation tables

A national table of frequency allocations provides a foundation for an effective spectrum management process. It provides a general plan for spectrum use and the basic structure to ensure efficient use of the spectrum and the prevention of RF interference between services nationally and internationally.

1.4 Structure and coordination

Spectrum management activities may be performed by a government body or by a combination of government bodies and private sector organizations. Which government bodies or organizations are given the authority to manage the spectrum, will however, depend upon the structure of the national government itself and will vary from country to country.

1.5 Functional responsibilities

The spectrum management structure is naturally formed around the functions that it must perform. The basic functions are:

– spectrum management policy and planning/allocation of spectrum;
– frequency assignment and licensing;
– standards, specifications, and equipment authorization;
– spectrum control (enforcement and monitoring);
– international cooperation;
– liaison and consultation;
– spectrum engineering support;
– computer support;
– administrative and legal support.

Administrative and legal support functions will necessarily be a part of the spectrum management organization, but they are common to all organizations and thus it is not necessary to discuss these in relation to spectrum management.

1.5.1 Spectrum management policy and planning/allocation of spectrum

The national spectrum management organization should develop and implement policies and plans relating to the use of the radio spectrum, taking into account advances in technology as well as social, economic and political realities. National radiocommunications policy is commonly associated with regulation development because the regulations generally follow the establishment of policies and plans. Accordingly, it is often a primary function of the policy and planning unit to conduct studies to determine existing and future radiocommunications needs of the country and to develop policies to ensure the best combination of radio and wireline communications systems employed in meeting the identified needs.

The primary result of the planning and policy-making effort is the allocation of frequency bands to the various radio services. The designation of frequency bands for specific uses serves as the first step to promoting spectrum use. From allocation decisions follow further considerations such as standards, sharing criteria, channelling plans and others.

1.5.2 Frequency assignment and licensing

Providing or assigning frequencies represents the heart of the daily operation of the spectrum management organization. The frequency assignment unit performs, or coordinates the performance of, whatever analysis is required to select the most appropriate frequencies for radiocommunications systems. It also coordinates all proposed assignments with regard to existing assignments.

1.5.3 International cooperation

Radiocommunications have a significance that goes beyond the borders of each nation. Navigation equipment is standardized to allow movement throughout the world. Satellite system transmissions facilitate worldwide communications. Radio wave propagation is unhindered by political boundaries. Communications system manufacturers produce equipment for many markets, and the more the markets encourage commonality the simpler and less expensive the production process will be. For each of these reasons, the national spectrum manager’s ability to participate in international fora becomes significant. International activities include those within the ITU, those within other international bodies, and bilateral discussions between neighbouring countries concerned with ITU Radio Regulations.

1.5.4 Liaison and consultation

In order to be effective, the spectrum management organization must communicate with and consult its constituents, i.e. the radio users composed of businesses, the communications industry, government users and the general public. This includes dissemination of information on the policies, rules and practices of the administration and provides mechanisms for feedback to evaluate the results of these policies, rules and practices.

1.5.5 Spectrum engineering support

Since spectrum management involves decisions pertaining to a field of technology, engineering support is required to adequately evaluate the information, capabilities and choices involved. Engineering support can assist the spectrum manager in many ways. For example, interference situations can often be prevented or resolved through technical analysis. The equipment specifications and standards necessary to ensure compatibility between systems can be determined. Frequencies can be assigned using models or methods developed through engineering support. Also, the resolution of many spectrum allocation issues can be facilitated by analysis of spectrum use and future requirements.

1.5.6 Computer support

The extent to which computer support facilities are available to be used and are used by the spectrum management authority depends on the resources, priorities, and particular requirements of the country concerned. Computer support may cover licensing records to complex engineering calculations and may include the development, provision, and maintenance of support facilities for nearly all spectrum management activities, including record keeping, forecasting and financial management related to licensing.

1.6 Performance of spectrum management functions

The previously described spectrum management functions need to be established in order to have an effective spectrum management system. However not every aspect of each function needs to be performed by the national spectrum management organization. The policy or overall management authority must, however, remain with the national spectrum management organizations. The following Chapters discuss the means by which spectrum management may be funded and the means by which economic approaches may improve the efficiency of spectrum use, methods of assessing the benefits of spectrum use and the use of other organizations to support and/or provide part, or all, of specific spectrum management functions.

CHAPTER 2

Strategies for spectrum financing mechanisms

2.1 Background

There is increasing interest in economic approaches to national spectrum management. This Chapter of the Report addresses issues pertaining both to the principles on financing a national spectrum management program and the strategies. The objective of economic approaches must be consistent with an administration’s spectrum management goals and objectives. When implementing an economic approach, using and managing spectrum efficiently and effectively should be a top priority.

2.2 Basic principles for financing national spectrum management

The following principles should be adhered to when establishing any fee system.

2.2.1 Legal principles

a) The radio-frequency spectrum is the property of the State. Thus, any spectrum occupancy relating to non-governmental activities is considered to be private occupancy.

b) 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.

c) As the owner of the spectrum, the State has the right to require private occupants thereof to pay <u>*spectrum fees*</u> (known also as *spectrum occupancy fees*, *frequency availability fees* or *spectrum usage fees*, or simply as *fees* where there is no ambiguity).

d) The planning, management and monitoring of the spectrum are carried out by the State or by entities to which the State has delegated such responsibilities. Those activities, together with the corresponding equipment and investment, are essential to ensuring that the spectrum is used under satisfactory conditions.

e) It is therefore lawful for the authorities to require, moreover, that private spectrum occupants also pay *administrative fees* (known also as *frequency management fees* or *service fees*, as well as *administrative charges* or, where there is no ambiguity, simply as *charges*) to cover all of the costs arising out of spectrum planning, management and monitoring activities.

f) The establishment of spectrum fees and administrative fees must be carried out with due respect for the rules of transparency, objectivity, proportionality and non-discrimination. Where transparency is concerned, it is particularly important that the rules governing the establishment of fees be simple and readily understandable by all concerned.

g) The rules governing the establishment of fees must be relatively stable over time in order to provide spectrum occupants with the necessary visibility and legal security.

h) In return for the fees they pay, users of assigned or allotted frequencies enjoy protection under the relevant provisions of the regulations in force. By contrast, users of freely accessible frequencies (used, for example, for low-range and low-power sets, WiFi, Bluetooth, amateur radio and radio-controlled models) are not protected and should therefore not be required to pay fees. A reality principle unites with this legal principle to dictate that fees should not be applied to freely accessible frequencies.

2.2.2 Economic principles

a) The frequency spectrum is a limited and, in some cases, scarce resource. The main objectives of the manager are to secure both optimum spectrum occupancy and effective frequency utilization.

b) The reasons for spectrum fees and administrative fees, and the ends to which they are put, are different. That difference should thus be reflected in two distinct approaches for establishing each kind of fee.

c) The sole purpose of administrative fees should be to pay for the service rendered by the authorities.

d) By contrast, the purpose of spectrum fees is multifaceted in that they must:

– enable achievement of the budgetary objective set by the authorities;
– not clash with the economic objectives of the authorities in regard to national development and the development of new services;
– take account of all the benefits that occupants derive from the spectrum;
– constitute a tool for spectrum management.

e) Fees constitute financial resources for the State and for the spectrum manager. The level at which they are set should systematically take account of inflation and the evolving status of the spectrum manager's budget.

2.2.3 Reality principles

a) Fees should not be introduced in cases where those subject to them would be hard to identify individually (for example users of freely accessible frequencies), since their collection would be uncertain and probably very limited in terms of completeness.

b) When choosing the parameters to be used as the basis for fee calculation, those for which it is difficult or impossible in practice to verify the values declared by the users in question (e.g. height of a station antenna or number of mobile stations in a private network) should be avoided. This would reduce the opportunities for making inaccurate declarations in an attempt to reduce the amount payable.

c) The establishment of a fee system should be based on a consensus among all the players, since this would make for a healthy collection rate.

2.2.4 Approaches by different administrations

2.2.4.1 Traditional national budget financing

Until recently, virtually all countries have funded their spectrum management programmes through a centralized national budget process. This approach simply involves allocating a portion of the administration's annual budget to spectrum management. Generally the amount provided depends on the priorities of the national government. In many cases, the national spectrum manager provides estimates of its funding needs. The national government response, however, is limited by its total tax resources.

2.2.4.2 Spectrum use fees

This approach involves charging some or all licensees for their use of the spectrum. Some countries are now funding their spectrum management programmes in whole or in part through fees. In some cases this includes financing a phased implementation of a national spectrum management programme. These fees are based either directly on spectrum use or indirectly through general administrative or regulatory charges. Fees can be established on a variety of bases and formulas for fee calculation can range from the simple to the complex.

2.2.4.3 Auctions

Another way of funding spectrum management is by using a percentage of the money raised through auctions. While no country has directly funded spectrum management through auction revenues only, such revenues in some countries have vastly exceeded spectrum management costs.

2.2.5 Advantages and disadvantages of these approaches

The national budget financing approach has been used successfully in some countries for a number of years. However, it depends heavily on the administration's recognition of the importance of radiocommunications and spectrum management. National governing bodies dealing with a host of national issues are often unfamiliar with spectrum issues or the impact of radio on the national economy. Furthermore, the national budget financing approach does not impose any immediate costs on those who directly benefit from spectrum use, but rather imposes an indirect tax on all citizens. Funding for spectrum management under this approach has often been difficult in developed countries, but may be a particular problem in developing countries, where budgetary resources are limited and where the importance of spectrum-using services to the economy may not be as evident as in developed countries.

The fee approach has also been used successfully in a number of countries, and it has the advantages of pre-determining revenues to be used for spectrum management and imposing costs on at least some entities that benefit from spectrum use. However, because fee levels can be based on a variety of considerations, such as policy direction or payment of administrative costs, determination of the levels for each type of radio use may represent a complex undertaking. Further, the use of fees to cover the cost of administrative processing may prove insufficient by itself to cover the costs of an adequate spectrum management programme. However, fee approaches that cover additional spectrum regulatory costs can be developed to fully fund spectrum management. It should be noted that in addition to fees charged to spectrum users, application fees could be charged for the right to participate in comparative processes, lotteries, or auctions.

Advantages of the auction approach are that it holds potential for an accurate reflection of the value of the spectrum and it imposes costs on those who directly benefit from spectrum use. However, the use of auctions may be viewed as a significant departure from normal practice. Furthermore, a disadvantage of this approach is that revenues are uncertain, and may exceed or fall short of what is needed to adequately fund spectrum management. If revenues exceed what is necessary, a portion of the revenues could be returned to the treasury, which would need to determine how this revenue will be distributed; whereas if revenues fall short, supplementary national budget or licence fee funding would have to be used to maintain all necessary spectrum management functions. Spectrum managers could attempt to ensure that revenues would be sufficient by establishing minimum bid amounts; however, if these amounts were set too high, no bids would be received. Auctions may not be suitable under certain circumstances and may need to be supplemented by other means. Auctions would not be suitable, for example, if there are no competing applicants, if a spectrum right cannot be properly defined, or if the anticipated costs of the auction exceed the anticipated revenues.

2.3 Economic approaches used to promote efficient national spectrum management

Economic (market-based) approaches can be used to improve national spectrum management in a variety of ways. As the term implies, these approaches promote economic efficiency; they also promote technical and administrative efficiency.

For any resource, including the spectrum, the primary economic objective is to maximize the net benefits to society that can be generated from that resource; this is what economists refer to as an economically efficient distribution of the resource. Resources are said to be efficiently distributed, and the overall benefits to society maximized, when it is impossible to redistribute so as to make at least one individual better off without making another worse off. Such a distribution of resources is referred to as the "Pareto Optimality Criterion", in honour of its developer, Italian economist Vilfredo Pareto (1848-1923). Strict adherence to this criterion in decision-making, however, greatly restricts the options available to spectrum managers because there will always be at least one person made worse off by any decision, hence, the less restrictive "Potential Pareto Optimality Criterion" is far more feasible. This criterion states that a redistribution of resources leads to an increase in overall social welfare and therefore should take place if those that are made better off by that redistribution could, in principle, fully compensate those that are made worse off and still receive greater benefits than was the case prior to the redistribution.

A second economic objective relevant to spectrum management is resource rent capture. Economists categorize the value of a resource, be it spectrum, oil, or timber, as a "rent". Rights or privileges to extract oil from the ground have value to companies who can sell that oil to consumers or use it to fuel their vehicles, so too does a right or privilege to use radio spectrum have value to a spectrum user who can sell wireless services (a paging company, for example) or use wireless technologies in the provision of other goods or services (a taxi company, for example). The rent accruing to a resource, including a spectrum licence, can be quantified by the price that the resource would bring in an open market. If a spectrum licensee receives for free a licence that has economic value, the licensee has captured the rent accruing to that licence.

The value of spectrum is reflected in two inherent rents: scarcity rent and differential rent. Scarcity rent exists because demand for spectrum, at least in certain bands and at certain times, exceeds supply at zero price. Differential rent exists because each frequency band possesses specific propagation characteristics that make it suitable for specific services. Having access to the most suitable frequency band could minimize the cost of implementation and optimize the performance of a radio system. Bands that are suitable for many different services using inexpensive equipment are more valuable than bands that are suitable for only one type of service using costly equipment. However, even for the former bands, their non-exclusive use in a particular geographic area may dramatically reduce their value. While some shared use of spectrum may be efficient, where transmitters operate at the same time in the same area and on the same frequency, they may cause mutual harmful interference, thus reducing the band's value in that area at that time.

In theory, both the goals of Pareto Optimality and resource rent capture can be promoted by creating a free market in spectrum. In such a market, all spectrum assignments would consist of well-defined, legal rights of possession that could be transferred, aggregated and sub-divided, and used for any purpose the owner saw fit, so long as this use did not interfere with the possession rights of other spectrum users. However, preventing interference among technically different services (for example, broadcast, mobile, fixed, and satellite) in a spectrum market would require extremely complex engineering analysis, and could lead to litigation among spectrum users. Further, most spectrum managers believe that there are other reasons for imposing some limitations on a spectrum market. These include the following:

– Critical government, scientific research, and other socially desirable requirements may not be adequately satisfied.

– Limits on spectrum aggregation by individual users may be desirable to preclude anti-competitive market dominance by rich users.

– By allocating certain bands to certain uses, whether on a unilateral, national basis or a multilateral, international basis, economies of scale in equipment production may be facilitated.

– Internationally allocated bands for globally mobile spectrum users such as mobile users aboard ships and aircraft help to ensure that multiple transmitters and receivers for the same communications function are not needed on board.

Accordingly, national spectrum managers worldwide have usually chosen to forego an unfettered spectrum market and have allocated frequency bands to particular uses, with varying technical restrictions. However, in the absence of a property rights system, spectrum managers may wish to consider spectrum valuations of competing groups of users – broadcasters versus mobile telecommunications service providers, for example. Without a spectrum market, such valuations can be done only imperfectly, but using market proxies such as estimation of service revenues and impact of the service on gross domestic product and employment can be helpful in generating data for use in making allocation and other spectrum management decisions.

2.3.1 Spectrum assignment methods

After spectrum is allocated to a particular use, it must be assigned to individual users. If demand for a particular frequency band in a particular geographic area is limited, there will be no necessity to resolve mutually exclusive (competing) requests for that band. Accordingly, licences may simply be assigned to applicants upon request, provided that applicants adhere to certain technical standards and regulations. However, if mutually exclusive spectrum requests exist, an assignment method must be used to choose from among competing applicants. Three methods of doing this are comparative processes (such as comparative hearings), lotteries, and auctions.

2.3.1.1 Non-market-based assignment approaches: comparative processes and lotteries

In a comparative process, the qualifications of each of the competing spectrum applicants are formally compared based on established and published national criteria. (Typically, these criteria might include population to be served, quality of service, and speed of service implementation.) The spectrum management authority determines who is the best qualified applicant to use the spectrum and awards the licence. However, comparative processes can be very time-consuming and resource-intensive, may not assign spectrum to those who value it most highly, and may not generate any revenues unless licence fees and/or application fees are charged. Additionally, comparative processes are often decided on the basis of minor differences among applicants, and may cause the decision to be contested by unsuccessful applicants.

In a lottery, licensees are selected at random from among all competing spectrum applicants. Lotteries can decrease some aspects of the administrative burden entailed in comparative hearings, such as legal expenses, but may create a different kind of administrative burden by encouraging more applications to be filed. Additionally, lotteries do not assign spectrum to those who value it most highly, except by chance, lead to significant transaction costs, and again generate no revenues, unless fees are attached to the licence assigned by lottery or an entry fee to participate in the lottery is charged. Rather, lottery winners in many cases transfer their spectrum rights to other parties, thus capturing the resource rents for themselves. Thus lotteries, without significant application fees or other measures that guarantee the applicant's intent to provide radio services, tend to encourage speculation.

While comparative processes and lotteries are not market-based assignment methods, market forces can be brought to bear after the spectrum has been assigned through the establishment of a secondary market (see § 2.3.2).

2.3.1.2 Market-based assignment approach: auctions

In an auction, licences are awarded by bidding among competing spectrum applicants. Auctions award licences to those who value them most highly while simultaneously generating revenues for the spectrum authority. However, as is the case with an unrestricted spectrum market, auctions may raise competitive concerns if not combined with an active competition policy and limits on how much spectrum an entity may purchase. Market forces do not ensure economic efficiency or maximize consumer welfare in markets that are not competitive because a dominant service provider or group of providers have market power. Additionally, auctions may fail to adequately provide certain socially desirable services or distribute licences to certain groups, such as small businesses (if that is an objective). However, "bidding credits" (discounts) and installment payments to selected entities may alleviate these problems. In fact, entities that would have little chance to win in a comparative process or a lottery may be successful in an auction if bidding credits are significant and if installment payments permit licence costs to be paid over a number of years.

Auctions and lotteries may significantly decrease the administrative costs and time associated with the spectrum assignment process and therefore improve overall administrative efficiency in contrast to comparative processes.

2.3.2 Transferable and flexible spectrum rights

While auctions are the assignment mechanism best suited to providing an initial economically efficient distribution of the spectrum resource, they will not ensure that spectrum continues to be used in an economically efficient manner in the future. As with other resources, economists recommend that spectrum users be allowed to transfer their spectrum rights (whether assigned by auction or some other assignment mechanism) and that spectrum users have a high degree of flexibility in the choice of the consumer services that they provide with their spectrum.

The least restrictive form of transferable property rights permits unlimited technical flexibility without regard to an allocation structure, provided that harmful interference is not caused outside the assigned band. This system, if applied to all frequency bands, would result in an unfettered spectrum market. However, as discussed in § 2.3, a totally free market spectrum approach has not been implemented by any country.

The most restrictive form of property rights permits transferability only within the confines of a given allocation and only within strictly defined technical parameters. This system has the advantages of ensuring that the entity within the allocated service who values a particular frequency assignment the most will be able to use that assignment, while minimizing the possibility of interference. However, by restricting technical flexibility to ensure interference control, economic efficiency may also be significantly reduced. Further, if property rights are simply vested in incumbent licensees, any resource rent accruing to a particular frequency assignment is captured by the incumbent, rather than the spectrum management authority, unless the rents have been captured initially via an auction or through licence fees.

The middle course with respect to property rights, and the approach used in some bands by New Zealand, the United States of America, and Australia, is to specify emission rights within a given allocation, which may be broadly defined, for example, broadcasting or mobile radio. This approach can lead to an increase in economic efficiency both because licensees are allowed to adjust their use of inputs in accordance with cost and demand considerations; e.g. a mobile radio provider may be able to satisfy increased demand by using a different modulation technique, and because licensees may freely transfer their frequency rights in whole or in part to entities that value those rights more highly. Hence a tradable spectrum rights system provides licensees with the full incentive to use their spectrum in a technically efficient manner. However, a disadvantage of this approach is that it may increase the potential for harmful interference among licensees because technical inputs are not specified. Specifying licensees' emission rights rather than specifying what inputs licensees must use places a heavier interference control burden on licensees. However, licensees can be allowed to negotiate their emission rights; e.g., one licensee may agree to accept additional interference in exchange for monetary compensation. Dependent upon how often disputes requiring resolution by the spectrum management authority or the courts arise, permitting such negotiations may prove advantageous or disadvantageous.

2.3.3 Advantages and disadvantages of auctions and transferable spectrum rights

Auctions have the advantages of awarding licences to those who value them most highly, while simultaneously generating revenues. When auctions are used to assign licences within a given allocation structure, licences are awarded to those who value them the most only within the confines of the allocation structure. For example, if a particular block of spectrum in a particular area is valued most highly by broadcasters but is allocated to mobile radio, revenues and the economic benefits generated from that spectrum will be less than if broadcasters were allowed to participate in the auction. Broadening the range of uses permitted under an auctioned licence also allows spectrum to be used for those services most in demand. However, broadly defining services has the potential disadvantage of increasing the cost of interference coordination between licensees in adjacent spectrum and areas. These arguments regarding allocation structure apply equally to a system of transferable spectrum rights after the initial spectrum assignment.

Other expected benefits associated with auctions may be fairness, transparency, objectiveness, and the speed with which licenses can be awarded. Auctions can reduce the opportunities for favouritism and corruption in the competition for spectrum, promote investment, and promote technological advancement.

However, in order to promote competition, it may be necessary to impose additional safeguards, for auctioned services. For example, in some situations some or all of the potential bidders may be dominant service providers who are endeavouring to strengthen their monopoly or oligopoly (limited number of competitors) positions. Restrictions on eligibility to participate in an auction or limits on the amount of spectrum that any entity may win can alleviate this problem, although this may limit the number of participants.

Finally, auctions may be inefficient or impractical for certain services or situations. One case is where there is no competition for spectrum. This could occur, for example, with fixed microwave systems where there are many individual links with narrow beamwidths and very exact locations. A second case is where, providers of socially desirable spectrum-using services such as national defence or scientific research may have difficulties in placing a financial value on spectrum which could lead to those services being under-provided to society if all providers of spectrum-using services faced auctions. While ideally these services could be funded to allow participation in spectrum auctions, the prospect of this happening in any country in the near future appears to be remote. Finally, if auctions to license global or regional satellite systems were held in multiple countries, it is likely that potential service providers would have to expend significant resources simply to participate in each auction, and such a cumbersome process could lead to delays in implementing new and innovative services. In addition, sequential auctions would create significant uncertainty for potential service providers because such providers would be unsure that they would win auctions in all countries in which they wish to provide service. If this uncertainty were sufficiently severe, it could impede the provision and the development of international satellite systems under current ITU Radio Regulations.

2.3.4 Licence fees

Licence fees represent another way which can be used to achieve some of the spectrum manager's goals and objectives.

Revenues may be generated and at least some of the resource rent that may exist for use of a particular frequency band in a particular area may be captured by establishing licence fees. (In some administrations fees may cover concessions, authorizations or permissions.) Further, a simple fee structure, such as charging for the direct cost of processing licence applications or charging for the amount of spectrum used, may receive public support because it appears equitable. In addition to auctions, licence fees can also encourage radiocommunications users to make an economically rational choice regarding spectrum use.

Licence fees range in complexity from a simple table by service, to a charge per frequency per station for each service, to complex formulas involving a number of variables. Most countries do not charge government entities for spectrum use, and many also do not charge for other public interest uses, such as by non-profit organizations; however, Australia, Canada, and the United Kingdom, among other countries, do charge government entities.

Licence fees can be efficiently implemented using the following principles:

– Decisions and changes related to fee collection should be undertaken in an open manner through consultation with users and industry.
– Fees should take into consideration, to the maximum extent possible, the value of the spectrum.
– Fee mechanisms should be easy to understand and implement.
– Fees should not be an impediment to innovation and use of new radio technologies, or to competition.
– Fees should support the attainment of the spectrum manager's national goals and objectives.

The basic types of fees are those based on the spectrum management costs for processing licence applications, revenues derived from licensee's use of the frequency spectrum, and incentive fee formulas. Spectrum management fees are based on direct costs incurred by spectrum managers in processing applications, and may also reflect indirect spectrum management costs; i.e., overhead costs. In order for national spectrum management to be conducted, resources are needed to cover the full range of spectrum management functions (see Chapter 1). As stated in § 2.2.4.2, fees may be a source of this funding. With this intent, fees can be linked to specific spectrum management activity, the overall annual funding requirement or to other spectrum management objectives. These fees can be charged for the initial application and for application renewals. Fees can also be charged annually in order to maintain the spectrum management activity since spectrum users continue to benefit from the activity of the national spectrum manager through monitoring, database maintenance, ITU representation, etc. even after their applications have been approved. Individual licensees are generally grouped into licence categories for the purpose of setting fees. Revenue-based fees are proportional to the gross income the licensees generate from use of the spectrum. Incentive fee formulas take into account the value of the spectrum.

Another option is to charge fees based on the “opportunity cost” of spectrum use. In an auction, the bidder with the highest willingness to pay will win, with a bid that is just above the valuation of the bidder with the second highest willingness to pay. This second highest valuation represents the best alternative use, or opportunity cost, of the auctioned item. Therefore, in a situation in which the spectrum management authority must set spectrum fees administratively, an economically efficient distribution can be ensured if the fee is set equal to this opportunity cost/market value. However, to calculate the opportunity cost accurately, a market must be simulated to determine spectrum users’ willingness to pay. To do this with absolute precision is extremely difficult, nonetheless an approximation can be obtained which may make this a practical option.

It should also be noted that in some instances administrations may charge fees on the basis of individual equipment or frequencies, while in other cases a single fee for the use of a block of frequencies will be charged. The latter approach may provide improvements in administrative efficiency.

2.3.4.1 Fees based on spectrum management costs

Fees based on spectrum management costs depend on two separate elements: the range of spectrum management authority’s functions included in the overall costs and the method used to determine the fees for an individual licensee. A spectrum management authority’s costs can be broadly divided into two areas: direct and indirect costs. The specific spectrum management functions associated with each category may vary according to the administration.

2.3.4.1.1 Direct costs

The immediate and identifiable cost of issuing licences for specific applications. For example, they include: the cost of staff time in the frequency assignment process, site clearance, interference analysis when it can be directly associated with a particular class of service – keeping the public news and entertainment channels clear, ITU and regional international consultation that is specific to an identifiable group of users. In some frequency bands and for some services, or if the equipment is located near neighbouring countries, the direct costs will include the cost of relevant international consultation.

2.3.4.1.2 Indirect costs

The cost of the spectrum management functions (see Note 1) used to support the administration’s frequency assignment process and the overhead of operating the administration’s spectrum management procedures. They represent costs that cannot be identified as attributable to specific services or licensees such as general international consultation, for example with the ITU and regional groups, propagation research covering many frequency bands and services, general spectrum monitoring, interference investigations arising from the complaints of rightful users and the cost of support staff and equipment.

In some administrations the definition of direct costs is very restrictive and is limited to the costs incurred for each individual licence applicant. Some administrations may not make any charge for indirect costs.

The methods used to determine fees from spectrum management costs range from the simplistic method of dividing the total costs by the number of licensees to the more complex "cost recovery". Cost recovery is used to apportion the costs of spectrum management functions to the licensee according to the costs incurred in issuing the licence and the associated frequency assignment process (for example: frequency assignment, site clearance, coordination) including any other necessary spectrum management functions. The licence fees are usually structured on the principle of recovering the costs directly and indirectly attributable to a specific licence category. In some countries the accounts are audited, by a national auditor, to ensure the costs, on which the licence fees are based, are appropriate and justifiable.

The exact definition and operation of "cost recovery" varies according to national spectrum management, legislative and constitutional requirements. These requirements may have an impact on the implementation of cost recovery in each country and affect how the costs and fees are justified. There are several reasons for these differences:

a) In some countries a distinction is made between the administration's total income matching or simply approximating its costs. In the former case the administration is not permitted to subsidize or overcharge the licensee, with any excess having to be repaid. In the latter case it is recognized that fees are based on an estimate of the expected costs, and therefore the income may exceed or not reach the administration's actual costs. It is to be noted that in those countries using the latter system, strict audit control may still be applied.

b) The fees set for cost recovery may be based on the work performed on an individual licence or the average for that licence category.

c) The complexity of the frequency assignment process and the number of spectrum management functions that need to be performed to issue a licence may vary due to:

   – national characteristics – for example the number of users, geographic features requiring the use of a detailed topographic database;

   – international requirements – for example bilateral or multilateral treaties, footnotes in the Radio Regulations.

d) How the costs of the individual spectrum management functions are attributed to a particular licence category may be different due to:

   – the government's interpretation of whether the cost should be the responsibility of the licensee, should attract a fixed fee or should be the responsibility of the State (paid from the national budget) – for example, some administrations consider monitoring is the responsibility of the state;

   – their allocation between direct and indirect costs.

All of these factors will affect the composition of the licence fee and the mechanisms an administration puts in place to monitor its income and costs.

NOTE 1 – There are activities associated with the management of the spectrum that some administrations consider to be separate from their licensing costs. These activities typically relate to approval processes not directly related to frequency assignment. In these cases the administrations tend to make a separate charge and this is usually based on a simple fee that does not recover the cost of the function. These miscellaneous spectrum management fees may include a type approval, test laboratory accreditation, EMC fees and charges, installation inspection, examination certificates (radio amateurs, maritime examinations, etc.).

2.3.4.2 Fees based on user's gross income

A fee can be charged based on a percentage of the gross income of a company. The value of the gross income used in the fee calculation must be directly related to the company's use of the spectrum to avoid difficulty in the accounting and auditing processes.

2.3.4.3 Incentive fees

An incentive fee attempts to use price to achieve spectrum management objectives and hence to provide some incentive to use the spectrum efficiently. Various elements of spectrum usage may be taken into consideration in the development of an approach or a formula (e.g. population density, bandwidth, frequency band, coverage area, exclusivity, power) and different formulae may be required for different frequency bands and services. Developing an incentive fee formula may not be a simple task if it is to accurately reflect the variation in spectrum usage across a country. Incentive fees may not be suitable for all services.

2.3.4.4 Opportunity cost fees

Opportunity cost is defined as the value of something in its best alternative use. In the case of spectrum, it means the alternative value that is foregone when a section of frequency spectrum is assigned to a particular user. An opportunity cost fee tries to simulate the market value of the spectrum. This process may require financial analysis, estimations of demand or market studies to achieve a valuation, and considerable expertise.

2.3.4.5 Fee calculation examples

Fees based on spectrum management costs may be represented by the general functional forms:

$$\mathrm{F} = \mathrm{Di} \tag{1}$$

$$\mathrm{F} = \mathrm{f(Di, LiI)} \tag{2}$$

where:

F: fee charged to licensee

Di: direct administrative costs of processing licensee's application

Li: licensee's proportion of indirect administrative costs

I: total indirect administrative costs.

Fees based on user revenues may be represented by the general functional form:

$$\mathrm{F} = \mathrm{f(a, G)} \tag{3}$$

where:

F: fee charged to user

a: proportionate fee established by regulatory agency

G: user gross income

Incentive fee formulas may be represented by the general functional form:

$$\mathrm{F} = \mathrm{f(B, C, S, E,} F_R, F_C) \tag{4}$$

where:

- F: fee charged to licensee
- B: bandwidth
- C: coverage area
- S: site location
- E: exclusivity of use
- F_R: frequency
- F_C : administration's financial coefficient.

Opportunity cost fee formulas may also be used. Such fee formulas will resemble incentive fee formulas. However, in this case the administration's financial coefficient (F_C) will be set so as to make the fee approximate the market value of the spectrum.

A number of the above formulas and those presented in other ITU documents contain an arbitrary factor which is set by the administration. Use of this arbitrary factor means the resultant fee is itself an arbitrary value. A number of countries have implemented or are considering the implementation of fee models based on the various general functional forms described above. In countries developing incentive fee or opportunity cost fee models, it has been recognized that this is a complex and difficult undertaking and some administrations are holding public consultations prior to implementation.

2.3.5 Advantages and disadvantages of fee approaches

In terms of their effect on economic efficiency, spectrum fees are an improvement on awarding licences at no charge, provided that fees are not set higher than the market value. If they are set higher, spectrum will not be fully utilized. In fact, if fees are set above the willingness to pay of all potential users, spectrum will go unused and generate no benefits to society. On the other hand, if fees are set lower than the market value, economic efficiency will be improved even though excess demand will remain for the spectrum, and revenues to the spectrum management authority will be below the market valuation. Detrimental consequences of setting fees too low are that spectrum potentially could be used wastefully and that spectrum congestion may increase.

For example, assume that there is a service provider who uses two blocks of spectrum and pays a below the market value fee of $100 per block, or $200 in total. Assume also that by purchasing more spectrally efficient equipment for $150, the same service could be provided using only one spectrum block. The rational service provider will see that the second alternative has a higher total cost of $250 ($150 for the new equipment and $100 for the single spectrum block) and thus will not choose it. If, however, the true market value of the spectrum of, say, $175 per block is now charged, then the service provider will choose to buy the new equipment and keep one spectrum block for a total cost of $325, as opposed to a total cost of $350 for keeping the old equipment and both spectrum blocks. Now that this spectrum block has been released, another party can use it, meaning that the public is now receiving the benefits of two services via the same amount of spectrum that used to provide only one service.

A similar problem created by fees that are below market value is the potential for services to wastefully use spectrum. For example, some services, such as the delivery of television programming, can be provided by either wired or wireless means. Other services, such as mobile telephony, can be provided only via the radio spectrum. When all resources (spectrum, fibre optic cable, copper wire, etc.) are priced at market rates, service providers will choose the combination of these inputs that is consistent with an economically efficient distribution. However, if spectrum is priced at a level below its market value, then service providers (such as the distributors of television programming) who have the option of using either wired or wireless infrastructure in their activities will be inclined to use more spectrum and less of the various available spectrum alternatives. The greater amount of spectrum used by television results in less being available for other services, such as mobile telephony, meaning that the total number of services available to the public has decreased – obviously, an inefficient outcome.

Formulae can be useful in setting licence fees, but must be tailored to the individual circumstances of the country. Development of formulae requires considerable effort on the part of the administration and spectrum users. In order to operate correctly, a formula must be designed to achieve a specific purpose within an explicit set of operational conditions. These conditions depend on particular aspects of the country including its geographical structure (e.g. terrain, size, latitude), its radiocommunications infrastructure, the potential demand for services, and the degree of coordination required with neighbours. Hence the applicability of any formulae, other than the most basic, is often limited to a specific administration, a particular service and even a limited number of frequency bands. Existing formula can be reused, but will invariably require modification. This process requires an understanding of the purpose and conditions behind the formula's original development as well as the details of its proposed implementation.

2.3.5.1 Fees based on spectrum management costs

This approach has the advantages of raising revenues for the spectrum management authority and ensuring that licensees will pay at least some nominal amount for their spectrum use, while eliminating those would-be licensees who place insufficient value on their use to pay even those nominal fees. However, a major disadvantage of this approach is that there is a disconnection between the level of the fee and the value of the spectrum used. For example, one licensee may use a spectrum band in a relatively unpopulated area and pay the same fee as a second user who uses the identical band in a heavily populated area, even though the latter band has far greater value. Because of this disconnection between fees and spectrum value, such fees do little to promote the efficient use of the spectrum. In some areas and frequency bands in which the spectrum has little value, fees can inhibit any use of the spectrum, producing an inefficient outcome. More typically, however, cost based fees are far less than the value of the spectrum, and therefore promote efficient use of the spectrum to only a minimal extent. Low fees can be a particular problem in countries that have a high inflation rate because fees generally are updated only every few years, and therefore may lag well behind the general price level. However, this problem can be alleviated if the political authority conveys to spectrum managers the ability to update fees as often as needed to reflect general price trends in the economy.

This approach could be used in the long run if scarcity of spectrum gradually reduces. In such case, fees can be used to cover the costs of administration spectrum management and to secure protection against interference[1].

2.3.5.2 Fees based on user's gross income

Establishing a fee based on a certain percentage of gross income related to spectrum use can generate significant revenues for the spectrum management authority for certain services. For example, a television broadcaster with annual revenues of $500 million would pay an annual fee of $500 000 if the fee were just 0.1% of revenues. Further, this type of fee generates more revenue for the spectrum management authority as the licensee's gross income increases, which could be viewed as both efficient and equitable. However, there are three major problems with this type of fee.

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[1] Source: A. M. YOUSSEF, E. KALMAN, L. BENZONI, "Technico-Economic Methods For Radio Spectrum Assignment", in IEEE Communications Magazine, June 1995.

First, it can apply only to users having a gross income directly linked to spectrum use and not to those users whose gross income results only indirectly from spectrum exploitation – as determining gross income may be difficult due to the complexity of company accounting and in addition determining how much of a users gross income is directly linked to spectrum use is virtually impossible, e.g., how much of a public utilities or telephone companies gross income can be attributed to their use of microwave links in portions of their fixed network.

Second, such a fee does not necessarily promote efficient spectrum use or equitable treatment of licensees because a user's gross income is not directly related to the value of the spectrum. For example, two broadcasters may have an identical gross income, but one may be reaping substantial profits, while the second may be reaping no such profits, and indeed may even be operating at a loss.

Third, it may suppress spectrum usage, reduce the growth in services, impair innovation and spectrum efficiency, and have an adverse effect on international competitiveness.

2.3.5.3 Incentive fee formulas

Incentive fee formulas have the advantage of representing to some extent the scarcity and differential rents of the spectrum. By taking into account factors such as population, area, bandwidth used, and the frequency band such formulas may approximate the market value. However, the disadvantage of such fees is that no formula, however complex, can take into account all the variations of the market-place. This requires that considerable care is exercised in setting licence fees in order to avoid a large discrepancy between the fee and the market value. For this reason an incentive fee formula may need to be linked to a market valuation in order to be used effectively.

For some services, technical factors preclude a reduction in bandwidth and therefore incentive fees based on bandwidth would be inappropriate; for example, radar services.

2.3.5.4 Opportunity cost fee formulas

Opportunity cost fee formulas have the advantage of being directly targeted at the desirable goal of simulating the market value, – thus encouraging consideration of alternative means of communication and the return, by existing users, of surplus spectrum. However, just as it is extremely difficult to establish an incentive fee formula that accounts for all relevant variables that influence the price of spectrum in a particular location, so too it is extremely difficult to accurately simulate an auction and the effort required to complete the analysis may exceed the costs of an auction. Such a simulation depends upon evaluating individual consumer decisions and somehow integrating this information into a usable model. Financial studies or extrapolations based on prior secondary market transactions may be useful to some extent, but simulating the market will always remain very much an imperfect exercise, e.g., the three US broadband PCS auctions produced results strikingly different than what had been forecast by almost all analysts. Nonetheless, such methods may have advantages over cost-based alternatives in terms of managing the spectrum to balance supply and demand and maximizing economic welfare where an auction is impracticable or illegal.

2.4 Factors that could affect various economic approaches

There are a number of factors which could affect both the need and the ability of different administrations to implement the economic approaches to spectrum management discussed above. Various legal, socio-economic, and technical infrastructure considerations will all have an impact with respect to spectrum auctions, transferable property rights, and licence fee regimes.

2.4.1 Auctions

2.4.1.1 Applicability of auctions

As discussed previously, there are several potential advantages to using auctions as a method of spectrum assignment. However, different countries will likely also have a number of spectrum management objectives which auctions by themselves may not adequately address. Often such objectives can be met through the use of other policy instruments (regulations, licence conditions, standards, etc.) which are fully compatible with spectrum auctioning, but each administration will have to consider its priorities and decide on the overall appropriateness of auctions in light of the various objectives it wishes to achieve. Should an administration decide to utilize auctions, it should be aware that, generally, the greater the number of regulations, conditions, or restrictions put on the use of spectrum to be auctioned, the lower will be the auction revenue, hence, administrations may wish to consider the trade-offs involved, depending on their priorities. On a related note, administrations could choose to restrict spectrum supply, which would generally lead to higher auction revenues; however, there is a trade-off here as well in that a restricted supply of spectrum will lead to a narrower range of consumer services, higher consumer prices, and an overall decrease in economic efficiency.

While it may seem obvious, it is also worth noting that auctions by definition are applicable only in those circumstances where the demand for spectrum exceeds the available supply. Depending on any particular country's level of economic development, the level of its communications infrastructure development, its investment climate, and any foreign ownership or trade restrictions it may impose with regard to the provision of spectrum-based services (among other factors), the possibility exists that an administration may receive insufficient interest to make an auction necessary for some spectrum.

Generally speaking, the higher the level of economic and communications infrastructure development, the more favourable the investment climate; and the lower the foreign ownership barriers and trade barriers, the greater will be the demand for access to spectrum, leading to more vigorous competition in an auction and presumably higher revenues for the government.

Auctions are a market based mechanism and a fundamental requirement for the proper functioning of any market is a solid legal underpinning. This means, first of all, that the political authority must authorize the use of auctions for specified services. Second, for an auction to perform optimally, the nature of the right being auctioned (geographic coverage, available bandwidth, tenure of licence, etc.) as well as the accompanying responsibilities (licence conditions, service restrictions, equipment standards, etc.) should be specified as precisely as possible. As well, there should be certainty that the government is both willing and able to act as necessary to ensure that licensees are able to exercise the rights or privileges granted to them while at the same time meeting the responsibilities required of them. Any uncertainty surrounding such factors as the length of tenure of the licence being auctioned will create confusion and may result in lower bids.

Before entering a spectrum auction, for example, bidders will wish to know what degree of protection from harmful interference they can expect with the spectrum to be auctioned, as well as the steps they will be expected to take to avoid causing harmful interference to others. They will also wish to be assured that the government will enforce this interference protection regime.

The quality of an administration's licence/licensee database, its spectrum monitoring capability, and its ability to impose meaningful penalties on those who cause harmful interference to others all impact the government's ability to protect the rights or privileges of spectrum users and hence have an impact on the ability to conduct successful spectrum auctions.

2.4.1.2 Pre-auction requirements

It is desirable that all the rights and responsibilities accompanying the spectrum to be auctioned are specified prior to the auction; otherwise, bidders will face high degrees of uncertainty which will significantly compromise their abilities to bid rationally, greatly increasing the chances of an unsuccessful auction. This means, of course, that administrations seeking to use auctions must be able, both legally and politically, to establish licence definitions, terms, conditions, and policies before knowing who the licensees will be.

Similarly, the rules and procedures of an auction should be known and clearly understood by all participants prior to the auction's commencement. Great advances in auction theory, and in its practical application, have been made in recent years. Any administration planning to implement spectrum auctions would be well advised to consult the growing body of literature on this subject and to review the experiences of spectrum auction "pioneers" such as New Zealand, the United States of America, and Australia, to learn both from their successes and from some of the problems that have been encountered with respect to auction design and operation.

Depending on the complexity of the auction in question, an automated auction system may be desirable. Thus, certain technical infrastructure may be required to hold an auction. As well, education and training for both spectrum managers and potential bidders may be required to ensure a sufficient level of "auction literacy".

2.4.1.3 Competition policy

Depending on a given administration's stance towards competition in spectrum-based services, it may be particularly important that the possibility of market dominance is considered. Existing competition policies, as well as proposed licence conditions and auction rules and procedures, should be reviewed to ensure that an unacceptable auction outcome is avoided.

2.4.2 Transferable property rights

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 licence 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 licence/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 licences not only in whole, but also in part, that is to say, to allow licence divisibility.

2.4.3 Licence fees

The applicability of various licence fee regimes may vary among different countries. Countries with more developed economies and communications infrastructures may, for example, be more inclined to pursue such goals as:

– ensuring that the total payments made by spectrum users, through fees and/or auction proceeds, are greater than or equal to the total costs of spectrum management so as to avoid the subsidization of spectrum users from the general treasury;

– having fees approximate the market value of the spectrum resource to promote efficient use; and/or

– capturing any economic rents that the spectrum resource may generate.

Countries with less developed economies may choose to pursue these same goals, or alternatively they might see fit to implicitly subsidize spectrum users through low licence fees if they feel that this will further other policy objectives.

With reference to the different types of licence fee regimes discussed previously, incentive and/or opportunity cost-based fees have certain requirements for successful implementation. These types of fees are generally based on notions such as "spectrum consumed" or "the economic value of spectrum", which are not always easy to practically define or estimate. Reliable automated licence/licensee databases and other informatics tools such as geographic information software may be necessary to perform the calculations imbedded in the fee model. Administrations wishing to reflect market values in their licence fees will need to consider to what extent the licences they grant resemble "market properties". Any attempt to extract fees which in actuality are beyond the value of the associated spectrum may have negative economic consequences such as stifling investment, limiting service penetration, or raising consumer prices.

Finally, in countries that have not previously charged fees, it is essential that spectrum managers have the legal authority in their communications law to charge for spectrum use.

2.5 Managing a change in spectrum management funding

Use of radio has been identified as providing a number of benefits (see Chapter 3). Whether the level of economic benefits from the use of radio grows or diminishes depends on the spectrum being used efficiently and managed effectively. As implementation of spectrum pricing, or spectrum rights, can have a significant impact on spectrum management processes it is advisable that change should be managed due to the potential implications for the economy, the licensing process, industry and radio users.

The issues that a spectrum management authority needs to consider related to these changes are likely to vary from administration to administration and the precise spectrum pricing procedure will differ, but they can be grouped into a small number of categories.

2.5.1 Legal

Whether or not an administration needs to develop new legislation to introduce spectrum pricing, it is essential that the administration ensures that its existing legislation is effective. If the administration plans to introduce auctions, transferable spectrum rights, or a secondary market, it is also essential that the administration has appropriate competition legislation in place. If effective competition legislation and any organizations required to implement it have not been created prior to the launch of spectrum pricing, this could inhibit its operation.

2.5.2 International obligations

Where an administration introduces spectrum pricing and particularly transferable spectrum rights, it is important that it should retain responsibility for the country's international obligations. However, the administration may need to consider establishing a mechanism for representing the users' views in the relevant international fora, especially if the user is permitted to take on any of the management responsibilities for their spectrum that normally may be associated with the administration (see Chapter 4). In most countries these mechanisms may already exist, whether they would need modification to reflect different levels of spectrum management responsibility between users may depend on the national spectrum management process structure and organization.

2.5.3 Funding implications

Administrations that have previously operated a "cost-recovery" system, or been dependent on fees for funding their spectrum management operations, need to consider the implications for their overall income arising from a change in spectrum management funding mechanisms, such as:

– auctions may be held only periodically, since at certain times there may not be suitable spectrum to be auctioned;

– incentive pricing is intended to relieve congestion, not to increase the levels of the administration's funding.

In the short term funding levels may increase, but as the spectrum pricing mechanisms take effect the levels of funding may fluctuate with time and adjustments to the level of supply and demand.

2.6 Summary

In view of increasing worldwide demand for radio services, economic approaches to national spectrum management are becoming essential. These approaches promote economic, technical, and administrative efficiency, and can also help fund national spectrum management programmes that can ensure that radio services are able to operate on a non-interference basis. While a free market in spectrum does not appear feasible due to technical, economic, and social considerations; auctions, transferable and flexible spectrum rights, and well-designed fees can enable a number of the benefits of a market approach to be realized. Auctions appear best-designed to promote efficient use of spectrum when there are competing applicants for the same frequency assignment, and transferable and flexible spectrum rights ensure that an assignment will continue to be used efficiently after the auction has taken place. However, auctions may not be appropriate for services in which there is limited competition for spectrum assignments, for socially desirable services such as national defence, and for international services such as satellite services. For some of these services, fees may be appropriate. Fees can promote efficient use of the spectrum provided that they incorporate the correct economic incentives and are not set so low as to be negligible in the eyes of spectrum users or so high as to exceed what a market would set, in which case spectrum will sit idle and generate no benefits.

Through spectrum pricing national spectrum managers can develop a variety of economic tools to promote more efficient spectrum use. If properly applied, these tools can help encourage investment in radio services, leading to growth of the telecommunications sector and benefiting the entire economy.

CHAPTER 3

Assessment of the benefits of using the radio spectrum

3.1 Background

Effective management of the radio spectrum is required to ensure spectrum access for new services (see Note 1) and technologies, growth in existing services and avoidance of interference between users. Funding for this task will be dependent on the competing claims of all government activities. The extent of radio usage within a country will influence the particular functions performed by the spectrum management authority. As radio usage increases, so does the requirement for spectrum management. Assessment of the economic benefits (see Note 2) arising from the use of the radio spectrum is useful in making spectrum planning decisions. If quantification of these benefits is required for spectrum planning and strategic development then suitable methodologies must be identified. This Chapter, which is based on a report from the UK, provides a comparison of two methods to quantify the economic benefits and examines the factors that may affect this value.

NOTE 1 – In this Report the use of the word "service" with a non-capitalized "s" means an end-user service (e.g. cellular radio) and not a Radiocommunication Service.

NOTE 2 – Here the term "benefits" is not used in its standard economic sense.

3.2 Methods of assessing the spectrum's economic benefits

Economic benefits are generally recognized to accrue from the expansion of manufacturing capability, or the creation of new radio industries and services. They also arise from the impact radio services have on generating improvements in the performance of a business. These improvements may include: increased productivity, increased exports, reduced operating costs and increased employment. Improvements in the performance of a business are not only found where radio forms part of the core business (e.g. a telecommunications service provider, radio equipment manufacturer), but also where it is used as a way to support the core business (e.g. a water supply company using telemetry and telecommand to remote reservoirs, a taxi company using mobile radio to pass passenger details to taxis).

Two methods used for quantifying economic benefits have been identified in the Report – The Economic impact of the Use of Radio in the UK[2], published in 1995 and subsequently updated with last update in March 2006. The methods calculate the contribution of radio use to the economy using:

– gross domestic product (GDP) and employment;

– consumer and producer surplus.

These methods may be used to estimate the economic benefits arising from the provision of a single end-user service, or each service's economic benefits can be added together to provide the total economic benefits arising from radio in a country. Both methods and their relative merits are presented in the following sections. Although in this Report measurement of employment is linked to the measurement of GDP, it is really a complementary measurement that could be equally applied to the measurement of consumer surplus.

3.2.1 GDP and employment

The use of the GDP method to estimate the economic benefits is based on the contribution radio makes to all business activity within a country. The contribution to GDP will be equal to the product of the price of a good or service, and the number that are sold. The expenditure of the resulting wages and profits provides a further increase (multiplier effects) in both GDP and employment which can be added to these figures.

In practice GDP and employment contributions may enter the economy at a number of different points that are determined by the operation of the particular service. Typically for a service which is sold to an end user (e.g. broadcasting), contributions will occur in:

– the business providing the radio service (company A). This contribution to the economy is known as the direct effect of the use of radio. When the whole of the business of "company A" is based on the radio service (e.g. broadcasting), determining the required information is

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[2] SMITH-NERA (1996) – Study into the Use of Spectrum Pricing; Report prepared by the Smith Group and NERA for the UK Radio Agency. See also the Report by Europe Economics for OFCOM for the year ending 31 March 2006.

relatively straightforward. When the radio service provides only part of the business (e.g. private mobile radio (PMR)) it can be more difficult;

– businesses manufacturing equipment purchased by “company A”, or supplying other services (e.g. cleaning services, recruitment services, information technology support, market research) in support of “company A’s” operations, these indirect contributions to the economy are called backward linkages;

– businesses manufacturing equipment for users of “company A’s” service, or distributing and retailing “company A’s” services, these indirect contributions to the economy are called forward linkages. These services need not be related to radio, e.g. airlines use aeronautical mobile but their services that are retailed relate to passenger and freight traffic.

In the case of a radio service provided by the end user, as in PMR, the direct effect and backward linkage would be the same. However, there is no forward linkage because the contributing elements are incorporated within the direct effect.

The contribution to GDP and employment from the service or services will be equal to the sum of the direct effect, the forward and backward linkages. This value will depend on the amount of capital equipment and materials originating within, and the level of profits retained in, a country. In practice all countries will import some of the capital equipment and materials used and this will reduce the GDP contribution. However, even in the worst-case scenario where all capital equipment and materials are imported (unlikely because of the impracticalities of importing all raw materials and the increase in overhead costs) there will still be a positive contribution to GDP and employment through salaries, supplies to users of the equipment, distribution and retailing.

3.2.1.1 Factors modifying the combined GDP and employment values

In all cases, the combined GDP and employment figures resulting from radio’s contribution towards the economy has to be revised downwards because of the impact of “displacement effects”. These are based on the principle there will always be an alternative to the existing use, e.g. if aircraft did not exist, then the shipping and railway industries would expand. These effects equate to the following scenarios:

– radio may be a substitute for another non-radio service, e.g. cable;

– if radio did not exist the resources used in its development would be employed in other parts of the economy.

Allowance can be made in the calculations for the impact of relative changes in GDP and employment arising from a substitute service. However, the latter case for the wider economic displacement is more of a problem. Although the theory that all resources are completely mobile has some validity, there are disagreements on the limitations to this theory and validation is hampered by a lack of substantive information.

Once the GDP and employment figures have been adjusted to take into account the displacement effects, the impact of “multiplier effects” can be considered. Multiplier effects arise from the impact of wages and profits, generated in all businesses associated with the use of radio, as they spread through the rest of a country’s economy and in the process create further income and employment. They are a function of a country’s economic structure and may be different values for assessment of GDP and employment. In the United Kingdom, the Report – The Economic impact of the Use of Radio in the UK, estimated that the “multiplier effect” allowing for imports was approximately 1.4 times for income and slightly more for employment.

Hence,

The total contribution to GDP and employment for a service = (DE + FL + BL – DPE) × MPE (5)

Where: DE = direct effect; FL = forward linkage; BL = backward linkage; DPE = displacement effects; MPE = multiplier effects.

The 2006 UK report uses company turnover data to compute direct effects, and then use the Input-Output tables to calculate multiplier effects. An alternative methodology could have been to calculate the value added by these firms, rather than use their turnover figures. However, preference is given to turnover, as it is better suited to computing multiplier effects and is consistent with the previous (1995) study which estimated the GDP effect of radio spectrum use. To compute direct GDP and employment effects, identify firms for whom radio spectrum contributes substantially to turnover, i.e. firms that are small scale users of spectrum are not included. The reason for this is that it is very difficult to break down, for each firm, how much of the turnover and employment arises due to the use of radio spectrum compared with other inputs. The total economic benefits arising from radio in a country would be equal to the summation of all of the total contributions arising from each service.

Two types of GDP and employment effects arise from direct employment and turnover: linkage effects and induced effects. Linkage effects refer to the jobs created in the supply or distribution chain. An example would be jobs in a mobile handset manufacturing firm which provides the physical equipment to cellular phone providers. The jobs of those employed in the manufacturing firm will be directly affected if there is a change in demand from the cellular phone provider. The second effect is the induced employment or the income multiplier effect that arises due to expenditure of the incomes that employees in the radio spectrum using sector earn. This additional expenditure creates further jobs as the money is spent on goods and services – a ripple effect. The method that we consider to be the most suitable for assessing sector level change is to use multipliers derived from Input-Output tables. Input-Output tables provide a complete picture of the flows of products and services within an economy for *all* sectors in an economy. Specifically, the tables detail the flows between various industries and also between industries and the final demand sector. Such linkages can then be used to estimate the extent to which any given industry contributes to the various final demand sectors. The main concept behind the multiplier is the recognition that the various sectors that make up an economy are interdependent. One can manipulate the Input-Output table to estimate different types of multipliers depending on whether there is an interest in output, employment or income effects. The constituent component of the multipliers is the Leontief Inverse matrix. This is derived from the symmetric industry-by-industry use matrix and shows how much of each industry's output is required, in terms of direct and indirect requirements, to produce one unit of a given industry's output. The output *GDP Effects* can be derived from the Leontief inverse tables, and then use industry level output-employment ratios to determine employment effects. The estimates of employment and income thus derived are for gross employment rather than net new employment, i.e. the figures are over-estimated as they do not adjust for factors of production which might have been displaced from other productive uses. There is a range of beliefs regarding displacement effects, with a Treasury view that there are no net effects in the economy of the employment and output of a single firm or project. This view stems from the idea that, if a particular firm did not exist, others would have arisen in its place in the long run. Still, other studies have attempted to measure specific short-run displacement effects and these can be used to provide benchmark figures.

3.2.2 Consumer and producer surplus

Consumer surplus is a measure of the difference between what a customer is willing to pay and the actual price of the product. Consumer surplus was formally explained by Alfred Marshall in his Principles of Economics. It can be defined as the excess utility (or surplus) above the price actually paid. In Marshall's words: "the price which a person pays for a thing can never exceed and seldom comes up to that which he would be willing to pay rather than go without it: so that the satisfaction which he gets from its purchase generally exceeds that which he gives up in paying away its price; and he thus derives from the purchase a surplus satisfaction. The excess of the price which he would be willing to pay rather than go without the thing, over that which he actually does pay, is the economic measure of this surplus satisfaction."

To determine the consumer surplus for a service it is necessary to estimate its demand curve – a plot of the item price (y-axis) against the quantity sold (x-axis). The consumer surplus is then equal to the area between a horizontal line at the item price from zero to the quantity purchased and the demand curve. To estimate the demand curve it is important to have historical information on the service that covers several years. This information is not always available. If the service is new then there will be no historical information. Without sufficient data it is extremely difficult to estimate the demand curve and if the demand curve cannot be estimated then the consumer surplus cannot be calculated.

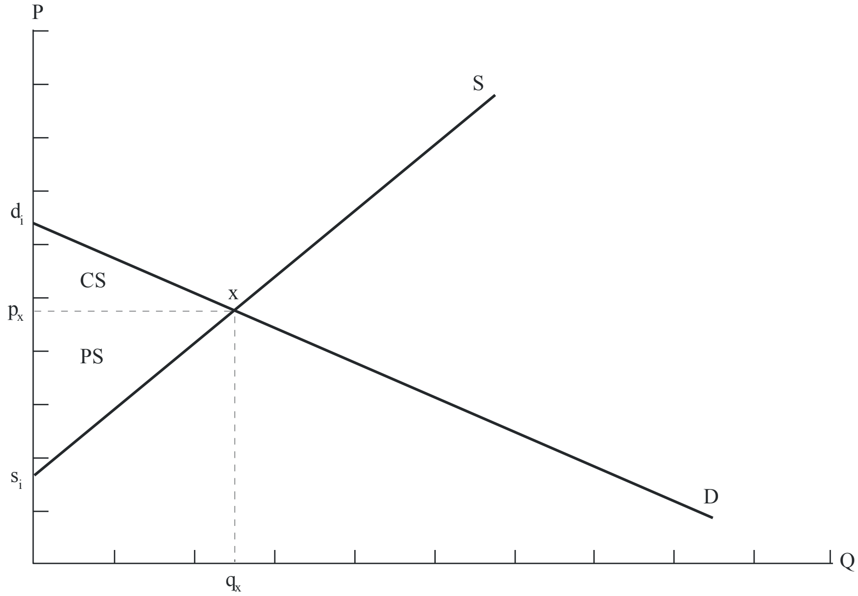
Producer surplus is the difference between what a producer actually earns and the amount it needs to earn to continue in business. Producer surplus is related to the consumer surplus. It can be defined as the revenue received by a supplier of any particular good or service over the minimum amount he would be willing to accept to maintain the same level of supply. To determine the correct value of producer surplus, the performance of the business needs to be monitored over a substantial part of its lifetime. In practice this is difficult to achieve as it requires consistent historical data for established businesses and accurate estimates of future performance for new businesses.

The total surplus arising from the use of radio would be equal to the summation of the consumer and producer surplus for each service.

Consumer and producer surplus are presented graphically in the Fig. 1. The price of the item (p_x) and the quantity (q_x) of the item sold at price p_x are shown on their respective axes. Consumer surplus (CS) is shown as the area between the demand curve and the price level (triangle p_x-x-d_i). Producer surplus (PS) is shown as the area between the supply curve and the price level (triangle p_x-x-s_i).

FIGURE 1

Consumer and producer surplus



P: price axis
Q: quantity axis
D: demand curve
S: supply curve
d_i: demand curve intercept
s_i: supply curve intercept
x: point of intersection between supply curve and demand curve
p_x: price of item
q_x: quantity sold at price p_x
CS: consumer surplus (triangle p_x-x-d_i)
PS: producer surplus (triangle p_x-x-s_i)

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3.2.3 The link between economic and social benefits

Some uses of the radio spectrum generate economic benefits but do not directly generate revenues. The economic benefits that the use of spectrum generates in such activities however, are not readily apparent. No clear or easily measurable financial values generally exist to directly quantify the magnitude of these benefits. Hence it may be assumed that economic analysis cannot account for these social benefits and can only account for such factors as the revenues and profits received by firms. This is not the case. A proper economic analysis considers benefits that do not directly generate revenues.

Examples of services providing social benefits include:

– broadcasting – providing education, training, news and recreation;
– emergency services – providing a link to the police, accident and rescue services including disaster control facilities;
– personal services – home health care/nursing, home security for the elderly;
– research – meteorology, radio astronomy.

3.2.4 Comparison of the methods for quantifying economic benefits

Both methods produce an estimate of the contribution of radio to the economy of a country, but are based on different assumptions for treatment of the wider economic displacement. GDP and employment do not take account of the wider economic displacement. Consumer and producer surplus take full account of wider economic displacement. In addition, the two methods measure different aspects of the impact of radio usage on the economy of a country. GDP measures what has been paid and consumer surplus measures what consumers would be willing to pay. Both methods include producer surplus. Accordingly, the results cannot be added together.

Although both methods can be used, and are used in the United Kingdom, for showing the spectrum's overall value to a country, it may be appropriate to select a method based on the application. GDP is better for assessing the value of multiple uses of radio within a country, or for comparison between individual uses/services, whereas consumer surplus provides more detailed information that may be used, for example, in determining licence fees or reserve auction prices. Comparison of the methods usually centres on the theoretical validity of the arguments and assumptions on which the particular methodology is based. However, it may be more realistic to review the methods based on the difficulty in obtaining data for analysis and the ease of comparison of the results with other economic data.

3.2.4.1 Advantages and disadvantages of the GDP method

The advantage of the GDP method is that it shows the collective impact of those involved in the radio using sector and provision of intermediate goods to that sector. The information required for the calculations is available in companies' financial reports and is easy to understand and compare with other areas of the economy which are represented in the same form. This enables funding (or investment) decisions to be compared using the same measures.

The disadvantage of the GDP method is that it does not take proper account of the wider displacement effects and these may be considerable in a diverse and flexible economy. In the extreme, if all displacement effects are taken into consideration, the net benefit of the use of radio to the economy would simply equal the improvement in efficiency that radio provides. However, this approach assumes that the resources currently provided for radio can be easily diverted into other areas of the economy. This is not necessarily correct. Furthermore, the estimated contribution in GDP and employment may not include consequential improvements in associated businesses arising from improvements in their efficiency (e.g., cellular telephone user's improved access to their business and clients) and may therefore lead to a more conservative estimate of GDP. The extent to which this occurs will be dependent on the relationship between the use of radio and the original business (e.g., is it a manufacturer of radio equipment, a service provider, a business using radio) and the type of service (e.g., broadcasting, fixed links, PMR).

3.2.4.2 Advantages and disadvantages of consumer and producer surplus method

The advantage of the consumer and producer surplus method is that it accounts for the impact of the wider displacement effects, indicating the benefits of providing a service by radio against the best non-radio alternative to be shown. In addition, the demand and supply curves can be useful for displaying the costs and benefits of a particular use of radio.

The disadvantage of the consumer and producer surplus method is that the demand curve can be difficult and time consuming to determine. A separate demand curve has to be produced for each service studied and this can be onerous if the aim is to measure the consumer and producer surplus for all radio services across the entire economy. If the demand curve cannot be produced, then alternative methods based on different assumptions have to be used and these may distort the results. Finally, consumer surplus is not easily comparable with GDP.

3.3 Potential uses for economic assessment

In recent years changes in radiocommunications technology together with the increasing tendency for shorter development cycles, have increased the pressure on spectrum managers for quicker decisions on who and which technology should have access to the spectrum. In addition to these changes in radiocommunications technology, further pressure has been added by the liberalization of telecommunications which has resulted in a growing demand for radio spectrum access. The increasing demand for spectrum access, combined with spectrum managers' difficulty in predicting which of several competing technologies and uses, will be successful and should therefore have access to the spectrum, is making the spectrum management process increasingly complex and time consuming. This can discourage investment, which can be especially detrimental when delays in providing spectrum access can make the difference between the success or failure of a new service. In addition, as demand has increased, the recurring spectrum management issues of achieving efficient spectral use and finding spectrum for the new services needed by society are becoming increasingly difficult to resolve for a number of countries. At the same time, governments' awareness of the overall burden of rising public spending on the economy has tightened control on funding for all government activities.

Management of the radio spectrum has traditionally been based on regulation of this finite resource. However, due to the pressures on spectrum management and particularly where difficulty in providing sufficient spectrum is limiting or distorting competition, or where it is inhibiting development of the radio spectrum resource, several administrations have moved away from a strict regulatory approach and are either using, or are considering using, economic factors as part of their approach to spectrum management.

3.3.1 Applications for funding spectrum management activities

Assessment of the economic benefits arising from the use of radio enables spectrum managers to demonstrate to the government that radiocommunications is not a self-contained industry, but is interwoven with other areas of a country's economy. Representation in economic form allows radio's contribution to the economy to be put in context with other areas of the economy. It also helps show the connection between spectrum management and radio's benefit to the economy.

3.3.2 National frequency assignment decisions

Knowledge of the economic and social benefits that competing uses and the manner in which they are provided give spectrum managers information, in addition to the standard technical and operational assessments, that could be used to help make assignment decisions and maximize the economic benefits from the utilization of the radio spectrum.

Economic benefits analysis can be used in a number of ways. It can show the impact of delays in introducing a new service, the relative benefits of different types of service, the economic benefits of introducing more spectrally efficient technology and the benefits from reassigning a frequency band to a new service or technology.

Technical and operational factors are obviously essential in any assignment decision, for without efficient use of the spectrum, economic benefits cannot be maximized. For some assignment decisions cultural/social aspects may be another factor. However, economic benefits analysis also has a role to play in determining assignment decisions, as failure to give due weight to economic benefits in spectrum management decisions could impose substantial costs on the economy.

The main advantage therefore of applying economic benefits analysis to assignment decisions, whether nationally or possibly internationally, is that it provides an analytical tool for optimizing the economic contribution made by radio. At present, perceptions of methodological difficulties may have meant that less emphasis is placed on benefits analysis than is warranted. As this Report shows, techniques are now available to estimate the economic benefits so that they can be taken into account.

3.3.3 Changes in spectrum management national legislation

For most administrations the provision of spectrum management is defined by legislation. This may limit changes in the way spectrum management can be provided, the way licences are issued and the type of support the spectrum management authority can receive from non-government organizations. Providing governments with justification for a change to legislation frequently requires assessment of the cost of implementation and the benefits the users and government will receive.

Economic analysis enables the economic benefits from using radio to be put in context with other areas of the economy and possibly an estimate of the consequential change in economic benefits arising from the proposed change in legislation to be provided. This information can provide governments with more information on the impact of the proposed legislation and the importance of the legislative changes relative to both spectrum management and the wider economy. Hence it can be used in the determination of timescales for introduction of the proposed changes to the legislature.

3.3.4 Support to the spectrum manager on the operation of auctions

Auctions are widely acknowledged to be the best method for determining the value of the spectrum (see Chapter 2 for a full explanation of auctions). However, the success of auctions can be affected by a number of different parameters. These include administrative limitations on auctions, administrative limitations on the operation of the new service or frequency assignment, and technical limitations imposed on the new service or frequency assignment. This last case may include issues of interference from another national or international radio source, coverage area, etc.

Economic analysis can be used to provide an initial assessment of the value of the frequency assignment. This may be used to determine if there will be sufficient competition for the spectrum, to support spectrum managers in their evaluation of bidders business plans, or to provide a reserve price for the auction.

A reserve price is a threshold value placed on a commodity by the owner that if not exceeded during the bidding process prevents the highest bidder winning the auction without the owner’s further consent. The reserve price is usually based on a percentage of the valuation of the item and is provided by either the auction house, or an expert in the field. Reserve prices are commonly used in many forms of auction, especially antiques and art.

3.3.5 Using economic assessment to monitor economic performance over time

Assessment at periodic intervals of the economic benefits from the use of radio can be used to provide information on the economic performance of radio usage over of time. Monitoring this performance provides a better picture of the radio spectrum’s condition than a single assessment and can be used with licensing data to show trends and developments in spectrum use. This information may be linked to spectrum management decisions, (e.g., frequency assignments, changes in licensing conditions, introduction of new services) so that the impact of spectrum management decisions may be evaluated and their application modified as necessary. In this way any detrimental impact on users can be rectified, and ineffective decisions reviewed or revoked.

For example, in the United Kingdom a follow-up study to the 1993/1994 economic Report has shown that radio’s contribution to GDP has increased by 11% per annum compared to the 3% for the rest of the economy and employment increased over the two-year period by 1 000 jobs a week. Employment (see Note 1) due to the use of radio has increased by 110 000 to 410 000 an approximate increase of 36%. Although this increase is perhaps exaggerated by an underestimation of the employment figures in the previous study, it compares favourably with an increase of 485 000 for the total economy over the same period. This study of economic performance will in future be repeated bi-annually.

NOTE 1 – Employment due to the use of radio includes industries, or services, which use radio, but in which radio is not the primary product, e.g. taxi companies.

3.4 Factors affecting benefits

This section examines a series of factors affecting the economic benefits that arise from the use of radio. It does not seek to quantify their impact; rather its purpose is to explain how these factors impact the national radiocommunications infrastructure, which in turn affects the value of economic benefits.

The radiocommunications infrastructure is the combination of all existing radio systems operating in a country, the frequency allocations, individual frequency assignments, any necessary coordination agreements and the spare capacity in the spectrum that can be used by the existing radio technology.

The benefits arising from the use of radio increase with the level of investment, increased usage and the introduction of new services and technologies. However the larger the investments and the more heavily developed the spectrum becomes, the less flexibility exists for introducing new services in the same band. Providing a balance between the contradictory requirements of increasing the use of the spectrum and retaining sufficient spectrum to meet future demand is an increasingly difficult problem, particularly in the lower frequency bands, and becomes more difficult as demand for spectrum access increases. The following sections review some of the information that characterizes the infrastructure. It should be noted that they apply equally to the entire country and its regions.

3.4.1 Frequency availability

The ability of administrations to make frequencies available for use is a major factor in determining the economic benefits they can achieve. Availability of specific frequencies or frequency bands may affect the cost of implementing new radio systems, radio system viability and the number of users that can be accommodated. The more users that a frequency can accommodate, within agreed performance limits, the greater will be the potential economic benefits.

Frequency availability is closely linked with coverage area and required bandwidth. The larger the coverage area the lower the frequency reuse in a given area. The wider the required channel bandwidth, the fewer channels can be fitted into a particular frequency band and the more spectrum denied to other users or uses. Coverage area is determined by many factors, e.g. transmitter power, antenna height, antenna pattern. Reducing the coverage area with improved antenna patterns or site shielding will increase frequency availability. By reducing the coverage area, the area denied to other users by those transmissions is also reduced.

NOTE 1 – The area denied to other users is normally larger than the coverage area.

3.4.1.1 Suitability

Providing spectrum for a new service is not necessarily a question of finding a vacant block of frequencies. Apart from the variation in cost of equipment between different frequency bands, and the impact of propagation considerations, both of which may determine whether it is economically viable to operate a particular service, there are some services and applications that have a requirement for a particular frequency band. For example: temperature profiling and climatic monitoring have a specific need for the oxygen absorption lines around 60 GHz, whilst international broadcasting needs HF; neither of these services could make use of the other’s frequencies. In addition, the frequency band selected for a service may affect the structure of the system, cost of implementation and operation. Selecting the right frequency band will therefore determine the viability and hence the benefits the new service can provide.

3.4.2 Demand

A country's population and industry provide the demand for radio services. The viability of introducing services on a commercial basis (i.e. not State funded) throughout a country will depend on the level of that demand, unless there are specific requirements placed on the service provider (e.g. in the United Kingdom, some broadcasters and telephone service providers are obliged to provide universal coverage for certain services). The level of demand in a country is therefore probably the most important element in determining radio usage and together with the country's geography, determines the shape of the radiocommunications infrastructure.

A large population will normally provide the demand for the introduction of a wide variety of radio services, although it may not guarantee their viability. Although most communications are based on population centres, or areas of employment, that demand can also occur in relatively uninhabited areas e.g. major transport routes are not necessarily in major population centres. However it can normally be assumed that the greatest demand will occur in areas with the greatest population density and/or the highest economic activity. Conversely the lower the population density the lower the level of demand and the less competition the market will be able to support. This may lead to less variety and consequently higher costs for a particular service.

3.4.3 The country's geography

The geography of the country covers a number of separate items that can affect the benefits arising from the use of radio. These include the country's size, its geographic shape, terrain structure, the number of countries within coordination distance and their radiocommunications infrastructure.

Broadly this translates into: countries with many close neighbours are more likely to have to coordinate the majority of their radio systems and may therefore be more likely to fit their radiocommunications infrastructure around that of their neighbours. The more developed the neighbouring countries' infrastructure the greater the difficulty there is likely to be in introducing new services. This may not be a big problem as countries with low population densities generally have smaller populations and hence make less demands on the spectrum. At the other end of the scale large countries have greater freedom to plan services above certain frequency bands without the need to resort to coordination. This freedom is increased if they have few neighbours. Those countries with no neighbours within the coordination distance for a specific frequency benefit from the fact that they have unrestricted access to this frequency everywhere within their borders.

For the purpose of this Report, terrain structure includes mountain regions, dense woodland and desert. When combined with the other elements of the country's geography and the population characteristics the terrain structure helps to determine which frequency bands may be the most appropriate for a particular service.

3.4.3.1 Regional variations and spectrum congestion

A country's geography and demand distribution can combine to provide a variation in the level of frequency availability across a country. The distribution of a country's population equally across a country is extremely unlikely and the population tends to group in a number of population centres of varying sizes. In practice this grouping is beneficial to the provision of radio services; however, there comes a point where the level of demand can be disproportionate to the area in which it arises and this can cause frequency availability problems and eventually spectrum congestion. Spectrum congestion is a major problem for spectrum managers and cited by many administrations as one of the major factors in their consideration of moving to a spectrum pricing structure. The following example shows the impact of regional variations on spectrum demand.

In the United Kingdom some 25% of the population live in about 7% of the total land area, an area that includes two of the world's busiest airports and is bounded by the world's busiest shipping lane. This concentration of the population and industry creates high demand for all types of service (e.g. mobile, fixed, broadcasting, satellite, radionavigation) whilst at the same time placing considerable restraints on frequency reuse because of the short distance separation. In addition, despite being an island, the United Kingdom's close proximity to neighbouring countries requires coordination in many frequency bands and places further limits on frequency availability. Public mobile telephone services have increased dramatically with increasing competition from new telecommunication operators, but the roll out of services is based on major centres of population and the prime road and rail links that connect them. Consequently there is a shortage of spectrum in some parts of the United Kingdom whilst in other areas this is not a problem. In areas like the South East of England there is congestion in many bands and a general shortage of available spectrum below 25 GHz. In particular below 3 GHz there is a problem with spectrum availability for mobile services. The United Kingdom is therefore putting considerable effort into opening up the frequency bands above 30 GHz.

3.4.4 Variation from country to country

The variation between countries is similar to the variation within a country except that it is generally on a larger scale but with some modifications and additional factors.

3.4.4.1 Frequency allocation

Probably the most fundamental difference between countries will be in the allocation of frequencies to services. This may arise through different allocations to countries between ITU Regions, footnotes in RR Article 5 and individual differences from RR Article 5 that have been coordinated between countries. These differences between countries may affect both Primary and Secondary allocations. These changes will primarily affect frequency availability and be subject to coordination agreements between individual countries.

3.4.4.2 Regulatory approach and planning criteria

The spectrum management authorities may be subject to different legislative requirements and as a consequence have a different regulatory approach. In addition there are a number of factors that would normally be expected to vary between countries. These are spectrum management objectives, aims, frequency planning criteria, and operational requirements.

3.4.5 Factors which may be taken into account in an international comparison of fee levels

The Spectrum Fees database contains details of the fees applied in a number of countries. In this connection, the question arises as to which fee levels to select and whether they can be used directly without modification or, "all other things being equal", with an appropriate transposition prior to application.

In replying to this question, there is a need to conduct an analysis of the economic conditions surrounding licensed operations and, on the basis of that analysis, to draw up a (non-exhaustive) list of factors to be taken into account prior to transposing the fees applied by one of the countries in the database to another country.

We shall confine ourselves to looking at the case of those fees that are set administratively and applied to telecommunication operators having been authorized to use frequencies (i.e. licensed operators).

Some of the aforementioned factors may be taken as criteria for comparing the economic conditions under which licensed operations are conducted in the countries in question. This comparison should enable the administrations concerned to identify how to effect the transposition on an economic basis.

3.4.5.1 Grounds for fees and their economic impact

In most countries the radio-frequency spectrum lies in the State's public domain, and its use for commercial purposes constitutes private occupancy within that domain.

Such occupancy is therefore normally subject to the payment:

– on the one hand, of a management fee calculated to cover the administrative costs of spectrum management (in the broad sense of the term, i.e. planning, domestic management and monitoring);

– on the other hand, of a fee for provision of the frequencies, which must be in proportion to the benefits derived therefore by the recipient.

The benefits derived by a telecommunication operator from its spectrum occupancy may be evaluated by considering, among other things, its net operating result. From this standpoint, the fees associated with frequency usage and applied to an operator should thus be in relation to its net operating result.

From the economic and accounting standpoint, operators experience frequency usage fees as a tying up of resources and/or an operational cost which thus reduces their net operating result by a corresponding amount.

This is why, although the application of frequency usage fees is a legitimate approach, those fees must not be set too high in order not to discourage initiatives and hamper the development of new services. In any event, the level of the fees cannot exceed operator’s propensity to pay.

3.4.5.2 Economic conditions surrounding licensed operations

An operator's net operating result comprises the difference between the total sale price of the goods and services marketed (turnover) and the total cost involved in acquiring those goods and services (operating costs).

It goes without saying that the economic conditions under which licensed operations are conducted have an impact on both turnover and operating costs and thus have a bearing on the operator’s net result.

Thus, the more the operating conditions are favourable to operators, the greater their propensity to pay fees, and vice versa.

It is therefore necessary to analyse and compare the economic conditions surrounding licensed operations in the countries under consideration.

Those conditions are determined by, among other things, the following factors.

a) Socio-economic factors in the countries under consideration

Factors to be covered by the analysis may include:

– GDP or GDP/inhabitant;

– total population or population density;

– geographic distribution of the population (concentrated in a few areas, dispersed, …);

– the country’s size, relief (plains, mountains, …) and degree of insularity.

b) Characteristics of authorizations or licences allocated

Particular attention may be focused on:

– the licence period;

– the stability of operating conditions;

– whether or not licences are renewable.

c) Terms of reference of authorized operators

The obligations imposed on operators in their terms of reference and which thus increase their operating costs may relate to:

– coverage of the territory in question;

– quality of service;

– participation in universal service;

– participation in research and development efforts in the telecommunication sphere;

– additional constraints (free calls to certain numbers, number portability, …).

d) Comparison/transposition of fee levels

The table below describes the influence that the economic conditions surrounding licensed operations have on operator's propensity to pay fees.

It goes without saying that those factors which help to boost turnover will serve to increase that propensity, while those which add to operating costs will drive that propensity downwards.

Factors which may be taken into account when comparing or transposing fee levels

<table>
<tr><th>Socio-economic factors in the countries under consideration</th><th>Remarks</th></tr>
<tr><td>GDP or GDP/inhabitant</td><td>Operator’s propensity to pay fees increases in line with GDP since the potential turnover increases with GDP.
Remark: The existence of a countertrading system may result in a calculated GDP that is lower than actual GDP.</td></tr>
<tr><td>Total population; population density</td><td>Operator’s propensity to pay fees increases in line with population size since, generally speaking, the potential turnover increases with population size.</td></tr>
<tr><td>Geographic distribution of the population (concentrated in a few areas, dispersed, ...)</td><td>Operator’s propensity to pay fees increases with concentration since, generally speaking, the cost of network deployment decreases with concentration.</td></tr>
<tr><td>Country size, relief and degree of insularity</td><td>Operator’s propensity to pay fees decreases in line with the country’s size and relief since, generally speaking, the cost of network deployment increases in line with those parameters.</td></tr>
<tr><td>Characteristics of authorizations or licences</td><td></td></tr>
<tr><td>Period of validity of authorizations</td><td>Operator’s propensity to pay fees increases in line with the period of validity since equipment amortization is better assured and the final years of operation are generally far more profitable than the initial years.</td></tr>
<tr><td>Stability of operating conditions</td><td>Operator’s propensity to pay fees increases in line with the level of stability since instability leads operators to cover themselves against the inherent risks.</td></tr>
<tr><td>Renewability of authorizations</td><td>The influence of this factor is similar to that of the period of validity.</td></tr>
<tr><td>Content of authorized operator terms of reference</td><td></td></tr>
<tr><td>Coverage of the territory in question</td><td rowspan="5">The inclusion of such obligations in the terms of reference increases the operating costs in line with the degree to which they are mandatory and has a corresponding negative effect on operator’s propensity to pay.
In order to make a detailed comparison, it would be necessary to analyse the degree to which each such obligation is mandatory, taking particular account of the following:
– conditions governing international access, which may influence quality of service;
– existence of local practices/customs such as cost-free service for certain categories of user, the effect of which is to reduce the operating result.</td></tr>
<tr><td>Quality of service</td></tr>
<tr><td>Participation in universal service</td></tr>
<tr><td>Participation in research and development efforts in the telecommunication sphere</td></tr>
<tr><td>Other obligations (free calls to certain numbers, number portability, spectrum monitoring,...)</td></tr>
</table>

3.5 Summary

The value that the use of radiocommunications and the development of new services can provide to a country's economy is indicated by the economic benefits identified in the studies undertaken by some administrations. In the past, failure to recognize radiocommunication's economic contribution to a country, perhaps coupled with uncertainty over the methodology, may have meant that benefits analysis was not considered to provide information relevant to spectrum management. This Report shows that techniques are now available to quantify the economic benefits and are capable of providing information, previously unavailable to spectrum managers that can be taken into consideration when making decisions on frequency assignments and for evaluating the effectiveness of spectrum management decisions. In addition, economic benefit analysis may be used to support justification for spectrum management funding. Effective spectrum management is essential for maintaining access to the radio spectrum and hence the benefits radio can provide to a country.

CHAPTER 4

Guidelines on methodologies for the establishment of spectrum fees formula and system

4.1 Formula development

Pricing requires the development of formulae to operate effectively. In developing these formulae it is advisable that the administration should consult the radio industry on the appropriate technical parameters and definition of the criteria to be used; for example, highly congested geographic areas and frequency bands. The spectrum pricing formulae need to be fair, objective, transparent and simple. Simplicity is important, otherwise there could be difficulty in operating and maintaining the formulae. Consultation can also help to ensure the parameters are appropriate for the service and any disputes on the definition of areas of high usage are resolved. The consultation process is also important for users as it provides transparency to the development of the spectrum pricing procedures.

If the introduction of spectrum pricing requires the development of new software, this may need to be tested and staff trained in its use. This is particularly important if the administration has previously never charged for a spectrum licence. The setting of the fee level is critical to the operation of spectrum pricing and it is necessary to have a suitable differentiation, in terms of the fee value, between areas with high and low levels of spectrum usage.

4.2 Guidelines for the establishment of administrative fees (or administrative charges)

4.2.1 Observations and general approaches

Administrative fees are intended to cover all of the costs:

– of activities relating to spectrum planning, management and monitoring;
– of activities carried out by the authorities and delegated entities in regard to the spectrum;
– arising out of spectrum occupancy solely on the private side.

Such costs will hereinafter be referred to as "administrative costs". The management function includes activities relating to the issuance of licences and authorizations for spectrum use and to the establishment and collection of the corresponding fees. Administrative costs are made up of staff costs, operational costs and the costs (amortization) of buildings and equipment corresponding to the aforementioned activities. By way of an example, the following entities may devote a more or less significant part of their work to spectrum-related matters and should therefore be taken into account in the determination of administrative costs: spectrum manager(s), telecommunication market regulator, entity responsible for radio and television, ministry(ies) responsible for radio, television and telecommunications, ministry of foreign affairs. The fee levels are normally established for a period of one year. Where the frequency usage period is less than one year, the corresponding amounts are determined *pro rata temporis*. If they turn out to be less than the minimum collection rate it is the latter which applies (the minimum collection rate is the threshold below which the cost of collecting a fee would be higher than the fee itself). The total annual amount of the chargeable administrative fees should be as close as possible to the total annual amount of the administrative costs. The annual administrative costs should therefore be evaluated with a view to their allocation among all the users of assigned or allotted frequencies. Administrative costs can be relatively accurately determined through the use of a suitable cost accounting mechanism. At the end of each calendar or fiscal year, and in the event of a not insignificant variance between the amount of the fees payable and that of the administrative costs actually recorded, it is recommended that an adjustment be made to absorb that variance. For the purposes of allocating the amount of the administrative costs among those subject to the administrative fee, it is recommended that the allocation rule adopted be both simple and, wherever possible, representative of the administrative work done in respect of each of the fee payer categories.

4.2.2 Rule for the allocation of administrative costs – Example 1

The annual administrative costs are allocated among all those subject to the management fee, in proportion to their respective turnover.

Thus, for a fee payer whose turnover is equal to *CA*, the annual amount of the administrative fee *Ra* for the year in question is equal to the product of administrative costs for the year in question with sum of the turnovers of each of the fee payers for the year in question.

While this rule has the advantage of being simple, it may prove particularly harsh for fee payers operating only a private radio network and whose industrial or commercial activities are significant but not associated with the frequency domain, since they could end up having to pay a fee that is much higher than the cost of the service provided.

This rule could be used in cases where it is not possible to implement the rule described in § 4.3.

4.2.3 Rule for the allocation of administrative costs – Example 2

Administrative costs are allocated in proportion to the number of assignments and number of allotments allocated, respectively, to each of those subject to the management fee. In practice, this rule calls for the determination of two reference monetary values corresponding, respectively, to the amount of the administrative fee for an assigned frequency (G) and to the amount of the administrative fee for an allotted 1 MHz frequency band (G’). The determination of G and G’ is such that it should be possible to get as close as possible to the following equation for a given year:

$$\text{Administrative costs} = \text{total number of frequencies assigned throughout the territory} * G + \text{total number of MHz allotted throughout the territory} * G' \qquad (5bis)$$

By way of an example, a fee payer with 50 assigned frequencies and an allotment of 20 MHz will pay an annual administrative fee *Ra* amounting to:

$$Ra = 50 * G + 20 * G' \qquad (6)$$

In many cases, the administrative work relating to an allotment is greater than that for an assignment. It is therefore recommended that this be taken into account by giving greater weight to allotments when allocating the administrative costs, i.e. when determining G and G’.

The values of G and G’ can be easily determined through the use of a suitable cost accounting mechanism. This rule for the allocation of administrative costs has the advantage of reflecting quite well the service provided, since the necessary administrative work increases with the number of assigned frequencies and number of allotted MHz allocated to a given fee payer.

4.3 Guidelines for the establishment of spectrum fees

There are five general steps to calculate the spectrum fees[3]:

4.3.1 Defining the goals of the spectrum fees

4.3.1.1 Observations and general approaches

The spectrum fee system must respect, among other things, the economic principles described before. It must, moreover, also take account of the reality principles when identifying the set of parameters to be used as the basis for fee calculation.

4.3.1.2 Budgetary objective of the authorities

Generally speaking, the budgetary objective is expressed in terms of the total income amount that the fees must generate for the State. While adhering to the total income amount established by the authorities, it is recommended that the fee levels be adjusted according to the applications in question so as to ensure that the other three purposes of spectrum fees and are taken into account as fully as possible.

4.3.1.3 Spectrum fees for frequencies intended for user’s own requirements

Observations and general approaches

Determination of the modalities for fee-setting should take account, first and foremost, of the factors as given earlier. In putting together the basis for fee calculation, it is recommended that only the minimum number of factors necessary for achieving the objectives of effective spectrum management and effective frequency utilization be used. Use of a simple calculation formula is recommended. Multiplication comes out as a very suitable formula for determining fee levels on the basis of the factors selected when putting together the calculation basis. For the purpose of adjusting fee levels according to applications, it is recommended to determine, respectively for each of the applications under consideration, a reference monetary value “k”, expressed in the prevailing currency. This “k” will then be one of the factors in the aforementioned multiplication.

4.3.2 Demand assessment for the spectrum

In this step, the demand for each service should be tested in order to find out if there is excess demand of the spectrum by any service.

4.3.3 Cost assessment for the spectrum

Cost of the spectrum could be considered as the cost of managing the spectrum which could include frequency assignment, site clearance, coordination and others according to the service type.

4.3.4 Choosing the fees approach

The approach for calculating the fees can be chosen from § 2.3.4.

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[3] NOZDRIN, V. [2003] Spectrum pricing. Regional Radiocommunication Seminar, Lusaka 2003.

4.3.5 Determining the fees

This step should be considered case by case by the administrations according to the different economic and political factors.

4.4 Examples of formulas for fee calculation

4.4.1 Notations and definitions of coefficients

The coefficients defined below are used in the examples of formulas for calculating fee amounts:

– The coefficient "L" represents the allocated bandwidth.

– The coefficient "bf" expresses the position within the spectrum of the frequency or allocated frequency band. In practice, a table is established giving, for each block of frequencies under consideration, the value of the corresponding "bf" coefficient.

– The coefficient "a" expresses the frequency usage authorizations by allotment.

– The coefficient "c" expresses the surface area covered by the frequency usage authorization. Generally speaking, the surface over which an assignment is allocated constitutes a disk with the station in question at its centre and with a radius equal to the maximum distance over which the assigned frequency may be utilized in cases where the station antenna is omnidirectional, or a segment of that disk corresponding to the angular width of the antenna in cases where it is directional. In practice, a table is established giving the value of coefficient "c" corresponding to the values of the surfaces considered. Such a table has the advantage of correcting the very wide range of fee amounts that would have been obtained by direct consideration of the area of the allocation surface.

– The coefficients "k1", "k2", "k3" and "k4" are reference monetary values that are specific to the applications in question. When setting these values, priority consideration should be given to enable achievement of the budgetary objective set by the authorities; and not to clash with the economic objectives of the authorities in regard to national development and the development of new services.

4.4.2 Fee applied to a point-to-point fixed-service assignment

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * k1 \qquad (7)$$

4.4.3 Fee applied to a point-to-point fixed-service allotment

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * a * c * k1 \qquad (8)$$

where "c" is the ratio between the surface area covered by the allotment and the total surface area of the national territory.

4.4.4 Fee applied to a wireless local loop allotment in the fixed service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * a * c * k2 \qquad (9)$$

where "c" is the ratio between the surface area covered by the allotment and the total surface area of the national territory.

4.4.5 Fee applied to an assignment to an earth station in the fixed or mobile-satellite service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * k3 \quad (10)$$

4.4.6 Fee applied to an allotment in the fixed or mobile-satellite service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * k3 * a \quad (11)$$

4.4.7 Fee applied to an assignment for private networks in the mobile service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = L * bf * c * k4 \quad (12)$$

4.5 Spectrum fees for frequencies used in the provision or marketing of services intended for a consumer market

4.5.1 Observations and general approaches

Generally speaking, the fees applied in respect of the above frequencies constitute the major part of the budgetary revenue that the State receives by way of spectrum-related fees. To reflect the income derived from the situation rent, various factors may be envisaged, such as the population covered by the licence, the portion of territory concerned by the licence, or turnover resulting from the provision or marketing of the services. It is very often the turnover that proves to be the most representative factor in terms of the situation rent. If the turnover is to be used as the basis for fee calculation, it is recommended that its perimeter and content be clearly defined.

4.5.2 Example of fees applied to the 2G mobile service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = F + t\% * CA \quad (13)$$

where:

F: represents a fixed amount to be paid each year. This amount may be proportional to the total bandwidth allocated to the operator in question for the 2G service

CA: represents the turnover of the operator for the corresponding year in respect of the 2G mobile service frequencies

t%: represents the percentage to be levied on the operator’s turnover. Generally speaking, the t% applied by administrations is 1% or close to 1%.

4.5.3 Example of fees applied to the 3G mobile service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = t\% * CA \quad (14)$$

where:

CA: represents the operator's turnover for the corresponding year in respect of the 3G mobile service frequencies

t%: represents the percentage to be levied on the operator's turnover.

To this annual fee is added an "entry ticket", payable upon allocation of the licence. The amount of the entry ticket, which may be proportional to the allocated bandwidth, should be set with particular reference to § [23] in order, as the case may be, not to hamper the deployment of new entrant's networks.

4.5.4 Another example of fees applied to the fixed wireless local loop service

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = t\% * CA \qquad (15)$$

where:

CA: represents the operator's turnover for the corresponding year in respect of the frequencies for the fixed wireless local loop service

t%: represents the percentage to be levied on the operator's turnover.

To this annual fee is added an "entry ticket", payable upon allocation of the licence. The amount of the entry ticket, which may be proportional to the allocated bandwidth, should be set with particular reference to "entry ticket" in order, as the case may be, not to hamper the deployment of new entrant's networks.

4.5.5 Example of fees applied to a television programme producer

The following equation could be used for determining the annual amount *Rs* of the spectrum fee:

$$Rs = F + t\% * CA \qquad (16)$$

where:

F: represents a fixed amount to be paid each year. This amount may be proportional to the total bandwidth allocated to the operator in question for broadcasting purposes

CA: represents the operator's turnover for the corresponding year derived from advertising income, supplemented, as the case may be, by income derived from subscriptions and per-view payments

t%: represents the percentage to be levied on the operator's turnover.

4.6 An analytical model for calculating license fees on the basis of specified incentives that are designed to promote efficient spectrum use

This model was developed in the framework of the BDT Asia and Pacific Project on Spectrum Validation and Licensing, Bangkok, 2000. The study focuses on a specific method of spectrum fee calculation. The model is derived from the conceptual base that there is a distinct need to price spectrum and that the pricing of spectrum resources should reflect more than administrative convenience. This has been reinforced by the views of administrations participating in the data collection and policy review of SE Asian countries under the above Project. Further detailed information is available from the ITU website:

http://www.itu.int/ITU-D/tech/spectrum-management/MODEL_FULL.pdf

The importance of the model rests on it providing to administrations a functional tool which can be used to calculate spectrum fees on the basis of tangible criteria. In fact it falls within the category of administrative incentive pricing approaches. In the manner of most prevalent administrative incentive approaches it allows variations in not only the criteria used as inputs to the pricing but supports weighting those criteria to reflect the importance of certain spectrum utilization variables. This can also be used to vary the pricing between different spectrum uses whereby the underlying scarcity of spectrum can be considered.

The model, while rather complicated for manual calculations, is most effective for application to automated national spectrum management systems. Relevant software can be customized in accordance with the Model and all the rest calculations will be fulfilled automatically without any involvement of the system operators. Similar experience is described by the Administration of the Kyrgyz Republic in § 5.2.6.

4.6.1 General purpose of the model

The purpose of this model is to increase spectrum utilization efficiency. It is designed to introduce non-discriminatory access to the spectrum for various categories of users, stimulate the use of less congested (particularly – higher) frequency bands, stimulate harmonized development of radio communication services throughout the country, and cover the cost of spectrum management. It includes the consideration of the phased development and/or maintenance of spectrum management and monitoring facilities and reimbursement of expenditures of a national telecommunication administration including its international activities within ITU.

The model determines the value of annual payments to be made for the spectrum use of each transmitting radio station using a pricing formula based on the following basic elements:

– Three-dimensional radio frequency-spatial-time resource (see Note 1), referred to as the *spectral resource*, used in the country and representing the common spectral value applicable to all frequency assignments, stored in the national spectrum management database and which is calculated on an annual basis.
– For each frequency assignment the spectral value is determined by the frequency band occupied by the emission, multiplied by an area, occupied by the emission (which is determined by the power of transmitter, height and direction of the antenna etc.), and multiplied by the fraction of time throughout which the transmitter operates with that emission in accordance with terms of relevant license. Relevant assumptions and criteria are presented below in § 4.6.5.
– The annual administration cost of spectrum management including the phased development and/or maintenance of spectrum management and monitoring facilities and the reimbursement of expenditures of a national telecommunication administration.
– The average price for the spectral resource unit determined from the above values.
– The annual payment by a specific user determined from the actual value of used spectral resource.

NOTE 1 – For reasons of simplicity and taking into account that spectrum sharing conditions are usually provided only by territory separation of stations, for purposes of the given Model a spatial (three-dimensional) resource is represented by a territorial (two-dimensional) one.

A number of incentive weighting factors are entered in the formula. Thus the spectrum price or fee will depend not only on the relevant occupied bandwidth and coverage area values, but also on time-sharing conditions, geographical location of the station, economic development level or population density in the coverage area, social factors, exclusivity, type of radio service, spectrum employment, as well as some operational factors such as complexity of radio monitoring and imposing sanctions, etc.

The proposed Model allows the user at any moment to determine the value of his annual payment for the spectrum and also renders it to be transparent and accessible to all users. Thus, if the user employs greater bandwidth and service area, operates in more populated geographical area or the area is more economically developed and operates full time in more congested frequency bands, the larger will be the payment.

The approach thus encourages more efficient spectrum use and is an incentive for the user to implement more modern equipment and operate in new higher frequency bands. It should also encourage the use if possible of time-sharing regimes with other users, avoid using redundant margins for the power of a transmitter and height of antenna etc. and support expansion of its coverage to rural and remote areas.

4.6.2 Steps in the model formulation

The proposed spectrum payment algorithm includes the following steps:

– Determination of annual expenditures of the State on management of actually used spectral resource and determination of the common value of the annual payments for all spectral resources.
– Determination of the value of the spectral resource used by each radio station and, through their summation, by all stations registered in a national Spectrum Management Database.
– Determination of the price for a unit of the spectral resource.
– Determination of the annual payment for a specific user on a differential and non-discriminatory basis, determined from the actual value of used spectral resource.

Each of these steps is described in detail below.

4.6.3 General principles for the model development

It is necessary to underline that the number and values of all particular coefficients below are given only as illustrative examples. They are based on available data and the experts' estimations in application to South-East Asia countries. Each national telecommunication administration can chose other values and add other coefficients reflecting its particular needs and experiences. All coefficient values, unless indicated specifically, can be integer or fractional numbers.

The model is intended to cover those cases (and they are the great majority of frequency assignments) for which simplified calculation methods of some important parameters (mainly – service or occupied areas) can be used.

This approach has been chosen also from the understanding that for purposes of fees calculation it is much more important to provide universal procedures to guarantee equal conditions for all users belonging to one group (by radio service or its particular application) rather than to obtain a high accuracy of technical parameter calculations.

Based on a general principle that not only a transmitter but also a receiver occupies a particular spectral resource by denying operation of other transmitters (other than a communicating one) in a particular frequency band within the limits of a particular territory (Recommendation ITU-R SM.1046-2), the Model can be used for calculating fees for receivers as well in a case when a user requires protection of a receiver from interference and it is registered in a National Frequency Assignment Database.

Annex 1 of Recommendation ITU-R SM.1046-2 also presents some options to administrations on simplification of calculation procedures implying the decrease in calculation accuracy, or on their somewhat complication for increasing calculation accuracy.

For certain new radio systems for which the service area or occupied frequency band calculations are very complicated and when they have not been definitively fixed (spread-spectrum systems, satellite mobile communications using LEO, MEO, etc.), calculations can be postponed and fixed license fee regimes may continue to be used.

4.6.4 Expenditures and income of a state concerning spectrum management

This section offers the framework on which the State or administration's costs for spectrum management may be considered.

The total amount of the annual payments for spectral resource C_{an}, to be collected from all users, can be presented as:

$$C_{an} = C_1 + C_2 - I_{an} \quad \text{(units of a national currency)} \tag{17}$$

where:

- C_1: share of the sum that is necessary for covering expenditures of the State on all national and international spectrum management activities
- C_2: net income of the State, if applied
- I_{an}: total amount of annual radio communication inspection charges, if applied.

The last term is applied if an administration uses separate additional tariffs for inspection and examination activities (examination of frequency assignment application forms, inspection of radio stations after installations before entering to operation, systematic inspection of radio installations on conformity to license terms, etc.). This value can be assumed for each current year based on previous year data.

It is possible to subdivide the terms C_1 and C_2 into additional components:

$$C_1 = C_{11} + C_{12} + C_{13} + C_{14} \tag{18}$$

where:

- C_{11}: funds necessary for the purchase and efficient operations using spectrum management system facilities and equipment, including radio monitoring station equipment, direction finders, computers and software for monitoring stations and for a national Spectrum Management Database, equipment for inspection purposes, materials, amortization of buildings, constructions, transport vehicles, etc.
- C_{12}: funds necessary for carrying out supporting scientific research purchase of the scientific and operational literature, international standards and recommendations, carrying out electromagnetic compatibility analysis for supporting frequency assignment process, etc.
- C_{13}: funds necessary to provide efficient activities of a national telecommunication administration within ITU-R and to fulfil bilateral and multilateral frequency coordination obligations relating to terrestrial and satellite radio services etc.
- C_{14}: spectrum management staff salaries.

Taxes are not included in the amounts $C_{11} - C_{14}$.

Coefficient C_2 can be presented as the following components:

$$C_2 = C_{21} + C_{22} \tag{19}$$

where:

- C_{21}: taxes on the incomes of a national spectrum management body and taxes included in the cost of the equipment, software, materials etc., which are bought by this body from the market
- C_{22}: additional payment for spectrum use coming directly to a State budget.

To encourage faster development of radio communication services to support economic development of a country some countries do not apply such additional charges. Equations (17) and (19) do not take into account any indirect income of the State from the used spectral resource in the form of taxes from the incomes of the telecommunication operators whose activity is connected with spectral resource use (for example, taxes from the incomes of the cellular communication operators). This component of the income of the State usually is collected and repeatedly exceeds reasonable values of C_{22}, if those would be collected. At the same time these taxes are also the State income from used spectral resource although an indirect one.

In essence C_{22} is some kind of advanced payment to the State for a spectrum and many telecommunication operators, especially in the developing countries, will not be immediately be able to make such large payments and furthermore this could be an obstacle to development.

A good measure of the provision of an economic incentive is to reduce to a minimum the C_{22} component, so that a telecommunication operator begins to provide service as quickly as possible. The loss of this C_{22} component can be easily compensated by a State from taxes from the telecommunication operator's activity.

Thus, for the purposes of rapid development of telecommunications and information services in a country and the creation of economic incentives to the telecommunication operators, it is essential to hold spectrum payments to the minimum necessary values to cover the costs of a national spectrum management. Administrations can gain further fees from the license for applications to which the spectrum is used and furthermore the taxes on operator revenues will compensate for the revenue foregone. This will be the case particularly where spectrum fees and licensing are treated separately.

4.6.5 Determination of the used spectral resource value

Proceeding from equations (17)-(19) it is possible to determine C_{an} representing the cumulative annual expenditures and income payment for all spectral resources, used in the country. The second step is to determine the spectral resource value used by each user and then by all users. These are calculated on the basis of data regarding each frequency assignment contained in a national Spectrum Management Database.

The method proposed is as follows.

For any *i*-th frequency assignment (from their total amount *n* incorporated in the national database) the three-dimensional value of the spectral resource, denoted as W_i, is to be determined as follows:

$$W_i = \alpha_i \cdot \beta_i \cdot (F_i \cdot S_i \cdot T_i) \tag{20}$$

where for *i*-th frequency assignment:

F_i: frequency resource

S_i: territorial resource

T_i: time resource

α_i: aggregate coefficient which takes into account a number of weighting factors, such as commercial, social and operational ones as it is given below

β_i: weighting coefficient which determines exclusiveness of the frequency assignment as it is given below.

Let us consider items of equation (20) in their reverse order.

4.6.6 Determination of a time resource used by an emission

A time resource T_i used by *i*-th emission is determined as:

$$T_i \leq 1 \text{ (year)} \tag{21}$$

and for each frequency assignment represents a fraction of time related to one year, determined in that or another way, during which the radio transmitter operates in accordance with terms set out in the relevant license. It can be a fraction of a day, which may be the case with broadcasting or PMR service, or a fraction of a year for seasonal operations such as expeditions, agricultural activities, etc.

For example, if particular TV transmitter in accordance with terms of its license is operating only 16 h per a day throughout the whole year, than: T_i = 16/24 = 0.67 year. If another transmitter (for example an HF one used for geological expedition), in accordance with terms of its license can operate totally only 3 months per year, then: T_i = 3/12 = 0.35 year.

It is obvious that for a transmitter which operates permanently, for example a microwave (RRL) one (short intervals of maintenance breaks usually do not taken into account if it is not especially stated in the license), $T_i = 1$ year. The last situation is usually typical for the majority of frequency assignments presented in any national Spectrum Management Database. Such a regime is the most commonly requested and licensed.

4.6.7 Determination of a territorial resource used by an emission

A territorial resource S_i used by i -th emission is determined as:

$$S_i = b_{ij} \cdot s_i \quad (\text{km}^2) \qquad 1 \leq j \leq m \tag{22}$$

where:

- S_i: the territory actually occupied (covered) by the emission in accordance with certain criteria (km^2)
- b_{ij}: weighting coefficient which depends on the *j*-th category of the territory actually occupied by the emission
- m: number of categories.

The number of categories m and the relevant values of the weighting coefficients b_j should be set out by a national telecommunications administration. These categories can take into account density of population and/or level of economic (industrial and/or agricultural) development of various regions of a country. It represents a measure of attractiveness for radio communication and broadcasting operators. Categories may also distinguish urban and rural areas, inland and coastal areas, mainland and island areas. Additionally settlement type and number of permanent or transitory inhabitants could also be included.

Illustrative examples are presented in Table 1.

TABLE 1

Example of weighting coefficients taking into account a density of population (a level of economical development) in various regions of a country

	Designation	b_j
1	The less populated and/or the less economically developed regions (deserts, high mountains, deep jungles etc.) which are usually the less attractive for radiocommunication and broadcasting operators	0.1
$2 - j - ...$	Regions with several intermediate and increasing gradations of density of population and/or indicators of economical development	0.2-0.9
...	The most populated and/or the most economically developed regions (capital region, main industry and/or agricultural areas etc.) which are the most attractive for radiocommunication and broadcasting operators	1
	Cities and settlements of an urban type	
…	With a population of 10 000 to 50 000 inhabitants	1.2
…	With a population of 50 000 to 100 000 inhabitants	1.5
$m - 2$	With a population of 100 000 to 500 000 inhabitants	2.0
$m - 1$	With a population of 500 000 to 1 000 000 inhabitants	3.0
m	With a population over 1 000 000 inhabitants	4.0

The territory actually occupied by the emission s_i is calculated individually for each i-th emission based on the relevant service area concept (and its equivalent for point-to-point communications) by criterion of nominal usable field strength E_n at its border. If the territory actually occupied by the i-th emission includes K regions belonging to different categories above, related territorial resource ΣS_i can be determined as:

$$\Sigma S_i = \sum_{k=1}^{K} b_{ik} \cdot \Delta s_{ik} \qquad (23)$$

where:

b_{ik}: relevant weighting coefficient for q-th area category

s_{ik}: relevant proportion of the whole occupied region s_i

i.e.:

$$s_i = \sum_{k=1}^{K} \Delta s_{ik} \qquad 1 \leq k \leq 3 \text{ (usually)}$$

Examples for the calculation of proportional values s_{ik} for different cases are also presented. If an administration has a digital administrative terrain database interrelated with relevant frequency assignment software, calculations of ΣS_i can be made automatically using software.

4.6.8 Determination of a frequency resource used by an emission

A frequency resource F_i used by i-th emission is determined as:

$$F_i = \chi\, B_{ni} \qquad \text{MHz} \qquad (24)$$

where:

B_{ni} : necessary bandwidth of the emission (MHz), calculated in accordance with Recommendation ITU-R SM.1138-2, taking into account that an occupied bandwidth of an emission should be equal to its necessary bandwidth (Recommendation ITU-R SM.328-11)

χ : adjustment $(0 \leq \chi \leq 1)$ can be used in some cases, for example, to decrease somewhat a very great difference in fees between sound and TV broadcasting, under the same powers of transmitters, due to significant difference in the necessary bandwidths. It also can be used in cases of radar applications (see example of calculations below), etc.

4.6.9 Determination of weighting coefficients

General weighing coefficient α_i in equation (20) can be presented as a product of the following fractional coefficients:

$$\alpha_i = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5 \tag{25}$$

where:

α_1: takes into account commercial value of the spectrum range used

α_2: taking into account social factor

α_3: takes into account features of transmitter location

α_4: takes into account the complexity of spectrum management functions

α_5: other coefficient (coefficients) which can be introduced by an administration reflecting its specific needs.

Illustrative examples of these coefficient values are presented in Table 2.

TABLE 2

Table of service depended coefficients

Service\\α_I	α_1	α_2	α_3		α_4
			City	**Village**	
Radio relay line in a range above 1 GHz	0.1	0.1	1	0.1	0.2
Radio relay line in a range below 1 GHz	0.4	0.2	1	0.1	0.2
Television in metre range (MW TV)	1	0.1	1	0.1	1
Television in decimetre range (DMW TV)	1	0.2	1	0.1	1
VHF sound broadcasting	2.4	1	1	0.1	1
LF – HF broadcasting	1	1	1	0.1	0.8
HF radiocommunications	2.6	1.2	1	0.1	0.8
Trunking	2.4	1.2	1	0.1	1
Cellular	3	1.2	1	0.1	1
Paging	3.5	1.2	1	0.1	1
PMR communications	2	1.2	1	0.1	1
Radiocommunications in CB range	0.1	0.2	1	0.1	0.2
Radiolocation	0.1	0.02	1	0.1	0.2

TABLE 2 (*end*)

Service\α_I	α_1	α_2	α_3		α_4
			City	Village	
Aeronautical radiocommunication and navigation	0.1	0.2	1	0.1	0.8
Maritime radiocommunication	1	0.2	1	0.1	1
Earth station for FSS	4	0.2	1	0.1	0.2
Earth stations for other satellite services including feeder links	1.4	0.1	1	0.1	0.2

Coefficient α_1 is basically determined by two factors:

– The commercial value of radio services. This factor is linked to the willingness of users and operators to pay for the right to provide services or use the services operated over a specific frequency.

– The necessity of using less congested (usually – higher) frequency bands. Some radio services may be moved to higher frequencies as experience is gained or technology changes, thereby decreasing the loading of lower frequency bands. This is the economic lever which should encourage the usage of higher bands.

Coefficient α_2 takes into account a social factor. For those radio services, whose existence is vital for all groups of the population, including the most needy, this coefficient has a low value reflecting a truly social value or obligation on behalf of the administration.

For example, for stations above 1 GHz, through which long-distance communications are provided, as well as for television broadcasting, the coefficient α_2 has a low value and for cellular communication, coefficient α_2 has a higher value.

Coefficient α_3 takes into account features of site location in urban and village conditions. In village conditions, where the density of the population is low and the level of the incomes is also low, the commercial value of communication services will also be low, at the same time technological costs for providing these services will also be high. Therefore with the purpose of support of the telecommunication operators and services as well as for encouraging development of radio communication services this can be a lower coefficient α_3, while in urban districts it may be considerably higher.

Coefficient α_4 is determined by the complexity of spectrum management functions performed. This coefficient is usually the highest for mobile services. It is here that it is required to carry out the function of radio determination of mobile objects. Likewise for television broadcasting, it is required to determine with a high degree of accuracy a number of relevant parameters.

Another weighting coefficient in equation (20) is β_i. This coefficient determines exclusiveness of the frequency assignment. If the given site of the spectrum is used on an exclusive basis, then $\beta_i = 1$. With sharing β_i varies within the limits from 0 up to 1 depending on conditions of sharing. Sharing may be on the basis of territorial separation that can result in reducing actual service area etc.

4.6.10 Determination of the whole value of the used spectral resource

Thus, with the help of weighting coefficients b_j, α_i and β_i, in accordance with equation (20), it is possible to determine (in view of the various factors) spectral resource W_i actually used for each frequency assignment. Then it is possible to determine the whole value of spectral resource W used in the country, according to the equation:

$$W = \sum_{j=1}^{n} W_j \qquad \text{(MHz} \cdot \text{km}^2 \cdot \text{1 year)} \qquad (26)$$

where:

W_i : spectral resource used by i-th frequency assignment

n : overall number of frequency assignments registered in the national Spectrum Management Database.

4.6.11 Price for the qualified unit of the used spectral resource

On the basis of the equations (17)-(19) the total amount of annual payment can be determined which should be received from all users of all or part of the spectral resource. This could be done for all users combined or for individual services such as mobile cellular or broadcasting. On the basis of the equations (20)-(26) the whole value of the annually used spectral resource in the country can be determined.

Then it is possible to determine the price of ΔC_{an} for a qualified unit of the spectral resource:

$$\Delta C_{an} = L(C_{an}/W) \qquad \text{units of a national currency/(MHz} \cdot \text{km}^2 \cdot \text{1 year)} \qquad (27)$$

where:

L: adjustment factor which takes into account possible changes in prices/costs in the country for the next fiscal year.

4.6.12 Annual fees for particular frequency assignment

According to equation (27) the price ΔC_{an} for the qualified unit of the spectral resource is determined. Equation (20) gives the value of the spectral resource W_i used for a particular i-th frequency assignment. Based on this, the amount of the annual payment C_i from the specific user of the spectrum for this frequency assignment will be determined as:

$$C_i = \Delta C_{an} \cdot W_i \qquad (28)$$

If the particular radiocommunication operator has several frequency assignments, the payment for each assignment is determined as above and then they are summated in relation to all operator's frequency assignments.

4.7 Procedures and examples of used spectral resource calculations in application to different radio services

It is important to point out that calculation methods and procedures of service occupied areas, fixed radio link lengths, etc. for exact operational purposes are usually very complicated, time consuming and require special qualification of the personnel.

Their implementation for license fee calculation purposes could impose a great additional workload on a national spectrum management staff and not lead to significant increasing accuracy of such kind of calculations. Moreover, for the purposes of fee calculations it is much more important to provide universal procedures to guarantee equal conditions for all users belonging to one group (by radio service or its particular application) rather than to have a high accuracy of technical parameter calculations.

Taking this into account, for purposes of the given license fees calculation model, considerably simplified calculation methods are proposed. The main orientation is given on using pre-calculated graphs and tables rather than complicated formulas. For the most difficult cases (HF broadcasting, satellite communications etc.) particular calculations of service areas, fixed radio link lengths etc. can be replaced by values taken directly from relevant license application forms or received from operators by special requests.

Another common approach is to make estimation of service or occupied areas only within the national borders of a country. For maritime services national maritime economical border concept may be used (usually 200 miles, i.e. 360 km).

For cellular mobile radiocommunications systems, paging etc. which may contain numerous base stations including micro- and pico-cell ones for nearby and indoor operations, it may be too time consuming to make calculations based on the determination of service areas of individual base stations. Therefore for this case the overall service area of the relevant cellular network and overall frequency bands assigned for base-mobile and mobile-base communications can be used for calculation of a spectral resource, used by the whole network.

Occupied areas of earth stations of satellite communication systems are proposed to be determined on the basis of coordination distances agreed during the process of coordination and notification of frequency and orbital assignments in the ITU-R. If they are not available, a universal coordination distance of 350 km for VSATs and 750 km for other stations is proposed to be used. In some cases the values as agreed between the administration and operator can also be used.

It is indicated above that the model is also applicable to receivers for which users especially demand protection from interference. To calculate the relevant fees, in accordance with the principle of reciprocity of a receiver and transmitter, the receiver is substituted by a transmitter of typical power (or a power agreed with user) and antenna, which effective height, gain and direction correspond to the receiving one. For this set of parameters the relevant spectral resource and then radio license fees are calculated in accordance with procedures presented below for related radio services and their applications.

It is necessary to mention that an administration, depending on particular conditions and abilities, may decide on simplification of some of the proposed calculation procedures. Particularly it concerns eliminating of service/occupied area subdivisions to different zones belonging to different license fees categories and the only one category, corresponding to the largest service/occupied area, can be used. It also concerns eliminating of the effective antenna height determinations, etc.

4.7.1 VHF/UHF sound and TV radio broadcasting calculation procedures

a) Service area radius calculation

In the absence of digital terrain map facilities and computerized propagation and frequency planning models, which can provide exact automatic calculations, it is proposed to use the following simplified method of service area determination. The procedure is mainly based on provisions of Recommendation ITU-R P.1546-4, which presents propagation curves and procedures of their use for determining distances at which field strengths take specific values adopted as minimal usable by Recommendation ITU-R BT.417-5.

The propagation curves presented in Recommendation ITU-R P.1546-4 represent field-strength values in VHF and UHF bands in dB(μV/m) as a function of various parameters and refer to land paths. The propagation curves relate to transmitter power of 1 kW radiated from a half-wave dipole and represent the field-strength values exceeded at 50% of the locations for 50% of time. These field-strength values are usually used for service areas determination. They also correspond to different transmitting antenna heights and a receiving antenna height of 10 m. For different values of effective height, a linear interpolation between the two curves corresponding to effective heights immediately above and below the true value can be used.

The effective height of the transmitting antenna, h_{ef}, is determined as its height over the average level of the ground between distances of 3 km and 15 km from the transmitter in the direction of the receiver. Procedures of h_{ef} calculations, to be used under service area radius calculations, are presented in (b).

Service areas are determined by values of minimal usable field strengths, E_{mu}, at their borders, which are usually utilized for frequency planning purposes. These are presented in Table 3.

Values of service area radius R taken from curves at Figs 2 and 3 under different values of effective radiated power (e.r.p.) P_{ef}, and effective height of the transmitting antenna h_{ef}, for minimal usable field strength values, E_{mu}, indicated in Table 3, are presented in Tables 4 to 9. Interpolation and extrapolation of field strength as a function of frequency is made in accordance with Annex 5 to Recommendation ITU-R P.1546. Particular frequencies, f_c, for re-calculation are shown in table headings. Calculations are made for effective antenna heights typical for broadcasting.

TABLE 3

Minimal usable field strengths E_{mu} values

Frequency band	**Below 76 MHz (TV)**	**76-108 MHz (TV)**	**108-230 MHz (TV)**	**230-582 MHz (TV)**	**Above 528 MHz (TV)**	**Below 108 MHz (Sound)**
E_{mu} (dB(μV/m))	48	52	55	65	70	54

e.r.p. is given as:

$$P_{ef} = P + G_t + \eta \qquad \text{dBW} \tag{29}$$

where:

P: transmitter power (dBW)

G_t: antenna gain against a half-wave dipole (dB)

η: feeder losses (dB).

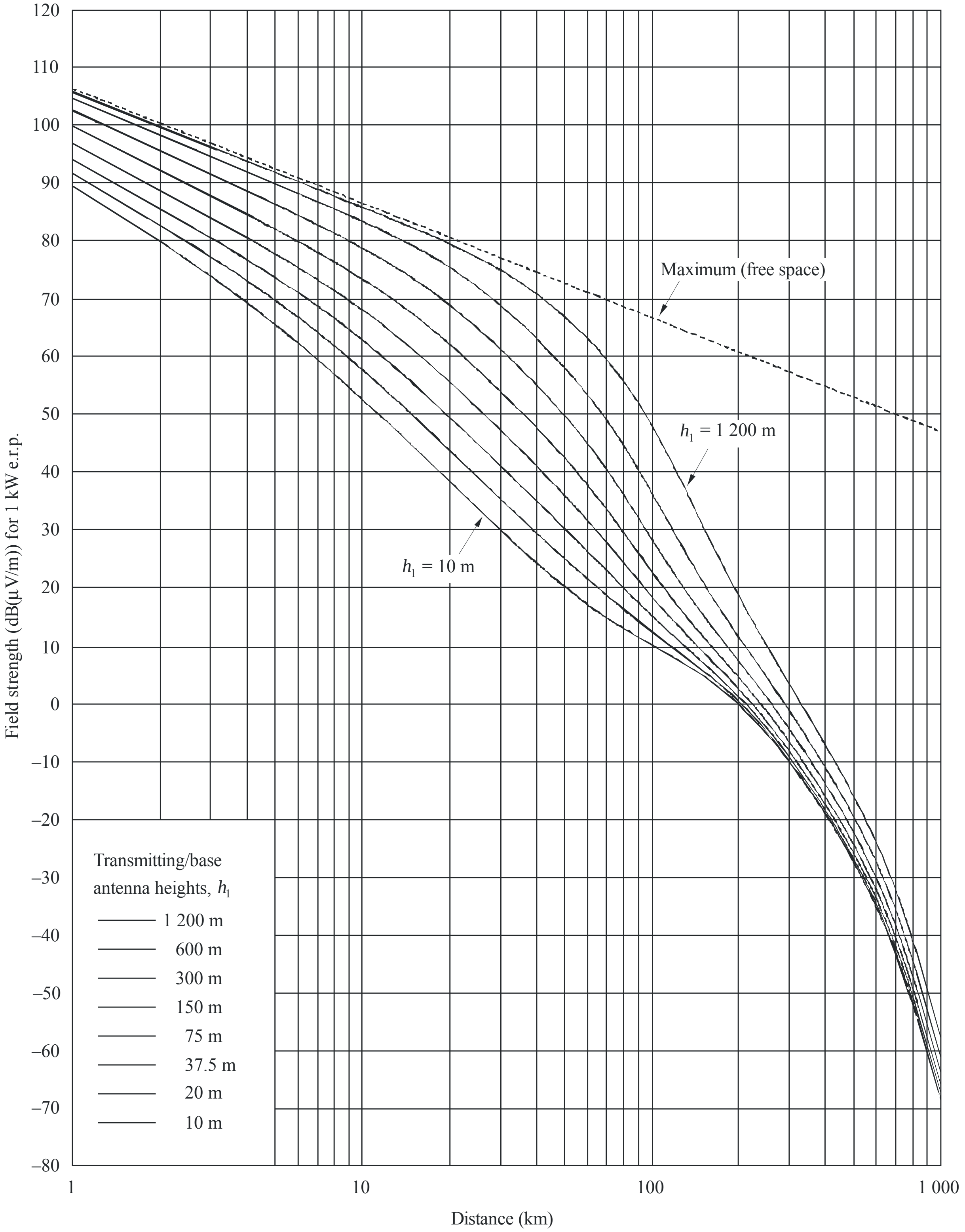
For purposes of the given licence fees calculation model it is proposed to accept $\eta = 0$ for all cases.

It is necessary to note, that under high power and low height antenna conditions and especially for lower frequencies, calculated service area radius exceeds the distance to radio horizon. As far as the quality of the service beyond the radio horizon is significantly decreases it means that excessive transmitter powers are used non-effectively. Relevant distances to radio horizon, when they are less than radiuses of service areas, are indicated by second figures in cells of Tables 4 to 6.

It can be mentioned that data of Figs 2 and 3 without any re-scaling correspond to data of Tables 5 and 8 for rows belong to 30 dBW (as far as 1 kW equals 30 dBW). For example, distances which correspond to points indicated at curves of these figures and can be read along the abscise axis, are highlighted in related rows of Tables 5 to 8.

FIGURE 2

Propagation curves for 30-300 MHz frequency band



50% of locations.

h_2: representative clutter height.

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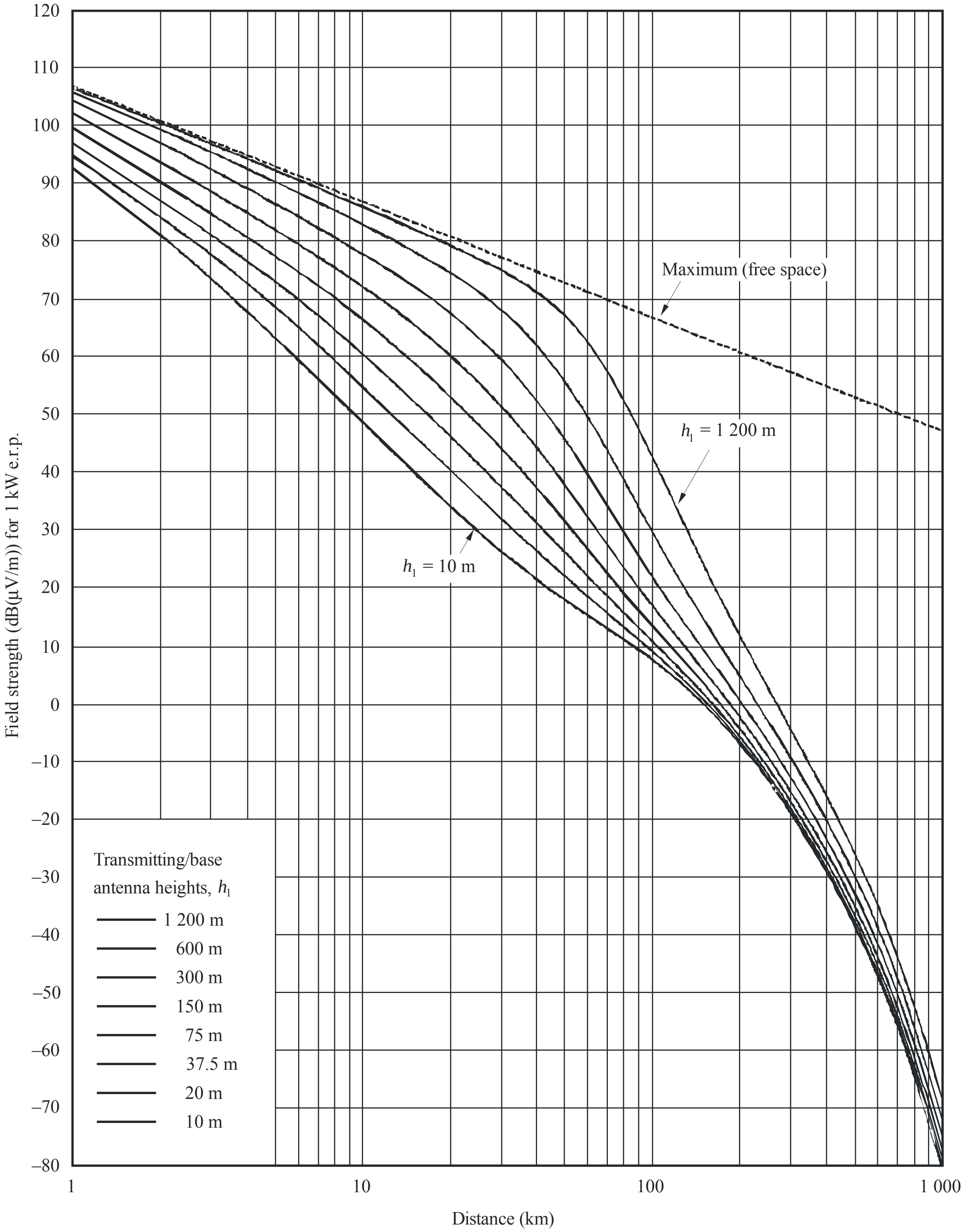
FIGURE 3

Propagation curves for 300-1 000 MHz frequency band



50% of locations.

h_2: representative clutter height.

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TABLE 4

Radius of service area (km) for TV below 76 MHz,
E_{mu} = 48 dB(μV/m), f_c = 70 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	9	12	14	16	20	23	26	28	31	33	37
20.0	12	15	18	21	25	29	33	36	39	42	47
25.0	16	20	24	27	33	37	42	45	49	53	58
30.0	20	25	30	34	41	47	52	56	60	64	70
35.0	26	32	38	43	51	58	63	68	72	76	82
40.0	33	41	48	54	63	70	75	79	84	88	95
43.0	38/36	47/42	55/49	61/54	70/63	77/71	83/78	87/84	92/90	96/95	103
46.0	44/36	54/42	63/49	69/54	78/63	85/71	91/78	95/84	100/90	104/95	112/105
50.0	54/36	65/42	73/49	80/54	89/63	97/71	102/78	107/84	112/90	117/95	124/105
55.0	69/36	80/42	89/49	96/54	105/63	113/71	119/78	124/84	130/90	135/95	143/105
60.0	88/36	100/42	108/49	115/54	125/63	134/71	140/78	145/84	152/90	157/95	166/105

TABLE 5

Radius of service area (km) for TV in 76-108 MHz,
E_{mu} = 52 dB(μV/m), f_c = 100 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	7	9	11	13	15	18	20	23	25	26	30
20.0	9	12	14	17	20	24	27	29	32	34	39
25.0	13	16	19	22	26	30	34	37	40	43	48
30.0	16	20	**24**	28	**33**	38	42	**46**	50	53	59
35.0	21	26	31	35	42	47	52	56	60	64	70
40.0	26.3	32.8	38.7	43.8	51.4	57.8	62.9	67.0	71.4	75.2	81.7
43.0	30	38	44	50	58	65	70	74	78	82	89
46.0	37/36	43/42	51/49	56/54	65/63	72/71	77	81	86	90	97
50.0	43/36	52/42	60/49	66/54	75/63	82/71	87/78	91/84	96/90	101/95	108/105
55.0	54/36	65/42	73/49	80/54	88/63	96/71	101/78	106/84	111/90	116/95	123/105
60.0	69/36	80/42	89/49	95/54	104/63	112/71	118/78	123/84	129/90	133/95	141/105

TABLE 6

Radius of service area (km) for TV in 108-230 MHz,
E_{mu} = 55 dB(μV/m), f_c = 150 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	6	7	9	10	13	15	17	19	20	22	25
20.0	8	10	12	14	17	20	22	25	27	29	33
25.0	10	13	16	18	22	25	29	31	34	37	41
30.0	13	17	20	23	28	32	36	39	43	45	51
35.0	17	21	26	29	35	40	45	48	52	55	61
40.0	22	27	32	37	44	49	54	58	62	65	72
43.0	25	31	37	42	49	55	60	64	68	72	78
46.0	29	36	42	48	55	62	67	71	75	79	85
50.0	36/36	43/42	50/49	56/54	64/63	71	76	80	85	89	95
55.0	50/36	54/42	62/49	68/54	76/63	83/71	88/78	93/84	97/90	102/95	109/105
60.0	57/36	67/42	75/49	81/54	90/63	97/71	103/78	107/84	113/90	117/95	125/105

TABLE 7

Radius of service area (km) for TV in 230-528 MHz,
E_{mu} = 65 dB(μV/m), f_c = 250 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	3	3	4	5	6	7	8	9	10	11	12
20.0	4	5	6	7	9	10	12	13	14	15	18
25.0	6	7	9	10	12	14	16	18	20	21	25
30.0	7	9	11	13	16	19	22	24	26	28	32
35.0	10	12	15	17	21	25	28	31	33	36	41
40.0	13	16	19	22	27	31	35	38	41	44	49
43.0	15	19	22	26	31	36	40	43	46	49	55
46.0	17	22	26	30	35	40	45	48	51	55	60
50.0	21	26	31	35	42	47	51	55	59	62	68
55.0	27	33	39	43	50	56	61	65	69	73	79
60.0	34	41	48	53	60	67	71	75	80	84	90

TABLE 8

Radius of service area (km) for TV above 528 MHz,
E_{mu} = 70 dB(μV/m), f_c = 550 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	2	3	3	3	4	5	5	6	6	7	7
20.0	3	4	4	5	6	7	8	9	9	10	11
25.0	4	5	6	7	8	10	11	12	14	15	17
30.0	5	7	**8**	9	**12**	14	15	**17**	19	21	24
35.0	7	9	11	13	16	18	21	23	25	27	31
40.0	9	12	14	17	20	24	27	30	32	35	39
43.0	11	14	17	19	23	27	31	34	37	39	44
46.0	13	16	19	22	27	31	35	38	41	44	49
50.0	15	19	23	27	32	37	41	44	47	50	55
55.0	19	24	29	33	39	44	48	51	55	58	64
60.0	25	31	36	41	47	52	57	60	64	67	73

TABLE 9

Radius of service area (km) for sound broadcasting below 108 MHz,
E_{mu} = 54 dB(μV/m), f_c = 550 MHz

h_{ef} (m) / P_{ef} (dBW)	30	50	75	100	150	200	250	300	350	400	500
15.0	6	8	9	11	14	16	18	20	22	24	27
20.0	9	11	13	15	18	21	24	26	29	31	35
25.0	11	14	17	19	24	27	31	34	37	39	44
30.0	15	18	22	25	30	35	39	42	46	49	54
35.0	19	23	28	32	38	43	48	52	56	59	65
40.0	24	30	35	40	47	53	59	63	67	71	77
43.0	28	34	41	46	53	60	65	69	74	78	84
46.0	33	39	46	52	60	67	72	76	81	85	92

b) Effective antenna height calculation

It was already mentioned that the effective height of the transmitting antenna, h_{ef}, is determined as its height over the average level of the ground between distances of 3 km and 15 km from the transmitter in the direction of the receiver (see Fig. 4), i.e.:

$$h_{ef} = h_s - h_{av} \tag{30}$$

where:

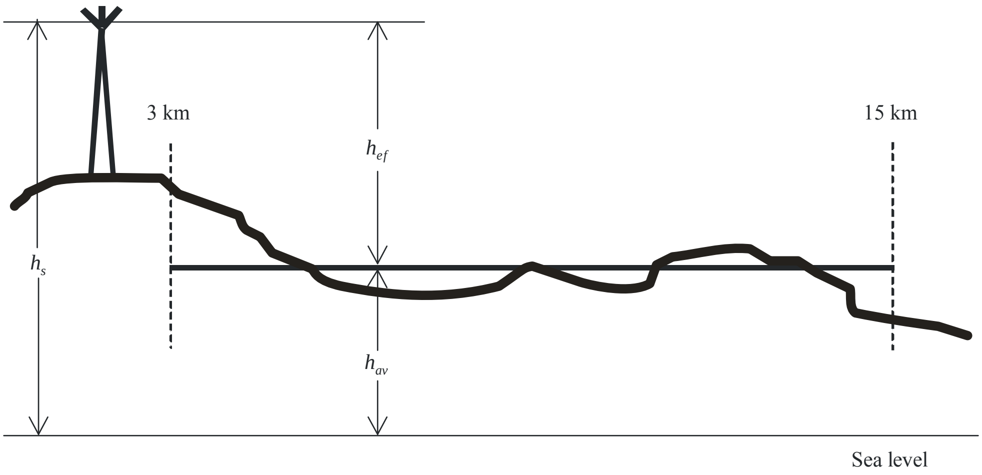
h_s : antenna height above the sea level (i.e. antenna mast height plus a height of the ground above the sea level at a place of installation)

h_{av} : average level of the ground between distances of 3 km and 15 km from the transmitter.

It is essential to take into account not physical (mast height) but effective antenna height because antennas are frequently installed at tops of hills which heights can be comparable or even more than a mast height (see Fig. 4). Average level of the ground between distances of 3 km and 15 km from the transmitter is calculated with relevant terrain maps (preferably having scales 1:200 000 of 1:500 000). Using the map readouts of the ground height along some direction should be taken through each 1 or 2 km between distances of 3 km and 15 km from the transmitter and an average level is calculated as a sum of all readouts divided by their number. For further cases of calculating effective height, refer to Annex 5 of Recommendation ITU-R P.1546-4.

FIGURE 4

Determination of antenna effective height



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It is obvious that even for non-directional transmitting antenna used, a real service area usually will not be a circular one as far as average levels of the ground between distances of 3 km and 15 km from the transmitter in various directions will be different and, therefore, relevant antenna effective heights will be also different. Nevertheless, for the purposes of the given licence fees calculation model it is assumed to be a circular one based on antenna effective height calculation in one direction.

If an administration likes to increase accuracy of calculations in cases of a rather variable terrain profiles in different directions from antenna, an average value of antenna effective height can be calculates according to its four values in the North, East, South and West directions from the antenna. Example of calculations is presented in Table 10.

TABLE 10

Example of effective antenna height calculation for a case of non-regular terrain

No.	Distance of readout from antenna (km)	Readouts of ground heights (m)			
		North	South	East	West
1	3	250	240	300	240
2	4	240	220	300	220
3	5	220	180	290	200
4	6	230	180	280	170
5	7	240	160	270	160
6	8	260	140	260	180
7	9	260	120	250	200
8	10	280	120	230	250
9	11	280	110	220	250
10	12	280	100	210	240
11	13	290	100	200	200
12	14	300	80	200	180
13	15	320	60	200	140
	Readout sums, Sd (m)	3 450	1 810	3 210	2 630
	Effective heights, Sd /13 (m)	265	139	245	202
	Averaged effective height, h_{ef} (m)	213			

c) Service area calculation

Having calculated service area radius, *R*, (km) in accordance with procedures presented in a) and b), a service area, *s*, is obviously calculated as:

$$s = \pi R^2 \qquad \text{km}^2 \tag{31}$$

It can happen that a service area contains two (see example at Fig. 5) or even three (see example at Fig. 6) zones belonging to different license fees categories, as it was mentioned in § 5.2 of the model. It can also happen at the border of a country with other ones. In these cases, and when an administration has not got an digital administrative terrain data base interrelated with relevant frequency assignment software, the following simplified procedures are applicable for calculation of parts of the service area belonging to different zones.

The actual border curves are approximated by straight lines situated in such ways that areas between actual border curves and relevant approximating lines, at each sides of these lines, would be approximately equal (see Figs 5 and 6). Approximating line between zones S_2' and S_3 at Fig. 6 should also go along a radius of a service area, as it is presented at that figure.

FIGURE 5

Example with covering two different zones

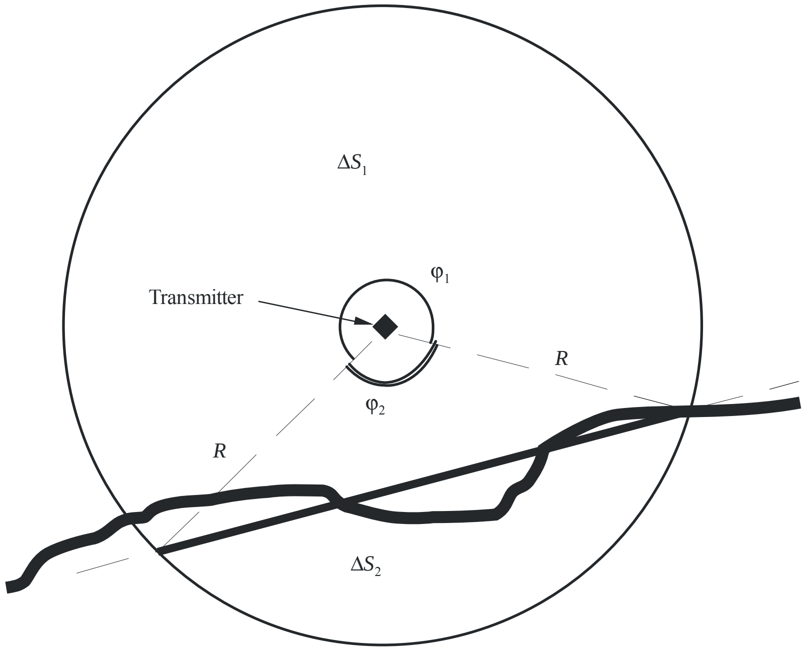

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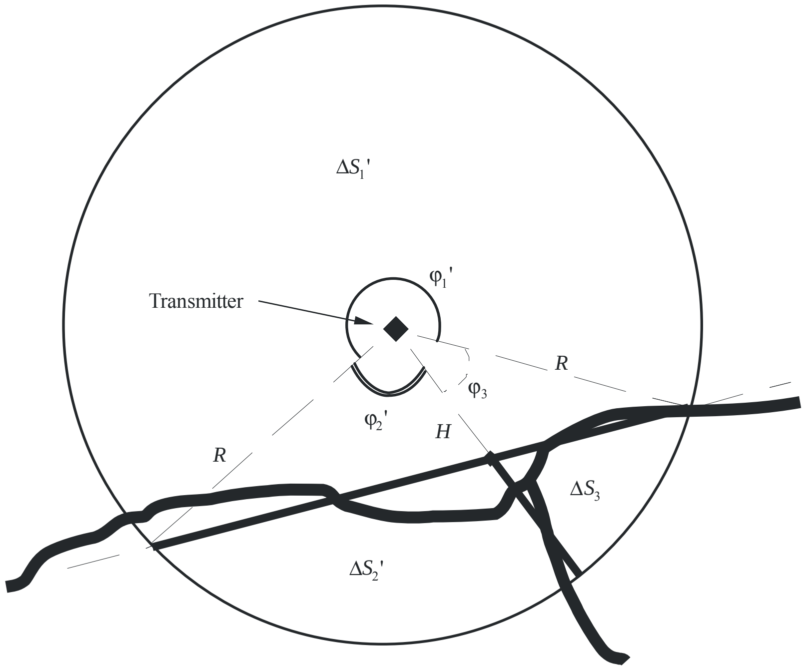
FIGURE 6

Example with covering three different zones



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Segment S_2 area ΔS_2 for two-zone case (Fig. 5) is calculated as:

$$\Delta S_2 = \frac{R^2}{2}\left(\frac{\pi\varphi_2}{180} - \sin\varphi_2\right) \tag{32}$$

where:

φ_2: relevant sector angle (see Fig. 5)

and segment S_1 area ΔS_1 is determined as:

$$\Delta S_1 = \pi R^2 - S_2 \tag{33}$$

In three-zone case (Fig. 6) parts S_2' and S_3 of common sector ($S_2' + S_3$) have correspondingly the following areas:

$$\Delta S_2' = \frac{R^2}{2}\left(\frac{\pi\varphi_2'}{180} - \Psi\sin\varphi_2'\right) \tag{34}$$

$$\Delta S_3 = \frac{R^2}{2}\left(\frac{\pi\varphi_3}{180} - \Psi\sin\varphi_3\right) \tag{35}$$

$$\Psi = \frac{H}{R}$$

where:

H: distance from a transmitter to the junction point of approximating lines (see Fig. 6) (km)

φ_2' and φ_3: relevant sector angles (see Fig. 6) (degrees).

Then:

$$\Delta S_1' = \pi R^2 - \Delta S_2' - \Delta S_3 \tag{36}$$

As an example, let us calculate relative areas for the three-zone case presented at Fig. 6. From the figure we have: $\varphi_2' = 88°$, $\varphi_3 = 39°$ and $\psi = 0.51$.

Then from equations (34), (35) and (36) it follows, correspondingly:

$$\Delta S_2' = \frac{R^2}{2}\left(\frac{\pi \cdot 88}{180} - 0.51 \cdot 0.999\right) = 0.51\,R^2$$

$$\Delta S_3 = \frac{R^2}{2}\left(\frac{\pi \cdot 39}{180} - 0.51 \cdot 0.63\right) = 0.18\,R^2$$

$$\Delta S_1' = (3.14 - 0.51 - 0.18)\,R^2 = 2.45\,R^2$$

4.7.2 Example of calculations

a) Incoming parameters

Let us calculate a spectral resource used by a FM sound broadcasting station working in an urban area 20 h per each day with a power 1.5 kW in exclusive regime (no sharing). Antenna, having mast height 100 m, situated at the top of a hill with ground height 360 m above the sea level. Terrain situation around the transmitter corresponds to example presented in (b), i.e. average level of the ground between distances of 3 km and 15 km from the transmitter, h_{av}, in accordance with Table 10 is equal to 213 m. Antenna gain against a half-wave dipole equals 3 dB. Modulation conditions are standard ones: peak deviation is 75 kHz, maximum modulation frequency is 15 kHz.

b) Time and frequency resources used

In accordance with equation (21), used time resource is:

$$T = 20/24 \text{ (each day)} = 0.83 \text{ year}$$

According to Recommendation ITU-R SM.1138-2 "Sound broadcasting" (class of emission F3E) the necessary bandwidth is 180 kHz, i.e., accepting $\chi = 1$, used frequency resource in accordance with equation (24) is:

$$F = 0.18 \text{ MHz}$$

c) Territorial resource used

Firstly, e.r.p. of the transmitter, effective antenna height and then service area radius should be calculated.

In accordance with data presented in § 4.7.1(a) and equation (29), e.r.p. of the transmitter is:

$$P_{ef} = 10 \log 1\,500 + 3 = 31.8 + 3 = 34.8 \cong 35 \text{ dBW}$$

In accordance with data given in § 4.7.1(a) and equation (30), it can be found:

$$h_s = 100 + 360 = 460 \text{ m}$$

$$h_{ef} = 460 - 213 = 247 \text{ m} \cong 250 \text{ m}$$

It is worth to indicate that in this particular case effective antenna height is 2.5 times greater than the mast height and this greatly influence on calculation results.

From Table 9 for P_{ef} = 35 dBW and h_{ef} = 250 m, it follows:

$$R = 47.8 \text{ km};\; R^2 = 2\,285 \text{ km}^2$$

Let us assume that service area under consideration is subdivided by three zones of different categories in proportion presented in § 4.7.1(c) i.e.: $\Delta S_1' = 2.45\, R^2$, $\Delta S_2' = 0.51\, R^2$ and $\Delta S_3 = 0.18 R^2$. Let us assume that relevant coefficients b_j from Table 1 are equal: $b_1 = 1$, $b_2 = 0.8$ and $b_3 = 0.6$. Then, in accordance with equation (23) it follows:

$$\sum S = 2285 \cdot (1 \cdot 2.45 + 0.8 \cdot 0.51 + 0.6 \cdot 0.18) = 6\;777 \text{ km}^2$$

It is instead of 7 179 km^2 when the whole service area lies within one zone having $b = 1$.

d) Spectral resource used

Substituting values calculated in (b) and (c) to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 2.4 \times 1 \times 1 \times 1 \times 1 \times 0.18 \times 6\,777 \times 0.83 = 2\,430 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.3 LF-HF sound broadcasting

For LF-HF sound broadcasting stations time and frequency resources used are determined similarly to § 4.7.1(b). Necessary bandwidths are calculated in accordance with Recommendation ITU-R SM.1138-2 "Sound broadcasting", row "Sound broadcasting, double-sideband" (class of emission A3E). It should be noted that for this kind of broadcasting the administrations usually use transmitters with different classes of quality, depending on highest modulating frequency which determines a necessary bandwidth value. Relevant data should be taken from a National Frequency Assignment Database.

As far as it concerns a territorial resource used, its calculation for this case meets some difficulties due to complexity of calculations, especially for HF broadcasting, which hardly to be significantly simplified without losing a minimal necessary accuracy. For MF transmitters service area greatly differ for day-time and night-time operations. Taking account rather low number of LF-HF broadcasting stations in many countries, it is proposed that instead of complicated calculations the relevant data on service area from a National Frequency Assignment Database are used. If those are not available, they can be asked from operators. Operators usually have information on their service areas through calculations and/or monitoring.

On obtaining these data, related spectral resource used can be calculated similarly to the procedure presented in (c). As far as for MF transmitters principally there are two considerable different values of service area for day-time and night-time operations, overall spectral resource used can be determined as a sum of two partial spectral resources which correspond to those different values of the service area.

It should also be noted that service areas of LF, MF (night-time) and HF broadcasting transmitters can be very large and may be extended beyond borders of countries which sizes are relatively small. In this case (determined in co-operation with relevant operators) the service area may be considered as a whole territory of the country, or its larger part. Areas of zones belonging to different categories are determined by relevant administrative documentation or estimated by maps.

In case of directional transmitting antennas application, a "service sector" concept, given by Recommendation ITU-R F.162-3, can be used.

4.7.4 Mobile radio services

4.7.4.1 Land mobile radio service

a) Background of calculation procedures

The procedure generally follows radio wave propagation model known as modified Okamura-Hata one, some information on which is given in Annex 8 to Recommendation ITU-R P.1546-4. The model assumes existence of homogeneous urban development in limits of the service area, lack of direct visibility between the transmitter of the BS and mobile personal receiver, heights of transmitting and receiving antennas are in limits 20-200 m (but in the majority of cases they are 40-100 m) and 1.5-10 m correspondingly.

Considering, for purposes of the given model, that antenna feeder losses at transmitting and receiving sides are both equal zero, the power of a signal P_r (dBW) at an input of the receiver can be presented as:

$$P_r = P_t + G_t + G_r - L(R) \qquad \text{dBW} \tag{37}$$

where:

- P_t : transmitter power (dBW)
- G_t : transmitter antenna gain (dB)
- G_r : receiver antenna gain (dB)
- $L(R)$: transmission losses between transmitter and receiver (dB).

To provide the necessary quality of the received signal at a border of the service area the following condition should generally be met:

$$P_r = P_{min} + k_f\,\sigma$$

where:

- P_{min} : minimal power of a received signal which equals to a sensitivity of the receiver (dBW)
- k_f : fading allowance a signal for a given time of the signal quality deterioration
- σ : mean square value of a signal fluctuations (dB).

For 50% of time k_f = 0, for 95% of time k_f = 1.65. For conventional urban areas σ varies from 6 to 8 dB. Accepting, similarly to broadcasting, that a service area is determined by the criterion of 50% time i.e. $k_f = 0$, overall coefficient $k_f\,\sigma$ becomes equal to zero and:

$$P_r = P_{min} \tag{38}$$

Equating right parts of equations (37) and (38) to meet condition at the border of the service area, we get:

$$P_t + G_t + G_r - L(R) = P_{min}$$

where:

$$L(R) = P_t + G_t + G_r - P_{min} \tag{39}$$

In accordance with modified Okamura-Hata radio wave propagation model, accurate for a signal median value (i.e. for 50% of time):

$$L(R) = \vartheta + \xi \log R \tag{40}$$

where ϑ and ξ are coefficients in dB whose values depend on frequency and heights of a transmitter and receiver. For conventional urban areas:

$$\xi = 44.9 - 6.55 \log h_t \tag{41}$$

$$\vartheta = 65.55 - 6.16 \log f + 13.82 \log h_t + a_r(h_r) \quad \text{for} \quad f \leq 1 \text{ GHz} \tag{42}$$

$$\vartheta = 46.3 - 33.9 \log f + 13.82 \log h_t + a_r(h_r) \quad \text{for} \quad f \geq 1.5 \text{ GHz} \tag{43}$$

where:

f : working frequency (MHz)

h_t : effective height of transmitting antenna (m)

h_r : effective height of receiving antenna (m)

$a_r(h_r) = (1.1 \log f - 0.7)\, h_r - (1.56 \log f - 0.8)$ (dB).

Effective height of transmitting antenna is to be determined as it is presented in Recommendation ITU-R P.1546-4, i.e. by procedure demonstrated in §§ 4.7.1(b) and 4.7.1(c). However, taking into account that recently powers of base stations are not too high and, therefore, related service areas are relatively small, for great majority of urban areas situated at a plain terrain, effective height of transmitting antenna can be approximated by its height above ground at a place of its installation. The antenna height of a mobile or portable station is taken as its height above the ground. These assumptions are taken for purposes of the given licence fees calculation model.

Following equations (39) to (43), a service area radius R can be calculated as:

$$R = 10^{\left(\frac{z - \vartheta}{\zeta}\right)} \tag{44}$$

where:

R : service area radius (km)

z : easily determined generalized power parameter (dB) calculated as:

$$z = P_t + G_t + G_r - P_{min} \tag{45}$$

Graphs of relationships $R = \varphi(z)$, calculated in accordance with equations (44) and (45), for frequencies below 1 GHz and above 1.5 GHz are presented at Figs 7-8 and 9-10 accordingly. Figures 7 and 9 correspond to transmitter antenna heights, h_t, equal to 40 m and Figs 8 and 10 to 100 m. In all figures line 1 corresponds to receiver antenna height, h_r, equal to 1.5 m and line 2 to 10 m. The last allows to use these graphs for calculations associated with VHF/UHF fixed communications and "point-multipoint" program distribution systems, when the collective reception antennas are placed on roofs of buildings. Line 3 indicates dependencies for free-space propagation conditions. It can be used for calculations associated with short distance VHF/UHF fixed communications with line-of-sight propagation conditions. For other antenna heights lying within above-mentioned limits, service area radius values can be obtained from Figs 7-10 by interpolation.

Somewhat typical values of parameters appeared in equation (45), for a number of land mobile radiocommunication systems including equipment for digitally enhanced cordless telecommunications (DECT) and private mobile radio (PMR), are presented in Table 11.

TABLE 11

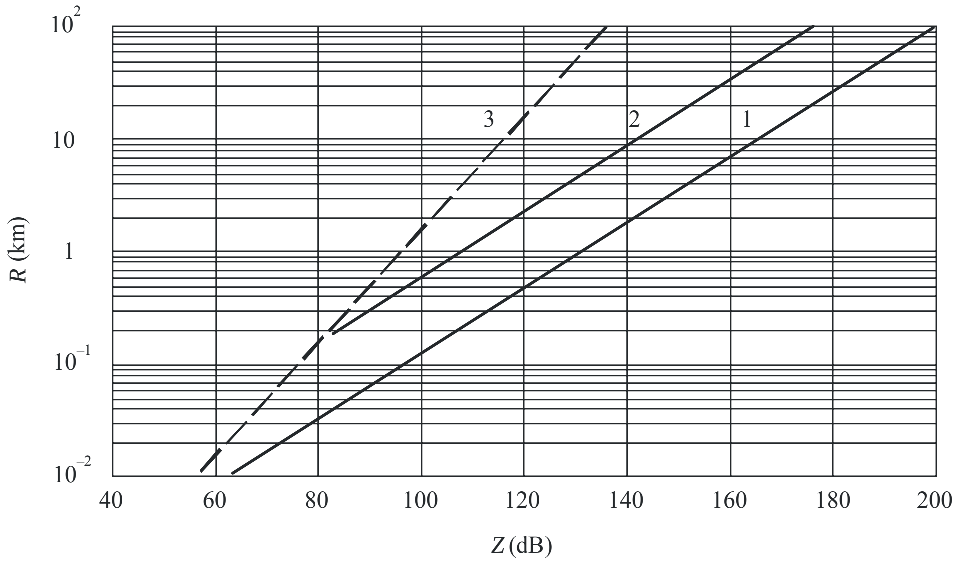
Values of equipment parameters

Parameter \ System	CDMA	GSM	AMPS	NMT	DECT	PMR
Transmitting antenna gain G_t (dB)	13	18	17	10-17	3	6-15
Receiving antenna gain G_r (dB)	0	0	0	6	3	3-6
Receiver sensitivity P_{min} (dBW)	–147	–138	–146	–115	–112	–110

Table 11 can be amended in future for new, more efficient, land mobile radiocommunications systems.

FIGURE 7

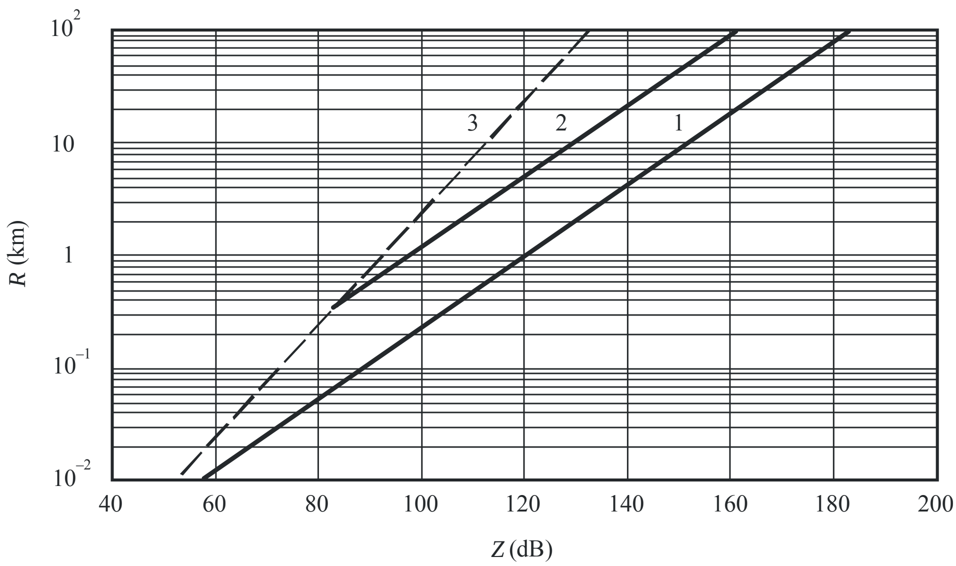
Service area radius calculation for frequencies below 1 000 MHz, h_t = 40 m
1: h_r = 1.5 m, 2: h_r = 10 m, 3: free space propagation



Report SM.2012-07

FIGURE 8

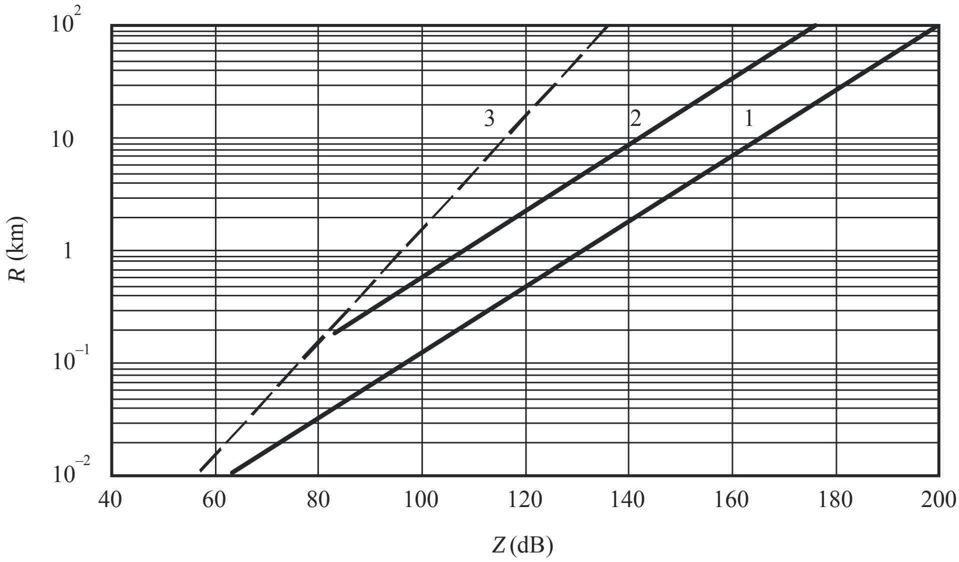
Service area radius calculation for frequencies below 1 000 MHz, h_t = 100 m
1: h_r = 1.5 m, 2: h_r = 10 m, 3: free space propagation



Report SM.2012-08

FIGURE 9

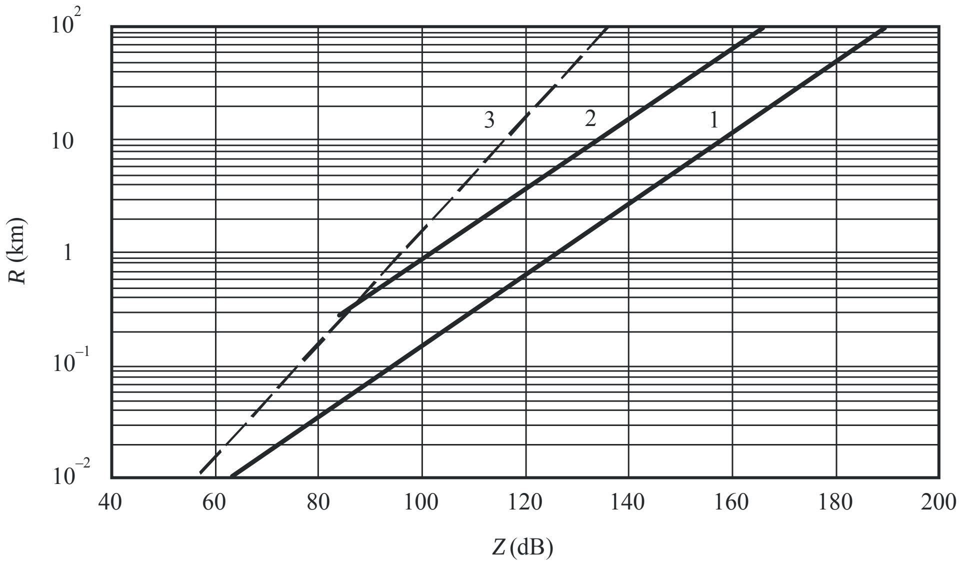
Service area radius calculation for frequencies below 1 500 MHz, h_t = 100 m
1: h_r = 1.5 m, 2: h_r = 10 m, 3: free space propagation



Report SM.2012-09

FIGURE 10

Service area radius calculation for frequencies below 1 500 MHz, h_t = 100 m
1: h_r = 1.5 m, 2: h_r = 10 m, 3: free space propagation



Report SM.2012-10

b) Calculation procedures

Having got graphs presented at Figs 7 to 10 calculation procedure becomes a quite simple one. It is only necessary to insert into equation (45) required parameters, taken from the national frequency assignment database (or, in their absence, from Table 11), and to read related service area radius R for calculated value of parameter z directly from Figs 7 and 8, depending on working frequency and antenna heights. Due to the fact, that for land mobile service, and especially for cellular systems, service areas of individual base stations are rather small ones, they will usually lie within only one zone of license fees category. Thereby service areas usually can be calculated by simple equation (31).

After determining service area value, procedure of used spectral resource calculation follows the same one, which is presented in § 4.7.1(b).

4.7.4.2 Example of calculations

a) Incoming parameters

Let us calculate a spectral resource used by a base station of GSM 900 MHz cellular system working with power 2.5 W without interruption 24 h per each day, without sharing, in a city with population 40 000 inhabitants (i.e. according to Table 1, $b_j = 1.2$). Overall frequency bands used for base – mobile and mobile – base transmissions are equal 0.8 MHz each. Transmitting and receiving antenna heights are 40 m and 1.5 m correspondently. Let us assume that other parameters correspond to Table 11.

b) Time and frequency resources used

In accordance with equation (21), used time resource is:

$$T = 24/24 \text{ (each day)} = \text{year}$$

As far as the system within the same service area uses two sets of frequency bands, one for base – mobile and other for mobile – base transmissions, the overall used frequency resource, accepting in formula (25) $\chi = 1$, can be found as:

$$F = 2 \times 0.8 = 1.6 \text{ MHz}$$

c) Territorial resource used

Substituting relevant data from § 4.7.1 and Table 11 to equation (45) we get:

$$z = 10 \log 2.5 + 18 + 0 - (-138) = 160 \text{ dB}$$

For this z value from line 1 of Fig. 7 and formula (31) it follows:

$$R = 10 \text{ km}, \quad S = 314 \text{ km}^2$$

From equation (22), taking into account relevant data from Table 24, it follows:

$$S_i = 1.2 \times 314 = 377 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated in §§ 1.3.1.3.2 and 1.3.1.2.3 to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 3 \times 1.2 \times 1 \times 1 \times 1 \times 1.6 \times 377 \times 1 = 2\,172 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.5 Maritime mobile radio service

a) Background of calculation procedures

For coast and ship stations of maritime mobile service working in VLF and HF frequency bands, proposed provisions for LF and HF broadcasting stations can be used taking into account limitations by national maritime economical border (usually 200 miles, i.e. 360 km). In cases of directional transmitting antennas applications, a "service sector" concept, given by Recommendation ITU-R F.162-3, can be used.

Service areas of VHF coast and ship stations working in 156-174 MHz frequency bands (RR Appendix 18 are determined by propagation curves given in Annex 2 to Recommendation ITU-R P.1546-4, i.e. on the same basis as for broadcasting. Technical characteristics of equipment are described in Recommendation ITU-R M.489-2.

For ship stations having omnidirectional antennas service areas, *s*, are calculated as:

$$S = \pi R_s^2 \qquad \text{km}^2 \tag{46}$$

where:

R_s: radius of circular service area calculated from propagation curves of Recommendation ITU-R P.1546-4 for 30-300 MHz frequency band, sea, 50% of time and 50% of locations (Fig. 4 of Recommendation ITU-R P.1546-4).

It is necessary to note, that for this particular case the curves are the same for cold and warm seas. Transmitting antenna heights are actual antenna heights above the sea level. For simplicity, receiving antenna heights for purposes of this particular calculation model are accepted as to be equal 10 m in all cases. However it should be noted that in reality, to provide equal communication conditions between coast and ship stations in both directions, receiving antennas of coast stations are usually have the same heights than their transmitting antennas.

For coast stations it is accepted that one half of an occupied area, being a service one, with a radius R_s lies at a surface of sea and the second half with a radius R_l, at a surface of land, i.e.:

$$S = 0.5\,\pi\,(R_s^2 + R_l^2) \qquad \text{km}^2 \tag{47}$$

where:

R_l: radius of half-circular service area calculated from propagation curves of Recommendation ITU-R P.1546-4 for 30-300 MHz frequency band, land, 50% of time and 50% of locations (Fig. 1 of Recommendation ITU-R P.1546-4, see Fig. 2).

Effective antenna height calculations for land service area are provided similarly to broadcasting case.

Taking into account that maritime mobile service belongs to safety services its reliability should be sufficiently high. Taking this into account, minimal usable field strength at the border of service area is accepted to be 30 dB above receiver reference sensitivity (2.0 µV in accordance with Recommendation ITU-R M.489-2), i.e. $E_{mu} = 36$ dB(µV/m).

Based on the above parameters and assumptions and accepting all antennas gains equal to 6 dB, relevant service/occupied areas radiuses were calculated for different transmitter powers from 10 W to 50 W (maximal carrier power of coast stations in accordance with Recommendation ITU-R M.489-2) and various effective antenna heights presented in Recommendation ITU-R P.1546-4. Results of calculations are presented in Table 12.

TABLE 12

Radiuses of occupied areas by sea and by land (km) for maritime radio communications in 156-174 MHz frequency band

	H_{ef} (m)						
P(W)	**Paths**	**10**	**20**	**37.5**	**75**	**150**	**300**
10	Land	11	14	19	25	35	48
	Sea	24	28	35	43	53	68
20	Land	13	16	22	29	40	53
	Sea	27	31	39	47	59	74
30	Land	14	17	24	32	43	57
	Sea	29	34	42	51	62	77
40	Land	14	19	25	34	45	59
	Sea	30	36	44	53	64	80
50	Land	15	19	27	35	47	61
	Sea	32	37	45	55	66	82

It is necessary to note that a land half-circle area of a coast station is only occupied but not service one because there are no ship stations there. Therefore its subdivision to different zones belonging to different license fees categories (like it is presented in § 4.7.1(c)) can be eliminated and the only one category, corresponding to the largest occupied area, can be used. Moreover, an administration may decide not to include this land half-circle area to territorial resource used. In this case radius R_l in equation (47) should be equal zero.

For coast stations situated along rivers or and rather narrow lakes the whole circular service/ occupied are is calculated by land propagation paths radius, i.e.:

$$S = \pi R_l^2 \qquad \text{km}^2 \tag{48}$$

b) Calculation procedures

Using known transmitter power and its antenna height above the sea level, relevant service area radius by see can be determined directly from Table 12. The usual procedure of linear interpolation can be used for intermediate power and height values. Based on this radius service area for a ship station or see half-circle service area for a coast station can be calculated by equations (46) or (47). For determination of a land half-circle radius for the coast station, antenna effective height against the terrain should be firstly calculated in accordance with methodology, presented in (b). For this particular application, the procedure can be simplified by calculation of effective terrain height only in one direction to be perpendicular to a generalized shoreline (see example below). After determination by Table 12 of relevant land half-circle radius, overall service/occupied area then can be calculated by equation (47).

4.7.5.1 Example of calculations

a) Incoming parameters

Let us calculate a spectral resource used by a VHF coast station situated in rural but highly developed area (let coefficient b_j = 1 in Table 1) near the shoreline generally stretched in East to West direction, see is southward. Let us assume that transmitting antenna, having mast height 30 m, situated at the top of a hill with ground height 270 m above the sea level. Terrain situation around the transmitter corresponds to example presented in (b), i.e. effective height of the ground between distances of 3 and 15 km in the northern direction from the transmitter, calculated from column "North" of Table 10, equals to 265 m. In accordance with § 4.7.1(b) for this application it represents average level of the ground, h_{av}, in equation (30).

Let us further assume that the transmitter power is 50 W and it works around the clock. Modulation conditions correspond to Recommendation ITU-R M. 489-2: class of emission F3E, deviation ±5 kHz, necessary bandwidth 16 kHz. That also corresponds to Recommendation ITU-R SM.1138-2 under Section III-A "Frequency modulation", Item 2 "Telephony (commercial quality)" (class of emission F3E).

b) Time and frequency resources used

In accordance with equation (21), used time resource is:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

Used frequency resource, accepting in equation (24) $\chi = 1$, can be found as:

$$F = 0.016 \text{ MHz}$$

c) Territorial resource used

Following approach and data presented for effective antenna height for sea propagation paths equals to sum of antenna mast and site ground heights, i.e. (see also b)):

$$h_{ef} = h_s = 30 + 230 = 300 \text{ m}$$

From Table 12 for transmitter with power 50 W and antenna height 300 m, sea propagation paths, it follows: R_s = 82 km.

For land propagation paths in accordance with data and equation (30):

$$h_{ef} = 300 \text{ m} - 265 \text{ m} = 35 \text{ m} \approx 37.5 \text{ m}$$

From Table 12 for transmitter with power 50 W and antenna height 37.5 m, land propagation paths, it follows: R_l = 27 km.

Substituting calculated radiuses to equation (47) we get:

$$S = 0.5\,\pi\,(82^2 + 27^2) = 11\,701 \text{ km}^2$$

and, taking into account that $b_j = 1$, from equation (22) it follows:

$$S = s = 11\,701 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 1 \times 0.2 \times 0.1 \times 1 \times 1 \times 0016 \times 11\,701 \times 1 = 3.7 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.6 Aeronautical mobile, radionavigation and radiolocation services

a) Calculation procedures

Common feature of these services is the fact that they provide radio communication (or location) operations with highly flying aircrafts. It leads to large service areas which borders are determined by distances up to radio horizon. If refraction of radio waves in the Earth's atmosphere is taken into account, a distance up to a radio horizon, R_g, can be calculated by formula:

$$R_g = 4.14\left(\sqrt{h_t} + \sqrt{h_r}\right) \qquad \text{km} \qquad (49)$$

where:

- h_t: height of transmitting antenna above the averaged ground surface (at the ground or at the aircraft) (m)
- h_r: height of receiving antenna above the averaged ground surface (at the ground or at the aircraft) (m).

With height of the aircraft, 10 000 m and terrestrial antenna height, 15 m, equation (48) gives radio horizon distance equals 429 km. Beyond the radio horizon the field strength sharply drops, as it is clearly demonstrated by curves of Recommendation ITU-R P.528-2. Therefore, in the given particular case, service area radius is accepted as to be equal to the distance up to the radio horizon irrespective to transmitter power and receiver sensitivity. The last parameters mainly determine only reliability of radio communication in the vicinity of service area borders in real influence environment that is very important for these of services as to be safety ones. Omnidirectional antennas are widely used. In case of directional transmitting antennas applications (mainly in radionavigation and sectorial radiolocation), a "service sector" concept, given by Recommendation ITU-R F.162-3, can be used.

Taking into account that spectral resource used for these services, as to be safety ones, will not be too high, for simplicity reasons subdivision of the service area to different zones belonging to different license fees categories can be eliminated and the only one category, corresponding to the largest occupied area, can be used.

Given approach to the determination of service areas for aeronautical mobile, radionavigation and radiolocation services is proposed to be use for purposes of this calculation Model. The same approach can be accepted and for maritime radionavigation and radiolocation applications by using in equation (49) a target height equals about 10 m.

4.7.7 Examples of calculations

4.7.7.1 Aeronautical radio communications

a) Incoming parameters

Let us calculate a spectral resource used by an aeronautical radiocommunication station working around the clock in 118-136 MHz band. Omnidirectional transmitting antenna height is 15 m and communications are provided with aircrafts flying at 10 000 m and higher, i.e. in accordance with $R_g = 429$ km. Let the largest occupied area lies in rural zone categorized by Table 1 as 0.8. Usual double-side AM is used (class of emission A3E), commercial quality.

b) Time and frequency resources used

In accordance with equation (21), used time resource is:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

Following Recommendation ITU-R SM.1138-2, "Amplitude modulation", Item 2 "Telephony (commercial quality)", double-sideband (class of emission A3E), related necessary bandwidth is 6 kHz. Therefore, used frequency resource, accepting in equation (24) $\chi = 1$, can be found as:

$$F = 0.006 \text{ MHz}$$

c) Territorial resource used

Substituting $R_g = 429$ km into equation (31) we get:

$$s = \pi \cdot 429^2 = 578\,182 \text{ km}^2$$

and, taking into account that $b_j = 0.8$, from equation (22) it follows:

$$S = 0.8 \times 578\,182 = 462\,546 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated in (b) and (c) to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 0.1 \times 0.2 \times 0.1 \times 0.8 \times 1 \times 0.006 \times 462\,546 \times 1 = 4.4 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.7.2 Primary radars

a) Incoming parameters

Let us calculate a spectral resource used by an aeronautical primary radar working around the clock with circularly rotating antenna of 15 m height and set aside for locating aircrafts flying at 10 000 m and higher. It means that in accordance with $R_g = 429$ km. Let the largest occupied area lies in rural zone categorized by Table 1 as 0.5. Radar uses shaped radio pulses with a half-amplitude duration equals 1 µs.

b) Time and frequency resources used

In accordance with equation (21), used time resource is:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

Following Recommendation ITU-R SM.1138-2 "Pulse modulation", Item 1"Radar", primary radar (class of emission P0N), related necessary bandwidth is 3 MHz. Therefore, used frequency resource, accepting in equation (24) $\chi = 0.1$, can be found as:

$$F = 0.1 \times 3 = 0.3 \text{ MHz}$$

c) Territorial resource used

Substituting $R_g = 429$ km to equation (31) we get:

$$s = \pi \cdot 429^2 = 578\,182 \text{ km}^2$$

and, taking into account that $b_j = 0.5$, from equation (22) it follows:

$$S = 0.5 \times 578\,182 = 289\,091 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated in §§ 1.3.3.3.2.2 and 1.3.3.3.2.3 to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions (β = 1), we get finally:

$$W = 0.1 \times 0.02 \times 0.1 \times 0.2 \times 1 \times 0.3 \times 289\,091 \times 1 = 3.5 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.7.3 Fixed radio services

a) Calculation procedures

All fixed radiocommunications, HF radio links and UHF/SHF radio relay links (RRL), nowadays use directional and highly directional antennas. Taking this into account, for calculation of area occupied by an emission a "service sector" concept, given by Recommendation ITU-R F.162-3, can be used. This Recommendation states that for HF fixed links the service sector is very close to twice the angular width of the main beam measured to the half-power (–3 dB) point. Taking into account the same physical background, for purposes of the given license fee calculation Model, this concept is accepted for RRL links and for all other radio applications when directional antennas are used.

Therefore, if relevant antenna beam-width is known (from the national frequency assignment database or, on special request, from the operator or user) relevant emission occupied area can be determined as

$$S_o = \frac{2\theta}{360} \cdot \pi \cdot L_c^2 = \frac{\theta}{180} \cdot \pi \cdot L_c^2 \qquad (50)$$

where:

S_o: area occupied by an emission (km^2)

θ: antenna beam-width (degrees)

L_c: length of the radio link (km).

Fixed radio links, especially RRL, usually are planned very carefully, planning methods are sophisticated and significant fading allowances are usually used. Taking this into account and aiming to avoid complicated calculations, for purposes of the given model it is proposed to use exact distance between relevant transmitter and receiver as the length of the radio link L_c. For RRL it will be one hop between two RRL stations.

On determination of S_o, related territorial resource can be calculated in accordance with equation (22). Provisions concerning coverage of several zones belonging to different license fees categories are the same although here influence of this factor is considerable smaller, especially for RRL, due to considerably smaller values of sector widths. Nevertheless, if an administration likes to increase calculation accuracy, the following equation is applicable for the case when a service sector crosses two areas in approximately perpendicular direction at a distance L_b from the transmitter:

$$s_1 = \frac{\theta}{180} \cdot \pi \cdot L_b^2$$

$$s_2 = \frac{\theta}{180} \cdot \pi \cdot \left(L_c^2 - L_b^2\right)$$

In accordance with the concept presented in § 4.7.1, for overseas HF communications L_c is determined by the distance from the transmitter to the country border in the direction of the transmission.

Frequency and time resources and, then, spectral resource are calculated similarly to other cases above. As far as multi-station RRL can carry different numbers of channels at different hops due to branching and hop-lengths are different, spectral resources are calculated separately for each hop and then all values are summed.

4.7.7.4 Example of calculations

a) Incoming parameters

Let us calculate a spectral resource used by one hop of a RRL in 2 GHz frequency band. Hop-length is 45 km, antenna beam-widths of both stations are 1.5° each (and it corresponds to $G \approx 40$ dB). This hop lies within one zone categorized by Table 1 as 0.4 and carries 960 telephone channels in both directions with parameters corresponding those indicated in Recommendation ITU-R SM.1138-2 “Frequency modulation”, subsection 5 “Composite emissions”, RRL with 960 channels.

b) Time and frequency resources used

Taking into account principally continuous mode of RRL operation, from equation (21) it follows:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

In accordance with data, presented in above mentioned subsection of Recommendation ITU-R SM.1138-2, B_n = 16.32 MHz (for both transmission directions). Therefore the overall used frequency resource, accepting in equation (24), can be found as:

$$F = 2 \times 16.3 = 32.6 \text{ MHz}$$

c) Territorial resource used

Substituting relevant data from § 1.4.2.1 to equation (50) we get:

$$s_o = (1.5/180) \times 3.14 \times 45^2 = 53 \text{ km}^2$$

From equation (22), taking into account the zone category, it follows:

$$S = 0.4 \times 53 = 21 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated in (b) and (c) to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions (β = 1), we get finally:

$$W = 0.1 \times 0.1 \times 1 \times 0.2 \times 1 \times 32.6 \times 21 \times 1 = 1.4 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.8 Earth stations of satellite communications

4.7.8.1 Calculation procedures

Similarly to the case of fixed radio communication services presented in § 4.7.7.3, for the calculation of occupied areas a "service sector" concept, given by Recommendation ITU-R F.162-3 is proposed to be used.

As it was already indicated, due to great difficulties in exact calculation of occupied areas of Earth stations of satellite communication systems, it is proposed to determine them on the basis of coordination distances agreed during the process of coordination and notification of frequency and orbital assignments in the ITU-R. If these are not available universal coordination distances of 350 km for VSATs and 750 km for other stations are proposed to be used. In some cases values agreed between administration and operator can also be used.

Occupied (necessary) bandwidth of an emission, or a bandwidth of a received signal, due to their absence in Recommendation ITU-R SM.1138-2, should be taken from related frequency assignment data, stored in a national spectrum management database or received from an operator on a special request.

4.7.8.2 Examples of calculations

4.7.8.3 Transmitting earth station

a) Incoming parameters

Let us calculate a spectral resource used by an earth station providing feeder link for non-GSO satellites operating in the mobile-satellite service. Due to absence of more detailed data, coordination distance is accepted as to be 750 km. The station is situated in rural area and its antenna beam-widths is 0.5^{o}. Occupied area of the emission lies within one zone categorized by Table 1 as 0.2. Let us assume that, in accordance with relevant frequency assignment recorded in the national spectrum management database, the bandwidth of the emission is 200 MHz.

b) Time and frequency resources used

Taking into account principally continuous mode of feeder link operation, from equation (21) it follows:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

In accordance with data presented in § 1.5.2.1.1 used frequency resource, accepting in equation (24) $\chi = 1$, can be found as:

$$F = 200 \text{ MHz}$$

c) Territorial resource used

Substituting related data to equation (50), where L_c represents coordination distance, we get:

$$s_o = (0.5/180) \times \pi \times 750^2 = 4\,909 \text{ km}^2$$

From equation (22), taking into account the zone category, it follows:

$$S = 0.2 \times 4\,909 = 982 \text{ km}^2$$

d) Spectral resource used

Substituting values calculated to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 1.4 \times 0.1 \times 0.1 \times 0.2 \times 1 \times 200 \times 982 \times 1 = 550 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

4.7.8.4 Receiving earth station

a) Incoming parameters

Let us calculate a spectral resource used by a receiving VSAT earth station working around the clock. Due to absence more detailed data, coordination distance is taken as 350 km. The station is situated in rural area and its antenna beam-widths is 1^{o}. Occupied area of the emission lies within one zone categorized by Table 1 as 0.3. Let us assume that, in accordance with relevant frequency assignment recorded in the national spectrum management database, the bandwidth of the received signal is 30 MHz.

b) Time and frequency resources used

Assuming continuous mode of the station operation, from equation (21) it follows:

$$T = 24/24 \text{ (each day)} = 1 \text{ year}$$

In accordance with used frequency resource, accepting in equation (24) $\chi = 1$, can be found as:

$$F = 30 \text{ MHz}$$

c) Territorial resource used

Substituting related data to equation (50), where L_c represents coordination distance, we get:

$$s_o = (1/180) \times \pi \times 350^2 = 2\,138 \text{ km}^2$$

From equation (22), taking into account the zone category, it follows:

$$S = 0.3 \times 2\,138 = 641 \text{ km}^2$$

d) Spectral resource used

Substituting values to equation (20), using values of weighting coefficients presented in Table 2 and taking into account non-sharing conditions ($\beta = 1$), we get finally:

$$W = 14 \times 0.1 \times 0.1 \times 0.2 \times 1 \times 30 \times 641 \times 1 = 54 \qquad \text{MHz} \cdot \text{km}^2 \cdot 1 \text{ year}$$

e) Summary of calculation results

Summary of calculation results for the purpose of comparison and for general orientation is presented in Table 13.

TABLE 13

Summary of calculation results

Section	Radio service, transmitter power or radio link characteristic	Spectral resource used (MHz · km^2 · 1 year)
1.2.1.2	FM sound broadcasting, 1.5 kW	2 430
1.3.1.3	Land mobile service, GSM base station, 2.5 W	2 172
1.3.2.3	Maritime mobile service, coast station, 50 W	3.7
1.3.3.2.1	Aeronautical radiocommunication aircraft height 10 000 m	4.4
1.3.3.2.2	Primary radar, aircraft height 10 000 m	3.5
1.4.2	Fixed service, microwave link, hop-length 45 km	1.4
1.5.2.1	Transmitting earth station, MSS feeder link	550
1.5.2.2	Receiving VSAT earth station	54

4.8 Guidelines on applying new fees system

In order not to disturb the market, the new fees system should not impose sudden increase in the fees for the users, Therefore, spectrum manager should design a transition strategy considering many factors including, but not limited to, market status, number of users for each service, current fees system and alternative services.

The following steps could be used when applying a new fees system:

1. Analyse the current spectrum usage.
   - Divide users into different groups.
   - Apply the old formula.
   - Analyse the results.
2. Apply the new formula on the current groups of users.
   - Analyse the results.
   - Modify formula for the different groups
   - Apply mitigation policies in order not to disturb the market.
3. Design transition strategy based on step two.

There are some principles that could be used in designing the transition strategy in order to move the current fees to its final market related fees[2, 4].

– There should be a trade-off between slowly increasing prices, which might not be sufficient to reduce congestion, and setting the prices at high level which might cause an adverse political reaction.

– Prices should increase at a fraction of the final target increase and in case where the initial prices are too low, doubling or trebling the prices would be appropriate.

– If the initial increase resulted in relieving the congestion, there would be no need to increase the prices further.

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4 ERC (1998) Report on the Introduction of Economic Criteria in Spectrum Management and the Principles of Fees and Charging in the CEPT, ERC Report 53, March, Manchester.

– Users should know in advance the direction of the prices change in order to adjust their investment decisions.
– Prices should be related to the market related prices on the long run.
– A transition period of five years would be reasonable.
– Existing legislation should be effective and compatible with the new pricing plan.
– Consultation process is essential in order to reach consensus with stakeholders.
– New software for calculating the prices should be developed and tested. Besides, the regulator stuff should be trained on the software.
– Regulator should not depend on the new fees system to increase its funding as the levels of funding may fluctuate with time and also with supply and demand.

CHAPTER 5

Administration's experience regarding the economic aspects of spectrum management

5.1 Experience with auctions and transferable property rights

Since the 1990s, some countries have used auctions to assign licences[5, 6]. Additionally, a few of these countries have recently introduced limited systems of transferable property rights, wherein licences to use spectrum may be sold to other parties.

5.1.1 Australia

In Australia, the Australian Communications and Media Authority (ACMA) in its role of managing the spectrum is pursuing objectives which include promoting economic efficiency, encouraging technological change and expanding freedom of choice. It has sought to develop an efficient, equitable and transparent system of charging for the use of spectrum, and to ensure an acceptable return to the community. To balance these potentially conflicting objectives, the ACMA has had to adopt a number of innovative approaches to managing spectrum. Its auctions and transferable property rights approaches are outlined below.

5.1.1.1 Making use of price as a tool in assigning licences

Generally, where supply of a particular spectrum band exceeds demand, the ACMA allocates the spectrum over the counter, upon application, for an issue charge and an annual set fee. But where demand for a particular spectrum band is likely to exceed supply, the ACMA will allocate licences by sale at auction.

The ACMA can auction spectrum either in the form of spectrum licences, or less commonly, as apparatus licences.

Because of the extensive planning, consultation and preparation involved, spectrum auctions are irregular events, and are most often used where there is strong competition for scarce spectrum with a high commercial value. They are seen as a transparent, price-based method for allocating the spectrum within a particular band in discrete parcels known as spectrum lots, which are defined by

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[5] MCMILLAN [1994] Why auction the spectrum? University of California.

[6] MCMILLAN, J. [Summer 1994] Selling Spectrum Rights. *J. Economic Perspectives*.

geographic area and frequency bandwidth. The combination of frequency bandwidth and geographic area is termed spectrum space.

A successful bidder may acquire a number of lots at auction. The buyer can combine or aggregate any contiguous lots to form broader spectrum spaces of greater utility. These aggregated lots can be used in accordance with access licence conditions so that any technology or service can be operated within the spectrum space, depending on its size and shape, without interfering with neighbouring services.

Of the many types of auctions that exist, only two have been used by the ACMA to auction spectrum, namely English open ascending bid and simultaneous multi-round.

5.1.1.2 Introducing a new form of licensing: the spectrum licence

The market system is based on the principle that direct marketing of spectrum will result in more efficient spectrum use. Under the market system, users of spectrum will make decisions on their spectrum access recognizing the pressures of demand and supply. To facilitate a more market-oriented approach to spectrum allocation and management, the ACMA introduced a new type of licence, analogous to a property right, called a spectrum licence. Spectrum licensing, instead of focusing on equipment and its uses (which in turn defines the area covered and the frequency bandwidth used), authorizes the use of spectrum within specified limits of frequency bandwidth and coverage area. Under spectrum licensing, licensees will have the flexibility to change their equipment, antenna, siting, in fact any aspect of their use of spectrum, provided they comply with the core technical conditions of the licence, and any coordination requirements.

In line with ss85-88 of the *Radiocommunications Act 1992*, spectrum licences are intended to be traded rather than transferred. They incorporate core conditions that define a spectrum asset or a set of property rights represented by the spectrum licence. Licensees are free to negotiate in the open market with interested persons to buy and sell spectrum space for any legal purpose.

Spectrum licences can be regarded as financial assets due to their defined spectrum space and long licence period, which is 15 years. These licences may be combined or sub-divided to form new licences, although they may not be subdivided smaller than a standard trading unit. Once a commercial agreement is reached on a particular trade, the transaction must be notified to the ACMA. The trade becomes effective only after the new licence details appear.

5.1.2 Canada

The Canadian Radiocommunication Act was amended in June 1996 to provide the explicit authority for the use of spectrum assignment auctions in appropriate circumstances. Auctions offer a number of advantages such as their ability to promote economically efficient use of spectrum, their openness and objectivity as an assignment mechanism, their procedural efficiency, and their ability to return appropriate compensation to Canadian taxpayers for the use of a public resource.

Industry Canada's first spectrum auction was conducted in 1999, using a simultaneous multiple round ascending format to award spectrum in the 24 GHz and 38 GHz bands. Within a ten year span, Industry Canada has held seven spectrum auctions, five of which were held over the Internet, using the simultaneous multiple round format, and two of which used a sealed-bid format. As both the theoretical and practical aspects of auction design continue to advance, Industry Canada will continue to examine new auction design developments and adopt them as appropriate.

The following table provides details of all auctions held to date by Industry Canada. Auctions 1 to 5 were conducted using the Simultaneous Multiple Round Ascending (SMRA) design while Auctions 6 and 7 were conducted using a sealed-bid, second-price auction design.

Auction No.	Year	Frequency Band/Range	No. of Licences Won/Available	No. of Winners
1	1999	24 and 38 GHz	260/354	12
2	2001	2 GHz – for Personal Communication Services (PCS)	52/62	5
3	2004	2.3 and 3.5 GHz	392/848	22
4	2004/05	2.3 and 3.5 GHz (Phase 2 – residual)	450/457	15
5	2008	2 GHz – for Advanced Wireless Services (AWS)	282/292	15
6	2009	849-851 MHz and 894-896 MHz for Air-Ground Services	2/2	1
7	2009	2.3 and 3.5 GHz (Phase 3 – residual)	10/10	5

Licences acquired through an auction are transferable in whole or in part (divisibility), in both the bandwidth and geographic dimensions to a qualified recipient. Auctioned licences have generally been issued for a ten-year term with a high expectation of renewal at the end of this term.

5.1.3 The Russian Federation's experience with auctions

With a view to improving the mechanism for charging for use of the spectrum, in February 1999 the Government of the Russian Federation adopted a decree stipulating that "after the entry into force of this decree, in respect of organizations applying for a licence or other authorization to use the radio-frequency spectrum for the provision of cellular telephone services in bands above 1 800 MHz and television programme distribution services using MMDS, LMDS and MVDS type systems, charges for use of the spectrum will be determined on the basis of the results of competitions for such licences or authorizations conducted under the procedure set by the Government of the Russian Federation" (see Note 1).

NOTE 1 – MMDS: multichannel multipoint distribution system, LMDS: local multipoint distribution system, MVDS: multipoint video distribution system.

In order to define the mechanism for competitive bidding, regulations were also adopted on the competitive award of licences for activities associated with the provision of these types of service. These regulations set forth the competitive procedure, conditions governing participation in the competition, financial arrangements and specifications for the issuing of licences on the basis of the results of the competition.

For the purpose of organizing and conducting competitions, the State Committee for Telecommunications of the Russian Federation (Gostelekom):

– forms a commission, decides on its composition and, where necessary, attaches to it the necessary independent experts;

– sets the amount of the minimum bid, based on the average annual income and profitability of cellular communication networks. The minimum bid will constitute the minimum annual charge for operations associated with the provision of cellular telephone services using radio frequencies;

– organizes the preparation and publication of an information note on the holding of competitions;
– receives applications from persons intending to take part in the competitions (hereinafter referred to as “candidates”), entering them in the register of applications in the order of receipt, with a corresponding registration number and an indication of when the documents were tendered (date, month, time in hours and minutes);
– verifies that the documents submitted by candidates are in due and proper form;
– organizes the receipt of deposits (in the amount of the designated minimum bid) from candidates.

The commission fulfils the following functions:

– examines the information transmitted by Gostelekom (or its representative) on applications received;
– examines the information transmitted by Gostelekom (or its representative) on the payment of deposits received from candidates and other documents and verifies their conformity with the requirements of Russian law;
– upon expiration of the deadline for receipt of applications, on the basis of the information on applications received transmitted by Gostelekom (or its representative), draws up the official list of applications received;
– makes a decision on whether or not to allow candidates to take part in the competition and draws up the official list of participants in the competition;
– draws up the official record of the results of the competition.

Participation in the competition is open to businesses and individuals who have submitted an application to participate in the competition by the deadline, have submitted in due and proper form the requisite documents listed in the information note published concerning the holding of the competition, and have deposited the requisite sum of money within the specified time-limit.

An application to participate in the competition from a candidate is deemed to constitute an expression of intent to take part in the competition under the conditions set in the regulations and published in the information note on the holding of the competition. The application form is endorsed by Gostelekom.

The deposit indicated in the information note pertaining to the competition will be transferred to one of the accounts indicated in the information note after submission of the application form. The number of the application will be indicated on the payment order.

Confirmation of receipt of deposits in the accounts opened with participating banks: Confirmation of the deposit must be provided to the commission before candidates are recognized as participants in the competition. A candidate assumes the status of participant when the members of the commission sign the official list of participants in the competition.

In order to determine the winner of the competition, the chairman of the commission opens the bid envelopes in the presence of the members of the commission and representatives of the candidates and announces the proposed amounts of the annual payment. The highest bidder wins. In the event of identical bids, the winner shall be the candidate that submitted its bid earlier.

The deposits of participants who do not win the competition are returned to them within 15 days after identification of the winner of the competition.

Upon receipt of the transfer of the full annual payment (equal to the winning bid) from the winner to the account indicated in the information note, the State Committee for Telecommunications of the Russian Federation grants the licence under the established procedure.

The annual charge payable by the winner of the competition is distributed as follows:

– 80% as income to the federal budget, to be used in equal proportions to finance the Ministry of Defence of the Russian Federation (to cover expenses associated with releasing frequency bands) and the Russian Space Agency.
– 10% as income to the budget of the unit of the Russian Federation in whose territory the licence is valid (if the licence covers the territory of several units of the Russian Federation, the amount is divided among them proportionate to their populations).
– 10% to Gostelekom to cover expenses incurred for licensing and the holding of competitions, for registration of radio frequencies and for monitoring services.

A method for determining the minimum bid based on an evaluation of the "shadow price" of the radio-frequency spectrum

While the Russian Federation has not actually conducted an auction the administration has developed a method for determining the minimum bid[7]. The proposed method hinges on an evaluation of the income index of the mobile communication network as a function of the system bandwidth. This income index provides a gauge of the annual effect of investment in the project with regard to a particular monetary unit, in this case USD 1.

The basic data required to carry out the analysis may be divided into three groups:

– data pertaining to the network's frequency plan;
– parameters defining the required volume of investment to set up the network;
– parameters defining income from operation of the network.

In the following example the technical parameters of a GSM cellular network are used. Nevertheless, the method can be applied to other cellular and trunking network standards.

a) *Number of base stations (BS) in the mobile network as a function of the bandwidth*

The first group of basic data includes the parameters shown in Table 14, which are used to determine the following key parameters of the mobile communication network:

N: cluster size

C: number of BS that have to be installed in a town

n_c: number of telephone channels.

[7] BYKHOVSKY, M. A., KUSHTUEV, A. I., NOZDRIN, V. V. and PAVLIOUK, A. P. [1998] Auctions as an effective contemporary method of spectrum management. *Elektrosvyaz*.

TABLE 14

Symbol	Parameter	Calculated value
F	Bandwidth for the mobile network in the service area	2-25 MHz
F_k	Channel bandwidth of the mobile network system (for NMT, AMPS-D and GSM systems, F_k = 25, 300 and 200 kHz, respectively)	0.2 MHz
M	Number of sectors served in one cell (M = 1 for θ = 360°; M = 3 for θ = 120°; M = 6 for θ = 60°, where θ is the width of the BS antenna radiation pattern)	1-6
n_α	Number of subscribers that can use one frequency channel at the same time (for NMT, AMPS-D and GSM systems, n_α = 1, 3 and 8, respectively)	8
N_α	Number of subscribers to be served by the cellular mobile network in a town	10 000-150 000 people
β	Activity of one subscriber at peak traffic times	0.025 E
P_α	Permissible probability of call blocking in the mobile network	0.1
ρ_0	Required protection ratio for mobile network receivers (for NMT, AMPS-D and GSM systems, ρ_0 = 18.9 and 9 dB, respectively)	9 dB
P_t	Percentage of time during which the signal/interference ratio at the input to the transmitter in the mobile network is allowed to fall below the protection ratio, ρ_0	10%
σ	Parameter determining the range of random variations in the received signal level at the place of reception (for mobile network systems, σ = 4-10 dB)	6 dB

A procedure[8] for determining the basic parameters of a cellular mobile network is as follows:

– Total number of frequency channels in a cellular mobile network in a town:

$$n_k = \text{int}(F/F_k)$$

where int(x) is the integer part of the number x.

– Required cluster size for given values of ρ_0 and P_T:

$$p(N) = 100 \int_{\frac{(10 \log(1/\beta_e) - \rho_0}{\sigma_p}}^{\infty} e^{\frac{t^2}{2}} \frac{dt}{\sqrt{2\pi}}$$

where $p(N)$ is the percentage of time during which the signal/interference ratio at the mobile station receiver input falls below the protection ratio ρ_0. The values β_e and σ_p depend on the parameters $q = \sqrt{3N}$ σ and M. The value of $p(N)$ decreases as N increases. For given values of ρ_0, σ and M = 1, 3 and 6, values of $p(N)$ are calculated for a number of values of N (i.e.: q). The value of N for which the condition $p(N) \le P_t$ is fulfilled is taken as the cluster size for the mobile network.

8 BYKHOVSKY, M. A. [1993] Frequency planning of cellular mobile networks. *Elektrosvyaz*.

The parameters β_e and σ_p used in the equation for $p(N)$ are determined using the following expressions:

$$\sigma_p^2 = \sigma^2 + \sigma_e^2$$

$$\sigma_e^2 = \frac{1}{\lambda^2} \ln \left[1 + (e^{\lambda^2 \sigma^2} - 1) \frac{\sum_{i=1}^{\lambda} \beta_i^2}{\left(\sum_{i=1}^{\lambda} \beta_i \right)^2} \right]$$

$$\beta_e = \left(\sum_{i=1}^{\lambda} \beta_i \right) \exp \left[\frac{\lambda^2}{2} (\sigma^2 - \sigma_e^2) \right]$$

Here, λ = (0,1 ln(10)) and the values λ and β_i depend on M and may be found using the following formulae:

$$\left.\begin{array}{lll} \text{if } M = 1, \text{ then } & \lambda = 6 & \beta_1 = \beta_2 = (q-1)^{-4};\ \beta_3 = \beta_4 = q^{-4};\ \beta_5 = \beta_6 = (q+1)^{-4} \\ \text{if } M = 3, \text{ then } & \lambda = 2 & \beta_1 = (q+0.7)^{-4};\ \beta_2 = q^{-4} \\ \text{if } M = 6, \text{ then } & \lambda = 1 & \beta_1 = (q+1)^{-4} \end{array}\right\}$$

where:

$$q = \sqrt{3N}$$

– Number of frequency, n_s, and telephone, n_c, channels used to serve subscribers in one sector of one cell:

$$n_s = \text{int}(n_k / MN)$$

$$n_c = n_s \cdot n_\alpha$$

– Admissible telephone traffic in one sector of one cell (E):

$$A = \begin{cases} n_c \left[1 - \sqrt{1 - \left(p_a \sqrt{\pi\, n_c / 2} \right)^{1/n_c}} \right] & \text{for} \quad p_a \le \sqrt{2/\pi\, n_c} \\ n_c + \sqrt{p/2 + 2n_c \ln\left(p_a \sqrt{\pi\, n_c / 2} \right)} - \sqrt{p/2} & \text{for} \quad p_a > \sqrt{2/\pi\, n_c} \end{cases}$$

– Number of subscribers served by one BS for a given value of blocking probability:

$$N_{BS} = M \cdot \text{int}(A/\beta)$$

– The number of BS in the cellular network is determined as follows:

$$C = \text{int}(N_\alpha / N_{BS}) + 1$$

Thus, the proposed method enables the calculation of the required number of base stations and number of channels for a given network's performance parameters and a given projected number of subscribers.

b) *Determination of expenditures for establishment of a mobile network*

The basic data in the second group are shown in Table 15.

TABLE 15

Symbol	Parameter	Calculation value
K_h	Average hourly rate of an installer	3 (USD/h)
K_{BS}	Price of a typical single-channel BS installation	USD 230 000
K_E	Cost of one receiving/transmitting unit	USD 11 000
	Fixed portion of cost of connection links, independent of link length	For digital radio-relay
A_1		USD 351/channel
A_2		USD 176/channel
	Variable portion of cost of connection links dependent on link length	For digital radio-relay
B_1		USD 23/channel km
B_2		USD 12/channel km

Expenditures comprise five components and are determined as follows:

$$K_\Sigma = K_1 + K_2 + K_3 + K_4 + K_5$$

where:

K_1: cost of construction and assembly work

K_2: cost of BS equipment

K_3: cost of establishing a switching centre (SC)

K_4: expenditure for purchasing software and technical facilities for billing systems

K_5: cost of establishing communication links between BS and SC.

Construction and assembly costs, K_1, are determined on the basis of statistical data [Boucher, 1992 and 1995] on the labour consumption of the various stages of work. These costs are proportional to C, which is the number of BS in the mobile network, and may be determined by the equation:

$$K_1 = K_h \begin{cases} 4\,900 + 1\,040\,C & \text{for} \quad 1 < C < 5 \\ 3\,900 + 1\,640\,C & \text{for} \quad 5 < C < 15 \\ 3\,900 + 1\,740\,C & \text{for} \quad 15 < C \end{cases}$$

Capital costs for BS equipment are determined by the equation:

$$K_2 = C\,[K_{BS} + (M \times n_s) \times K_E]$$

where $(M \times n_s)$ is the number of frequency channels in one cell.

The cost, K_3, of establishing the SC of a mobile network is determined from the data in Table 16 on the basis of the number of subscribers in the network.

TABLE 16

Required number of telephone channels in the network	**Switching centre costs K_3 (USD)**	
	Analogue	**Digital**
$N_a \leq$ 500	300 000	3 500 000
$N_a \leq$ 2 000	500 000	3 600 000
$N_a \leq$ 10 000	1 300 000	4 000 000
$N_a \leq$ 50 000	3 000 000	5 000 000

The cost K_4 is determined from the data in Table 17. Calculations are made for the case in which the mobile network uses a very simple billing system for 10 000 subscribers that can be expanded as required as the number of subscribers increases.

TABLE 17

Type of system	**Cost K_4 (USD)**
Simple system for 5 000 subscribers	130 000
Simple billing system for 10 000 subscribers	240 000
System with additional capabilities up to 10 000 subscribers	750 000
System with additional capabilities up to 100 000 subscribers	1 400 000

For determining the costs of establishing communication links between the BS and SC, the number of communication links, N_{ck}, needed to connect one BS to the SC can be calculated. In cellular mobile networks, two types of communication links can be used, with a capacity of 60 or 30 telephone channels (with a transmission speed of 2 or 4 Mbit/s). The required number of communication links with a capacity of 30 telephone channels is as follows:

$$N_2 = \text{int}((M \times n_c)/30) + 1$$

In order to reduce the capital outlay for BS-SC connections, communication links of Type 1 should be used as much as possible. The number of such links will be:

$$N_1 = \text{int}(N_{30}/2)$$

If N_{30} is an even number, then the given number of type 1 communication links is sufficient for BS-SC connections. If it is an odd number, one more communication link with a capacity of 30 telephone channels is required. Thus, for BS-SC connections, N_1 communication links of Type 1 and N_2 communication links of Type 2 are required.

Unit costs for one telephone channel with Type 1 or Type 2 links of length L_i are determined by the equation:

$$T_{1i} = A_1 + B_1 \times L_i$$

$$T_{2i} = A_2 + B_2 \times L_i$$

where A_1, B_1, A_2 and B_2 for cable, optical and radio-relay links may be determined on the basis of statistical data.

The cost of establishing communication links between the *i*-th BS and the SC is:

$$K_{5i} = 60 \times N_1 \times T_{1i} + 30 \times N_2 \times T_{2i} = A + B \times L_i$$

where:

$$A = 60 \times N_1 \times A_1 + 30 \times N_2 \times A_2 \qquad B = 60 \times N_1 \times B_1 + 30 \times N_2 \times B_2$$

The total cost of establishing communication links to connect all base stations to the switching centre may be determined by the following equation:

$$K_5 = \sum_1^c K_{5i} = C\,[A + B \times L_m]$$

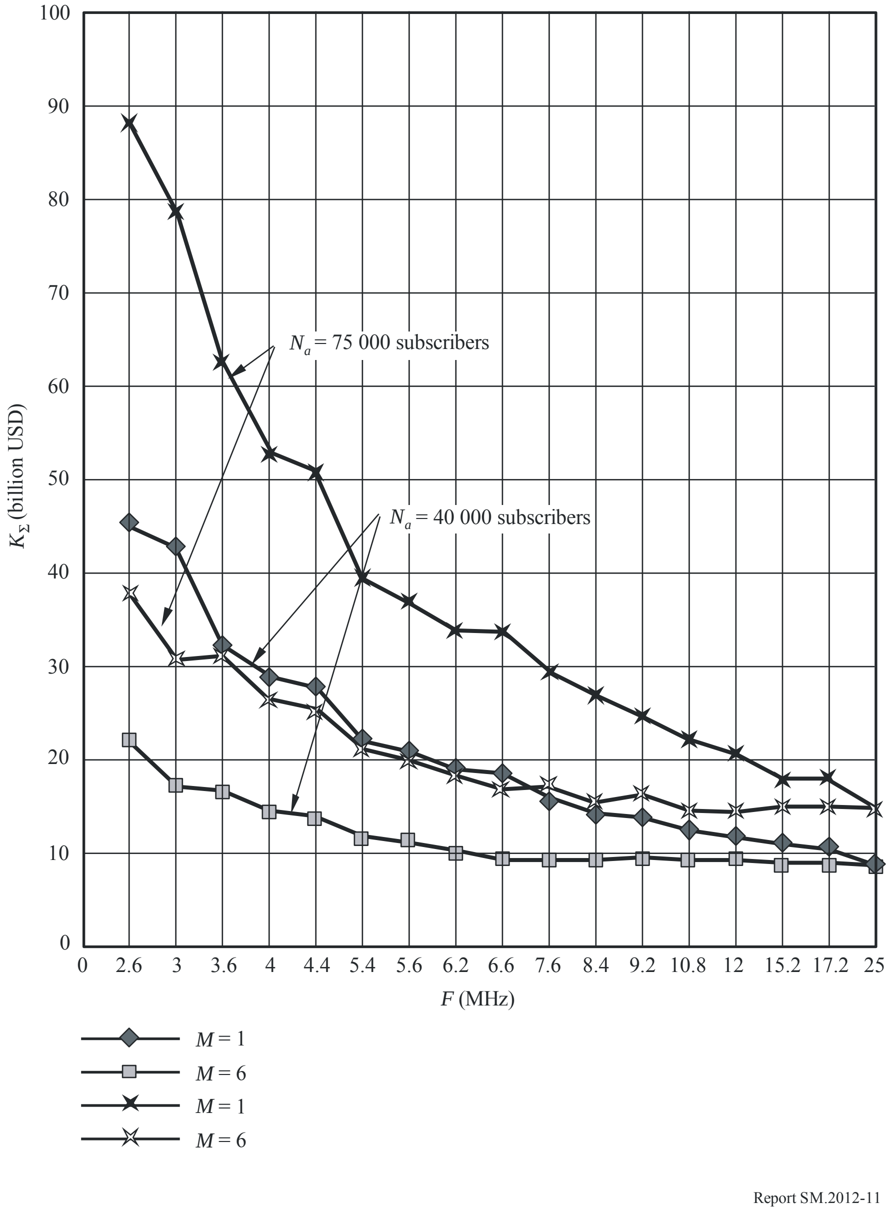
where $L_m = \left[\sum_1^c L_i\right] / C$ is the average length of all BS-SC connection links. The length of these links may vary from 5 to 25 km. If the mobile network's coverage area is assumed to be a circle and base stations are uniformly distributed throughout this area, then:

$$L_m = 2\,[25^3 - 5^3] / 3 \times 25^2 \cong 16.6 \text{ km}$$

Figure 11 shows capital expenditure K_Σ as a function of the bandwidth, F, and the number of subscribers to be served, N_a. It reveals that the operator can reduce the necessary expenditure for the establishment of a network quite significantly by using a wider bandwidth, i.e. making less efficient use of the spectrum.

FIGURE 11

Capital investment vs. bandwidth



c) *Determination of the discounted income index of a mobile network project*

Table 18 shows a set of calculation parameters based on statistical data and standards used in the Russian Federation:

TABLE 18

Symbol	Parameter	Calculation value
N_0	Initial number of subscribers in the mobile network	300 subscribers
T_1	Tariff per minute for the lease of a channel in the public network	USD 0.05/min
X	Coefficient characterizing the proportion of calls entering the public network	0.7
K_{PH}	Traffic concentration coefficient characterizing the proportion of average daily traffic occurring during the busy hour; this is the ratio of busy-hour call time and mean daily call time	0.18
β	Activity of the subscriber during the busy hour	0.025
P_1	Mean one-time payment for connection to the network	USD 200
P_2	Mean monthly subscription fee	USD 50/month
P_3	Mean call rate	USD 0.35/min
n	Licence period	10 years
δ	Rate of national profit tax	0.38
E_n	Discount rate, equal to the average annual bank rate	0.1

When determining the operator's income and annual expenditure, it must be borne in mind that the number of network subscribers constantly varies through time according to a specific equation, $N_a(t)$, which may be calculated based on statistical data on the development of mobile networks. For cellular mobile networks being developed in the Russian Federation, this may be expressed as follows:

$$N_a(t) \; = \; \max \{N_0 \times \exp(\nu_k \times t)\} \qquad \text{where } (k-1) < t < k; \; N_\alpha$$

Table 19 gives data on the evolution in the number of subscribers to GSM standard networks in the Russian Federation, together with the correspondingly calculated values of ν_k:

TABLE 19

Year	1994	1995	1996	1997	1998-2005
k	0	1	2	3	4-11
$N_{ak} = N_a(k)$	2×10^3	13×10^3	53×10^3	132×10^3	$N_{a11} = 2 \times 10^6$
ν_k	0	1.87	1.48	0.92	0.34

Current annual expenditure, $Z_{\Sigma k}$, comprises three components:

$$Z_{\Sigma k} = Z_{1k} + Z_{2k} + Z_{3k}$$

where:

Z_{1k}: annual expenditure for operation, amortization, equipment maintenance, administrative costs, salaries, share dividends or interest on loans, payments for public utilities, land rental. On the basis of statistical data, the following approximation may be used:

$$Z_{1k} = 805 \times N_{aki}$$

Z_{2k}: annual expenditure for maintenance of the billing system, which may be taken as:

$$Z_2 = \text{USD}\,30\,000$$

Z_{3k}: annual expenditure for the lease of public network channels for one year (12 months):

$$Z_{3k} = 12 \times N_{ak} \times Y_M \times X \times T_1$$

The value of Y_M, the monthly traffic for one subscriber, is the number of minutes per month during which a subscriber occupies a communication channel, and is determined by the equation:

$$Y_M = 30.4 \times \beta / K_{PH}$$

Income from operation of a mobile network varies with the number of subscribers using the network's services. It is calculated by the following equation for k years of operation:

$$D_{\Sigma k} = D_{1k} + D_{2k} + D_{3k}$$

where:

D_{1k}: income from one-time payments for connection to the mobile network for k years of operation, which directly includes: connection fee, guarantee deposit, access number, use of local public network operator's line, sales mark-up for subscriber equipment, as follows:

$$D_{1k} = N_{ak} \times P_1$$

It should be noted that the operator receives income, D_{1k}, from network subscribers in a single payment.

D_{2k}: income from monthly subscription fees

D_{3k}: income from monthly call fees.

Using the above relationship, $N_a(t)$, we determine D_{2k} and D_{3k} as follows:

$$D_{2k} = 12 \times P_2 \times \int_0^k N_{ak}(t)\,\mathrm{d}t = 12 \times P_2 \times \{N_0 + \sum_1^k N_{ak} \times [1 - \exp(-v_k)] / v_k\}$$

$$D_{3k} = 12 \times P_3 \times Y_m \times \{N_0 + \sum_1^k N_{ak}\ [1 - \exp(-v_k)] / v_k\}$$

In order to evaluate the economic efficiency of the operation of a mobile network, the discounted income index, I_D, is calculated as the ratio of the sum of discounted net profit of the project to overall capital expenditure.

The current worth of future income is determined using the discounting index $(1 + E_n)$, where the value of E_n is taken as the mean annual bank rate. Thus:

$$I_D = \frac{1}{K_\Sigma} \sum_{k=0}^{n} [(1-\delta)(D_{\Sigma K} - Z_{\Sigma K})] \frac{1}{(1+E_n)^k}$$

On the basis of the results obtained, the discount rate for the project may be calculated:

$$E_p = p\sqrt{I_D}$$

Discounted income is calculated as an annual amount relative to one dollar of investment in the project.

The relationship between a cellular mobile network operator's discounted standard profit and bandwidth F, the number of subscribers served, N_a, and the number of sectors served, M, is shown in Fig. 12. The graph reveals that an operator can make additional profit by using additional bandwidth. When determining the minimum bid, one fundamental principle must be to give operators an incentive to make more efficient use of the radio-frequency spectrum.

d) *Calculation of the minimum bid*

Table 20 gives values of minimum bids for GSM cellular mobile network operators calculated according to the described method. It should be pointed out that this example is given as an illustration. In the calculations, the profit standard for an operator set by the State for mobile communication enterprises is $E_r = 1.25$; and six sector antennas are used in each network. It is assumed that operators are allocated a bandwidth of 5 or 10 MHz.

The minimum bid is calculated by the equation:

$$T = (E_n - E_r) \times D_{pr}/n$$

where D_{pr} is the net profit of the operator during the licence term.

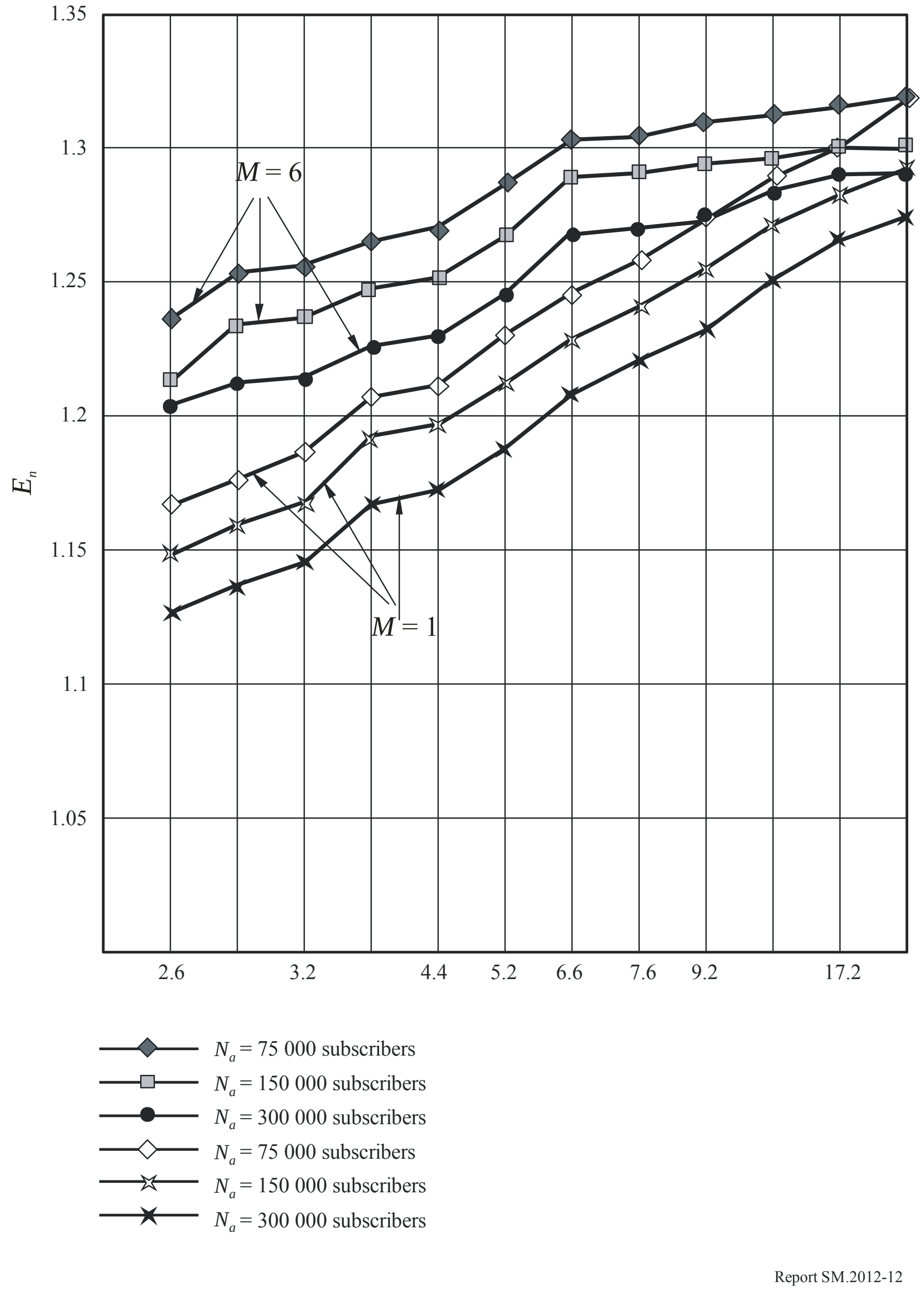
TABLE 20

Number of subscribers in network, N_a (persons)	**75 000**		**150 000**		**300 000**	
Bandwidth (MHz)	5	10	5	10	5	10
T (millions of USD)	1.08	1.68	0.93	2.1	0	1.73

NOTE 1 – The values of minimum bids should be refined on the basis of a market analysis for each specific case.

FIGURE 12

Profitability index vs. bandwidth



5.1.4 New Zealand

Most administrations that have begun applying market based approaches continue to allocate spectrum based on consideration of national priorities, and have applied market approaches only to licensing within an agreed allocation. New Zealand, however, has applied a broader market based approach to use of some frequency bands where the impact is limited to a national, rather than an international, scale.

The Radiocommunications Act 1989 heralded a new era for the management of the radio spectrum in New Zealand. This Act enabled the creation of property rights for spectrum and also the use of market driven allocation mechanisms for the distribution of the newly created rights. The Act does not specific any particular allocation mechanism. Radio spectrum was initially sold using second price then first price tender systems; however in 1996 an Internet based computer system was developed for the sale of spectrum by auction.

The auction process currently used by the Ministry is a simultaneous ascending auction. This type of auction involves making all lots available for bidding at the same time. The auction takes place over a number of rounds of a specific duration (say 30 min), until no further bidding takes place on the lots being offered. This type of auction allows bidders who wish to purchase specific combination of lots to take a part in the auction. Advantages of this type of auction are that bidders obtain full market information and are able to determine their level of success on any combination of lots at any time during the auction. In developing the auction mechanism, the Ministry contracted a private company to help develop software that would allow the operation of radio spectrum auctions over the Internet. Use of the Internet allows bidders to purchase radio spectrum from their own offices using current web browser technology. The Ministry has produced the report Spectrum Auction Design in New Zealand. The report outlines how New Zealand has competitively allocated radio spectrum, factors pertinent to auction design and alternative options for competitive allocation. The Ministry will take into account the findings of the report when designing future auctions.

5.1.5 United States of America

5.1.5.1 Authority

In the United States of America, spectrum management functions are divided between the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA). The FCC is tasked with managing non-Federal Government use of spectrum, including use by the private sector and local and state governments. The NTIA is authorized to manage Federal Government agencies' spectrum use, including the military. The U.S. Congress gave the FCC authority to issue licences via auctions in 1993. This authority is limited to using competitive bidding in instances where mutually exclusive applications have been received and where the principal use of the spectrum is reasonably likely to involve the receipt by the licensee of fees from subscribers in return for enabling those subscribers to receive or transmit communications signals. In granting the FCC auction authority the U.S. Congress sought to promote the following objectives:

"(1) the development and rapid deployment of new technologies, products, and services for the benefit of the public, including those residing in rural areas, without administrative or judicial delays;

(2) promoting economic opportunity and competition and ensuring that new and innovative technologies are readily accessible to the American people by avoiding excessive concentration of licences and by disseminating licences among a wide variety of applicants, including small businesses, rural telephone companies, and businesses owned by members of minority groups and women;

(3) recovery for the public of a portion of the value of the public spectrum resource made available for commercial use and avoidance of unjust enrichment through the methods employed to award uses of that resource;

(4) efficient and intensive use of the electromagnetic spectrum."

In granting authority to use competitive bidding, the U.S. Congress also specified that the use of competitive bidding:

"(1) shall not alter spectrum allocation criteria and procedures;

(2) shall not be construed to relieve the FCC of the obligation in the public interest to continue to use engineering solutions, negotiation, threshold qualifications, service regulations, and other means in order to avoid mutual exclusivity in application and licensing proceedings."

The U.S. Congress further specified that the FCC cannot make allocation or service decisions based on the expectation of public revenue from auctions.

The majority of the proceeds from auctions conducted by the FCC are deposited in the general U.S. treasury. The FCC is permitted to retain only that portion of the auction proceeds necessary to pay for the cost of holding the auctions. This portion is well under 1% of the revenues generated by auctions. Generally, the licences that have been issued pursuant to auction are for a ten-year period, and it is intended that after this period the licence would be renewed if the licensee has complied with applicable FCC rules and has provided substantial service.

The following are services that have been licensed in the United States of America pursuant to auctions.

5.1.5.2 Personal communications services

Personal communications services (PCS) providers are expected to give the public new communications capabilities by providing a variety of mobile services to compete with existing cellular, paging and other land mobile services. These services will be provided via a new generation of communications devices with two-way voice, data and/or message capabilities. These devices include small, lightweight, multi-function wireless phones, portable facsimiles and other devices. PCS is composed of several distinct categories, two of which are narrow-band PCS and broadband PCS.

The FCC held its first auction in July 1994, auctioning 11 nationwide licences to provide narrow-band PCS in the 900 MHz band. Narrow-band PCS can be used to provide new services such as voice message paging, two-way acknowledgment paging in which a subscriber can receive a message and transmit a response back to the sender, and other data services. Licences for narrow-band PCS may cover the entire nation (nationwide licence), large regions (regional licence), or smaller areas. Of the nationwide licences, five are 50/50 kHz paired, three are 50/12.5 kHz paired, and three are 50 kHz unpaired.

From 26 October through 8 November, 1994, the FCC auctioned 30 regional narrow-band PCS licences: six licences in each of five regions of the United States of America. Two licences in each region are 50/50 kHz paired and the remaining four are 50/12.5 kHz paired.

In December 1994, the FCC held its first auction of licences to provide broadband PCS in the 2 GHz (1 850-1 990 MHz) band. Broadband PCS encompasses a variety of mobile and/or portable radio services, using such devices as small lightweight, multifunction portable phones, portable facsimile machines, and advanced devices with two-way data capabilities that are expected to compete with existing cellular, paging and other land mobile services.

The 1 850-1 990 MHz band was divided into six licence blocks. Licence blocks A, B, and C are each for 30 MHz of spectrum (two paired 15 MHz-wide segments). Licence blocks D, E, and F are each for 10 MHz of spectrum (two paired 5 MHz-wide segments). (Note that all six blocks combined contain 120 MHz of spectrum. The other 20 MHz (1 910-1 930 MHz) in the 1 850-1 990 MHz band is used by unlicensed PCS services.)

Licences for blocks A and B cover regional major trading areas (MTAs). There are 51 MTAs that, combined, cover the entire United States of America and its territories. Licences for blocks C, D, E, and F cover basic trading areas (BTAs). BTAs are components of MTAs, and there are 493 BTAs that combine to cover the entire United States of America and its territories. MTAs and BTAs are economic trading areas based on designations contained in the Rand McNally Commercial Atlas and Marketing Guide.

In the auction beginning in December 1994, the FCC auctioned licences in both frequency blocks A and B in 48 MTAs. In the other three MTAs, only the block B licence was auctioned. In those three MTAs (New York, Los Angeles, and Washington-Baltimore), the block A licence was previously awarded under the FCC's pioneer's preference rules. Thus, a total of 99 licences were auctioned. Thirty bidders qualified to bid in the auction and the auction lasted more than 112 rounds before concluding in March 1995.

The FCC began auctioning licences for broadband PCS block C in the 493 BTAs in December 1995. Unlike the MTA auction, bidding credits and instalment payment plans were available to small entities for Block C. The auction concluded in May 1996 after 184 rounds. Auctioning for broadband PCS blocks D, E and F began in August 1996 for 153 bidders who qualified to participate for 1 479 different licences. Bidding credits and instalment payment plans were available for block F only. The auction concluded in January 1997 after 276 rounds.

Although PCS is a new service, the spectrum that it occupies was previously allocated and licensed to a variety of fixed service (point-to-point) microwave users, including public safety services. Therefore, it is necessary either to move the incumbent microwave systems to another frequency band or to provide for their communications needs through some alternative means, such as cable. In establishing the PCS service, the FCC determined that the fastest and fairest way to make this transition was to have the new PCS licensees pay to move the microwave users out of the band. The FCC therefore established a procedure whereby the new PCS licensees and the incumbent microwave users have a certain period to negotiate the terms of the re-accommodation. In any event, however, the microwave users must vacate the band as of a certain date and cannot therefore prevent implementation of the new services.

5.1.5.3 Interactive video data service

The FCC held its second auction, for 594 interactive video data service (IVDS) licences, during July 1994. IVDS is a two-way communications service in the 218-219 MHz band. Licences are for a ten-year period, and consist of two 500 kHz licences in each of 297 metropolitan statistical areas (MSAs), which are essentially the urbanized areas of the United States of America. In each market, both licences were available for auction at the same time, with the highest bidder given a choice between the two available licences and the second highest bidder winning the remaining licence. The FCC auctioned all 594 licences within two days.

5.1.5.4 Specialized mobile radio service

The specialized mobile radio (SMR) service is a land mobile radio service that provides dispatch, voice, and data services to commercial businesses and specialized users, although licensees are also permitted to provide service to the general public. The SMR service operates in both the 800 MHz and 900 MHz bands.

The FCC established the SMR service in the 800 MHz band in 1974 as a private land mobile radio service intended as a spectrally efficient method to provide dispatch radio service to businesses and other users that qualified as private radio users. Originally, applicants were limited to a relatively small number of channels to be located at a single base station. Coverage and service options were therefore limited. These licences were issued on a first-come, first-served basis, with a lottery used to resolve instances of mutual exclusivity. Over the years, however, the demand for this service increased and the rules limiting eligibility and licensing were gradually reduced. SMR providers today offer a range of services from traditional radio dispatch for local customers to more sophisticated voice and data transmissions for customers over large geographic areas. SMR licensees, in recent years, have been authorized to expand the geographic scope of their services and aggregate large numbers of channels to provide service more directly comparable to cellular radio and PCS. In October 1994, the FCC proposed to issue 800 MHz SMR licences based on FCC-defined service areas and subject to competitive bidding. The 800 MHz band will be the subject of a future auction.

The 900 MHz SMR service consists of 5 MHz of spectrum divided into twenty 10-channel blocks in each MTA. Assignments in the 900 MHz SMR service offer the potential for such competitive services as wireless data, specialized dispatch, two-way paging, and interconnected voice transmission. Licences for this service were initially issued for single transmitter sites in the 50 largest cities in the United States of America with licensees selected by lottery. Licensing, however, was suspended for a number of years, and the FCC recently restructured the service to issue area-wide licences pursuant to competitive bidding. Original licensees are protected from interference from new licensees; however, they can expand their operations only by obtaining a new licence.

5.1.5.5 Multichannel multipoint distribution system

Multichannel multipoint distribution system (MMDS) is often referred to as "wireless cable". It offers delivery of video programming to subscribers using MMDS and/or instructional television fixed service (ITFS) channels. Only MMDS channels at 2 150-2 160 MHz and 2 596-2 680 MHz have been auctioned. MMDS resembles cable television, but instead of coaxial cable, "wireless cable" uses microwave transmission and signals. In the past, MMDS licences have been issued for specific coordinates at which the central transmitter was located. However, the FCC recently revised the MMDS licensing procedures so that all licensees will be authorized to operate throughout particular BTAs. New licensees will be required to avoid interference within the protected area of existing MMDS operations (a 35-mile radius). The FCC stated that mutually exclusive applications that are filed for a particular BTA will be processed using competitive bidding.

5.1.5.6 Direct broadcast satellite

The direct broadcast satellite (DBS) service is a radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public. This includes direct reception by both individuals and the community. The FCC held a very limited DBS auction for two orbital slots in January 1996. In adopting auction procedures, the FCC noted that there are characteristics of a national broadcast satellite service, such as the footprint of the satellite falling within the United States of America, that make DBS different from many other satellite services. One winning bidder received a construction permit for 28 channels and the second winning bidder received a construction permit for use of 24 channels.

5.1.5.7 Satellite digital audio radio

The satellite digital audio radio (DAR) service is a broadcasting-satellite (sound) radiocommunication service located in the 2 320-2 345 MHz band, in which high-quality audio signals are transmitted to the Earth by satellite, either to subscribers or to the general public. The FCC held a satellite DAR service auction for two 12.5 MHz licences in April 1997. Both winning bidders plan to offer subscription-based services. Licences are for an eight-year period.

5.1.5.8 Wireless communications

The wireless communications service (WCS) is a radiocommunication service located in the 2 305-2 320 MHz and 2 345-2 360 MHz bands. WCS licensees have the flexibility to offer a variety of fixed, mobile, radiolocation, and broadcasting-satellite (sound) services, except that broadcasting-satellite (sound) and aeronautical mobile services may not be offered at 2 305-2 310 MHz. The FCC held a WCS auction for two 10 MHz licences for each of 52 major economic areas (MEAs) and two 5 MHz licences for each of 12 regional economic area groupings (REAGs) in April 1997. MEAs and REAGs consist of groupings of smaller economic areas, as defined by the U.S. Department of Commerce. There are 176 economic areas that cover the United States of America and its territories. A large variety of companies won licences in the WCS auction. Licences are for a ten-year period.

5.2 Experience with fees

5.2.1 Australia's experience with licence fees

In addition to conducting spectrum auctions and implementing a limited system of property rights, the Australian Communications and Media Authority (ACMA) has attempted to improve the efficiency of the traditional system of licensing. Underpinning the ACMA's approach has been a fundamental restructuring of radiocommunications apparatus licence fees. In April 1995, then Spectrum Management Agency (now ACMA), in consultation with industry, moved from a traditional, service-based methodology of charging for spectrum usage, to a system which charges on the basis of the amount of spectrum that a particular service denies to other users. Thus, licence fees are calculated in a more consistent and transparent manner, as opposed to the somewhat arbitrary approach that focused predominantly on the characteristics of the radiocommunications service being licensed.

Under the new apparatus licence fee structure, each licence fee generally consists of three identifiable components:

– an issue or renewal component, reflecting the cost of issuing or renewing the licence;

– a spectrum maintenance component, reflecting the ongoing cost of managing the spectrum, including protection from interference (a fixed percentage of the spectrum access tax (SAT) described below);

– a SAT, which represents a return to the government for use of a community resource, and is based on a formula involving spectrum location, geographic location, channel bandwidth, and communications coverage area.

The calculation of the SAT represents a market demand based pricing strategy in so far as services operating in higher demand areas of the spectrum (i.e., UHF/VHF) or more densely populated geographic areas (i.e., major capital cities) attract a higher licence fee than those operating in lower spectrum demand or geographic demand areas. Furthermore, in accordance with the spectrum denial methodology, services with larger operating bandwidths attract a higher licence fee than more spectrum efficient services, thereby encouraging users to seek more technically advanced equipment that utilizes narrower operating bandwidths, or alternatively encouraging users to operate in segments of the spectrum that are in greater supply.

The ACMA has also introduced measures which allow greater flexibility and certainty for users in the radiocommunications market. Flexibility has been achieved by allowing licensees to transfer their apparatus licences to third parties, while greater certainty has been accomplished by permitting licensees to acquire licences for periods of up to five years.

5.2.2 Canada's experience with licence fees

Industry Canada's policy objective in managing the spectrum, as reflected in the 2007 *Spectrum Policy Framework for Canada*, is to maximize the economic and social benefits that Canadians derive from the use of this resource. The Policy Framework also includes enabling guidelines that call for increased reliance on market forces, implementation of flexibility in spectrum management, and minimization of administrative burden.

In accordance with these enabling guidelines, the department has been moving in the direction of increased reliance on market forces as a means of carrying out its policy objective. This includes relying on technology and service neutral licences, auctions and fees that promote the efficient use of the spectrum resource and earn a fair return to Canadians for its use. For a number of years, Industry Canada has been issuing spectrum licences for new services that are technology neutral, tradable and have ten year terms.

Currently, Industry Canada is studying the development of a fee model based on spectrum consumption in three dimensions: bandwidth, geographic coverage, and exclusive use. Although this model has not been implemented, its methodology and recommendations remain under consideration for future licensing regime modifications.

5.2.3 China's experience with licence fees

In 1989, the Radio Regulatory Department (the former Office of State Radio Regulatory Commission) of China began collecting licence fees, most of which were spent on spectrum management facilities. This spending has improved spectrum management and has contributed to the deployment of radio services. In 1998, the fee mechanism was adjusted to make fee collection formulas simpler, in order to avoid ambiguity and reduce the cost of fee collecting.

Fee collecting in China is not only regarded as a source of revenue but also an effective means of increasing the efficiency of spectrum management. The following factors are taken into consideration when setting fee levels:

– *Bandwidth used*: Setting the fee level according to the amount of spectrum a user receives encourages the applicant to apply for only the necessary amount of spectrum, thus reducing hoarding.

– *Coverage area*: The coverage area may be a city, a province or more than one province. For each type of coverage area, there is a different fee level.

– *Frequency*: For the same service, different fees are charged, depending on the frequency band. For example, the fee per MHz for a microwave station operating above 10 GHz is only half as much as for a station operating below 10 GHz. Thus, the fee structure encourages service operators to introduce new services in less congested parts of the spectrum.

According to factors mentioned above, China's license fees policies are implemented in two ways. The first one is that fees are collected according to the bandwidth of assigned spectrum. For example, mobile communication operators apply for many frequency spectrums to construct their networks. In order to encourage operators to make full use of spectrum and to provide more convenient service for the public, license fees of mobile communication networks are charged according to the total width of spectrums which allocated to the network, but not levied for every station in the network. Meanwhile, as radio waves in different frequency bands have different characteristics, the license fee policy (price for spectrums) varies in different bands used by mobile communication. For example, compared with radio waves in 1 800 MHz band, those in 900 MHz band have better propagation characteristics and larger coverage. Therefore, the price of spectrum in 900 MHz band is higher than that of in 1 800 MHz band by 13.3%. The second way of license fee charging is that services operators pay for every station that has been assigned frequencies, such as earth station, microwave station.

In additional, there're some favorable policies. For instance, stations meet with the followed situation can be exempt from license fees:

1. Stations set up by government for official business.
2. Special stations for national defense.
3. Official business stations owned by police, security department, justice organs, penitentiary, fishery administration.
4. Emergency rescue and disaster relief work stations, maritime distress stations on guard, safety information delivery stations, safety navigation stations.
5. Experimental stations installed by broadcasting authorities, stations for foreign radio and TV broadcasting.

6. Amateur station.

7. TV transposing stations set up by the peasant through funding.

The policy of license fee exemption mentioned above was carried out within the first license fee collection rule in 1998. In 2006, another favorable policy about license fees was made which primarily prompts communication and broadcast services for farmers in rural area. In a lot of rural area, economy develops correspondingly slow. In order to provide universal communication and broadcast services, the government launched a special project to set up communication and broadcast establishments in rural area, which facilitates farmers in every village of China to communicate with others and receive radio and TV broadcasting programs. To support this project, the government brings out a favorable policy which reduces or exempts the license fee of stations. In this favorable policy, the operator of any station of analog wireless access system, MMDS and SCDMA could pay the license fee at half price of normal, and the license fee of earth station, radio and TV transposing station are totally exempted. The objective of above favorable policy is to ensure people in countryside to get necessary and guaranteed radio services with low cost.

5.2.4 Germany's experience with spectrum usage fees

The telecommunications sector in Germany is subject to the Telecommunications Act of 22 June 2004. The purpose of the Act is, through technology-neutral regulation, to promote competition and efficient infrastructures in telecommunications and to guarantee appropriate and adequate services throughout the Federal Republic of Germany.

The Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway is a separate higher federal authority within the scope of business of the German Federal Ministry of Economics and Technology, and has its headquarters in Bonn. On 13 July 2005 the Regulatory Authority for Telecommunications and Posts which superseded the Federal Ministry of Posts and Telecommunications (BMPT) and the Federal Office for Posts and Telecommunications (BAPT), was renamed Federal Network Agency. The Federal Network Agency's task is to provide, by liberalization and deregulation, for the further development of the electricity, gas, telecommunications and postal markets and, as from 1 January 2006, also of the railway infrastructure market.

Frequency regulation is based on a national table of frequency band allocations, frequency usage plans and frequency assignment procedures.

Frequency assignment fees and frequency usage contribution charges are regulated by the Telecommunications Act and ordinances having the force of law.

5.2.4.1 Frequency assignment and frequency assignment fees

Each frequency usage requires prior assignment by the Federal Network Agency. Frequencies are assigned for a particular purpose in accordance with the frequency usage plan in a non-discriminatory manner on the basis of transparent and objective procedures.

Frequencies are typically assigned ex officio by the Federal Network Agency as general assignments for the use of particular frequencies by the general public or a group of persons defined or capable of being defined by general characteristics. Where general assignment is not possible, frequencies for particular usages are assigned by the Regulatory Authority upon written application, as individual assignments.

The Federal Network Agency shall charge fees for the decisions on the grant of rights of use for frequencies. The fee scales are to be calculated in such a way as to recover the costs incurred by the official acts. In addition the fees payable for decisions on the grant of rights of use for frequencies may be determined in such a way that they serve as a steering mechanism to secure optimal and efficient use.

5.2.4.2 Frequency usage contribution charges

The Federal Network Agency shall levy annual contribution charges to recover costs it incurs for the management, control and enforcement of general assignments and rights of use for spectrum usage. This includes, in particular, costs incurred by the Federal Network Agency for the following activities:

1. the planning and further development of frequency usages, including the necessary measurements, tests and compatibility studies to secure efficient and interference-free use of frequencies;
2. international cooperation, harmonization and standardization.

Liable to make contributions are all those who have been assigned frequencies. The share of the costs shall be allocated to the separate user groups produced by frequency allocation, as far as possible on an expenditure-related basis. Within these groups, the costs shall be split in accordance with the use of frequencies.

5.2.4.3 Current procedure for calculation of frequency assignment fees and frequency usage contribution charges

In 1994 the former Reg TP introduced a performance and accounting system (known by the acronym KLR) with the intention of establishing a recording system and a controlling instrument for the calculation of frequency assignment fees and contribution-related costs (staff costs and other expenditure). The idea – based on the new German telecommunication legislation – was to develop a tool which offers the possibility to carry out real calculations instead of estimations in terms of fees and contributions. With the introduction of the KLR a step was made towards the development of performance and cost transparency within the Federal Network Agency. The definition of cost units (e.g. user groups) as the smallest unit in the performance structure of the Federal Network Agency is the basic element of the whole KLR concept. A module called "expense record" was developed which allows the direct assignment of upcoming costs with regard to the most important categories of staff costs, costs for measurement equipment as well as costs for cars for individual transport and for vans of the monitoring service. The expense record is carried out by using an electronic aided worksheet which has to be filled in by the employees who worked in the relevant performance range. The expense record contains on a daily basis precisely (accuracy-limit of time is equal to half an hour) the duration of the period needed for the accomplishment of the specified tasks in the framework of a monthly evaluation.

5.2.4.4 Calculation of frequency assignment fees

Frequency assignment fees are calculated on the basis of firstly the costs according to the cost accounting data and secondly statistical data (e.g. number of new frequency assignment applications, changes in frequency assignments, frequency assignment waivers). Under the cost accounting method, all fee-related costs (staff costs and other expenditure) are recorded and allocated according to service and user group on a daily basis.

A number of spectrum management functions carried out by the Federal Network Agency do not lead to an income. For this reason the cost coverage cannot be 100%. However, the record and the evaluation of the free-cost spectrum management functions (specified in the Ordinance of frequency usage contributions) and for other authorities (e.g. Ministry of Defence) provides the necessary transparency of the fee and the reasons for not being able to achieve full cost recovery.

5.2.4.5 Calculation of frequency usage contribution charges

Frequency usage contributions are also calculated on the basis of all the contribution-related costs according to the cost accounting data. As with the fee-related costs, the contribution-related costs (staff costs and other expenditure) are recorded and allocated according to service and user group on a daily basis. The contribution per user group is calculated taking account of the number of frequencies assigned to each user group. The principle of solidarity applies within each user group, i.e. all user groups under the same service group pay, although one individual user group may have a financial advantage.

The annual contribution must be recalculated annually on a cost-recovery basis in relation to each user group. The underlying principle in the calculation of frequency assignment fees and frequency usage contributions is that the fees and contributions must cover the staff costs and other expenditure associated with the activity in question. However, the cost-accounting method applied in Germany forms the basis for calculation.

5.2.5 Israel's experience with licence fees

The Ministry of Communications of the State of Israel has established a few licence mechanisms:

– one time payment for submittal of application for telecommunication service providing;

– annual fee for usage of the frequency spectrum;

– annual royalties, which are a percentage of the income, for telecommunications service provider;

– one time payment, paid by a winner of an auction.

Annual spectrum fees

As an amendment to the Wireless Telegraph Order, the Administration of Israel started annual spectrum fees in January 1995, in order to persuade operators and private users to pursue more efficient spectrum use. The Ministry of Communications may modify, once a year, the structure or the value of a specific fee. This is done through the Financial Committee of the Kneset (The Israeli Parliament), and any service provider or a private user of the spectrum who may be affected by those modifications, has the right to present his case to the Committee.

Because the fee decreases with frequencies above 960 MHz, the use of a higher frequency is encouraged. Below 960 MHz, the spectrum fee is about USD 170 000 per 1 MHz. This approach has been taken to encourage the use of less occupied bands and to encourage spectrum users to take advantage of the higher frequency reuse associated with high attenuation and lower antenna side-lobes at higher frequencies.

The frequencies spectrum fees are categorized to different services, such as:

– Private mobile radio.

– Trunking mobile radio service providers.

– Cellular service providers.

– TV and radio broadcasting.

– Microwave point-to-point link.

– Fixed wireless access.

– Satellite communication (private and commercial users).

– Radio amateurs.

– Aeronautical and maritime services.

– Temporary licences for tests or demonstrations.

The fee system has some measures to encourage better and higher reuse of frequencies. Some examples are:

– Lower fee for lower transmission power, for TV and radio broadcasters.

– Discount for TV broadcasters which reuse the same frequency in different locations.

– No charge for radio broadcasters that reuse the same frequency in additional locations.
– Discount for telecom service providers which reuse the same frequency for multiple point-to-point microwave links.

Some examples from Israel's short experience of the last few years, utilizing incentive fees:

– Within two years all point-to-point links on frequencies below 960 MHz (about 100), were relocated to higher frequencies.
– An agreement with TV broadcasters to modify frequencies, to obtain more efficient use of the spectrum.
– Migration of different systems from frequencies below 1 GHz, to clear bandwidth for a third cellular operator in the GSM band.
– Some of the operators have been paid to move their systems, and the cost of this migration was covered by the licence fee advanced payment paid by the new entrant to the Government (not directly to the existing user of that spectrum).

5.2.6 Experience of the Kyrgyz Republic on application of licence fees

In 1997 in the Kyrgyz Republic, the independent regulating body of communications, the National Communications Agency (NCA), was established. According to the Law of the Kyrgyz Republic on "Postal and Telecommunications", accepted in 1998, spectrum management began.

In 1998 the NCA created a licence fee model. The purpose of this model was to increase spectrum efficiency, introduce a non-discriminatory approach to various categories of users, stimulate the use of unused frequency ranges, develop radiocommunications services throughout the Republic, and cover the cost of spectrum management.

The model determines the value of annual payment for the spectrum and contains the following basic elements:

– radio-frequency resource, used in the Republic, representing all frequency assignments stored in the national database, is determined on an annual basis. For each frequency assignment this resource is determined in view of the band used and the coordination area;
– the annual cost of spectrum management;
– the average price for the unit of the frequency resource used is determined from the above values;
– the annual payment of a specific user is determined from the value of the frequency resource used.

A number of incentive factors are entered in the formula, so the payment depends not only on the bandwidth used and coverage area, but also on geographical location of the station, population density in the coverage area, social factors, exclusivity, type of radiocommunications service, spectrum employment, and spectrum monitoring complexity.

The developed software allows the user at any moment to determine the value of the annual payment for the spectrum and also renders the model transparent and accessible to all users.

Thus, for the user the greater the bandwidth and the more populated the geographical area, the larger the payment. This encourages the use of more modern equipment, new frequency ranges and expansion of coverage to rural and remote areas.

The NCA has adopted licence terms of up to 7 years. Determination of the spectrum payment algorithm includes the determination of:

– the annual expenditures of the State on management of radio-frequency resource use and determination on this basis of the common value of the annual payment for all radio-frequency resources;
– the value of the radio-frequency resource;
– the price for a unit of the radio-frequency resource;
– the annual payment for a specific user on a differential and non-discriminatory basis, determined from the value of the frequency resource and the unit price of this resource.

5.2.6.1 Expenditures and income of the State on spectrum management

The total amount of the annual payments for spectrum, C_{ann}, collected from all users, can be submitted as:

$$C_{ann} = C_1 + C_2 \tag{51}$$

where:

C_{ann}: total annual cost of the users for the spectrum

C_1: share of resources that is necessary for covering of costs of the State on spectrum use management

C_2: net income of the State.

It is possible to separate the terms C_1 and C_2 into additional components:

$$C_1 = C_{11} + C_{12} + C_{13} \tag{52}$$

where:

C_{11}: means necessary for purchase and operation of a spectrum management system, including radio monitoring station equipment, direction finders, computers, software, materials, amortization of buildings, etc.

C_{12}: means necessary for carrying out scientific research, purchase of scientific literature and recommendations, electromagnetic compatibility analysis, frequency assignment, coordination, etc.

C_{13}: spectrum management staff salaries.

Taxes are not included in the amounts C_{11}, C_{12}, C_{13}.

C_2 can be separated into the following components:

$$C_2 = C_{21} + C_{22} \tag{53}$$

where:

C_{21}: taxes imposed by State spectrum management agency on telecommunications equipment, software, materials etc.

C_{22}: payments for spectrum use. At present in Kyrgyzstan, to encourage development of radiocommunications services $C_{22} = 0$.

Formulas (51) and (53) do not take into account the indirect income of the State taxes on the incomes of telecommunication operators whose activity is connected with radio-frequency resource use (for example, taxes from the income of cellular communication operators). This component of the income of the State is essential and exceeds component C_{22}.

In essence C_{22} is an initial payment for spectrum. However, no telecommunication operator, especially in the developing countries, will immediately be able to make a large payment and this would be an obstacle to development. A good way to provide an economic incentive is reducing to a minimum the C_{22} component, so that the telecommunication operator may begin to provide service with no initial spectrum payment. The loss, C_{22}, will be compensated for the State by the taxes from the telecommunication operator's activity.

Thus, for the purposes of rapid development of telecommunication and information services in the country and the provision of economic incentives to the telecommunication operators, it is essential to hold spectrum payments to the minimum necessary for covering the costs of spectrum management.

5.2.6.2 Determination of the value of the radio spectrum

Proceeding from formulas (51), (52) and (53) it is possible to determine C_{ann}, representing annual payment for all radio-frequency resource, used in the country. Further this amount is necessary for collecting from all telecommunication operators using radio-frequency spectrum on a fair and non-discriminatory basis. To accomplish this, according to this Report and the ITU World Telecommunication Development Conference (Valetta, 1998), it is necessary to determine the value of the spectrum used by each operator.

Limitations regarding use of frequency assignments are given to users by the NCA. These limitations concern installation and operation of their radio equipment. The necessary information on all frequency assignments (frequency bands, transmitter capacity, geographical coordinates, antenna type and height of its installation, etc.) is stored in the national database. Total frequency assignments are designated as "n".

The method used is as follows.

For any i-th user on the basis of its frequency assignment characteristic incorporated in the national database, it is possible to determine a three-dimensional value of the spectrum used, as follows:

$$Z_i = F_i \cdot S_i \cdot t \tag{54}$$

where:

Z_i: frequency resource used for i-th frequency assignment

F_i: radio frequency band used for i-th frequency assignment

S_i: area of the territory used for i-th frequency assignment

t: time.

Each component may be considered in more detail:

a) The time t for all users is equal to one year ($t = 1$).

b) The population density of the territory is not uniform. The high population density area is more attractive to the telecommunication service operator. Therefore, the whole territory of the republic is divided into, m, territories according to its administrative structure and for each j-th territory, $1 \leq j \leq m$, the population density coefficient (according to the data of the census) is K_j (see Table 21). $K_j = 1$ for the area with the lowest population density.

TABLE 21

Population density coefficient for various territories of the Kyrgyz Republic

Designation – Province (oblast)	*Bj*
Naryn	1
Talas	3.7
Issyk-Kul	3.5
Jalal-Abad	5.6
Osh	5
Chuy	8
Cities and settlement of an urban type	
With a population of 10 000 to 50 000 inhabitants	16
With a population of 50 000 to 100 000 inhabitants	32
With a population of 100 000 to 500 000 inhabitants	64
With a population over 500 000 inhabitants	128

The population density coefficient permits a fair annual payment for users. Then, if the coordination area of *i*-th frequency assignment covers, q, sites in different territories, the area is determined as follows:

$$S_i = \sum_{j=1}^{q} K_j \lambda_j \qquad \text{km}^2 \qquad (55)$$

where:

S_i: area of the territory used by the *i*-th frequency assignment

q: overall number of territories covered by coordination area of *i*-th frequency assignment ($q \leq m$)

K_j: population density coefficient in *j*-th territory (from Table 21)

λ_j: area of coordination area site located in *j*-th territory.

c) For each *i*-th frequency assignment, frequency band Δf_i is used. But different ranges are used by various radiocommunication services. Therefore there is a number of the coefficients, which are necessary to take into account, as they influence are the price of the frequency band used. In the general case it is possible to determine the value of the used frequency band for *i*-th frequency assignment, as follows:

$$F_i = \alpha_i \cdot \beta_i \cdot \Delta f_i \qquad \text{kHz} \qquad (56)$$

where:

F_i: theoretical frequency band used by *i*-th frequency assignment

Δf_i: actual frequency band used by *i*-th frequency assignment

α_i: coefficient which takes into account a number of the factors, given below in equation (57)

β_i: coefficient which determines exclusiveness of use. If the given site of the spectrum is used on an exclusive basis then $\beta_i = 1$. With sharing β varies within the limits of $0 < \beta_i < 1$ depending on conditions of sharing.

It is possible to examine the coefficient α_i in more detail. A number of factors influence the value of α_i factor and it can be presented as product:

$$\alpha_i = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \tag{57}$$

where:

α_i: general coefficient taking into account the various factors of spectrum use

α_1: commercial value of the spectrum range used

α_2: social factor

α_3: takes into account features of transmitter location

α_4: takes into account the complexity of spectrum management functions.

The values of coefficients α_1, α_2, α_3 and α_4 are given in Table 22.

Coefficient α_1 varies in limits from 0 up to 100 and, basically, is determined by two factors:

– the commercial value of radio services; this factor increases with value;

– many radio services may be moved to higher frequencies as experience is gained, thus, decreasing the loading of lower frequency bands. This is the economic level which encourages use of higher bands. For example, for the purposes of encouraging transition of stations at frequencies below 1 GHz to frequencies above 1 GHz, the value of the coefficient α_1 in the range above 1 GHz is less than the value used for stations below 1 GHz. Currently frequencies below 1 GHz are used by several radio services at the same site and hence there is also a question of their electromagnetic compatibility. The range above 1 GHz is poorly mastered in the Republic, but at the same time in the world the newest technologies are used which, allow effective use of the spectrum.

Coefficient α_2 varies in limits from 0 up to 10 and takes into account a social factor. For those radio services whose existence is vital for all sections of the population, including the most needy, this coefficient has a low value. For example, for stations above 1 GHz in which long-distance communications are organized, as well as for television broadcasting, the coefficient α_2 has a low value. However, for cellular communication, coefficient α_2 has a higher value.

TABLE 22

Values of coefficients α_1, α_2, α_3, α_4

Service \ α	α_1	α_2	α_3		α_4
			City	**Village**	
Radio-relay line in a range above 1 GHz	0.5	0.30	1	0.1	1
Radio-relay line in a range below 1 GHz	1	4.00	1	0.1	1
Television in meter range (MW TV)	5	0.30	1	0.1	5
Television in meter range (DMW TV)	5	0.40	1	0.1	5
USW broadcasting	12	5.00	1	0.1	5
SW broadcasting	5	5.00	1	0.1	4
SW radiocommunication	13	6.00	1	0.1	4
Trunking	12	6.00	1	0.1	5
Cellular communication	13	6.00	1	0.1	5
Paging	60	6.00	1	0.1	5
Mobile communication	10	6.00	1	0.1	5
Radiocommunication in CB range	0.12	1.00	1	0.1	1
Radiolocation	0.15	0.10	1	0.1	1
The security radio signal system	6	1.0	1	0.1	2
Earth station for fixed-satellite service	40	1.00 0.30*	1	0.1	1
Feeder link for broadcasting-satellite service	7	0.30	1	0.1	1

NOTE 1 – α_2* – Value taking into account a social factor is entered for international organizations working in the territory of the Kyrgyz Republic, not representing commercial communication services and whose activity is directed towards stability of economy, development of a science, or culture.

Coefficient α_3 takes into account features of site location in urban and rural areas. In rural areas, where the density of the population and the level of incomes is low, the commercial value of communication services is also low and the technological costs of providing these services is high. Therefore with the purpose of support of these telecommunication operators and services, as well as for encouraging development of radiocommunications services, there is a reduction coefficient $\alpha_3 = 0.1$ (in urban district $\alpha_3 = 1$).

Coefficient α_4 varies in limits from 0 up to 10 and is determined by the complexity of spectrum management functions performed. This coefficient is the highest for mobile services, as here it is required to carry out the function of radiodeterminations of mobile objects, and for television broadcasting, where it is required to determine with high accuracy a number of parameters.

Thus, with the help of weighting coefficients K_j, α_i, and β_i in formulas (55) and (56), according to formula (54) it is possible to determine the given (in view of the various factors) frequency resource Z_i for each frequency assignment. Then it is possible to determine the general frequency resource used in the Kyrgyz Republic, according to formula (58):

$$Z = L \sum_{i=1}^{n} Z_i \qquad \text{kHz} \cdot \text{km}^2 \cdot 1 \text{ year} \qquad (58)$$

where:

Z: general frequency resource used in the Republic

Z_i: frequency resource used with *i*-th frequency assignment

n: overall number of frequency assignments registered in the national database

L: estimated expansion coefficient for the spectrum used. The introduction of this coefficient permits prices for spectrum to be determined in advance for the next fiscal year.

5.2.6.3 Price for the unit of the frequency resource used

On the basis of formula (51) and in view of formulas (52) and (53) the total amount of annual payments is determined.

On the basis of formula (58) the value of the spectrum annually used in the Republic is determined.

Then it is possible to determine the price of ΔC_{ann} for a conventional unit of the frequency resource:

$$\Delta C_{ann} = \frac{C_{ann}}{Z} \left(\frac{Som^*}{\text{kHz} \cdot \text{km}^2 \cdot \text{year}} \right) \tag{59}$$

Som^*: name of the national currency.

5.2.6.4 Annual fees for a particular frequency assignment

According to formula (59) the price ΔC_{ann} for the conventional unit of the frequency resource is determined.

According to formula (54) the frequency resource Z_i used for a particular frequency assignment is determined. Then the amount of the annual payment C_i from a specific user of the spectrum for a specific *i*-th frequency assignment is determined by formula (60):

$$C_i = \Delta C_{ann} \cdot Z_i \tag{60}$$

If any telecommunication operator has more than one frequency assignment, the payment for each assignment is determined and then they are summated.

5.2.6.5 Application of the method

This method is authorized by the NCA in a text on determination of the annual payment for all the spectrum used in the Republic. Its application is coordinated with the National Commission of the Kyrgyz Republic on Protection and Development of Competition.

There is software for the national database on frequency assignments, and calculation of the payment for a specific user does not present difficulties.

Seminars for telecommunication operators regarding this method were conducted. Because the method is known for practically all users, transparency is provided.

5.2.6.6 Funding the monitoring system

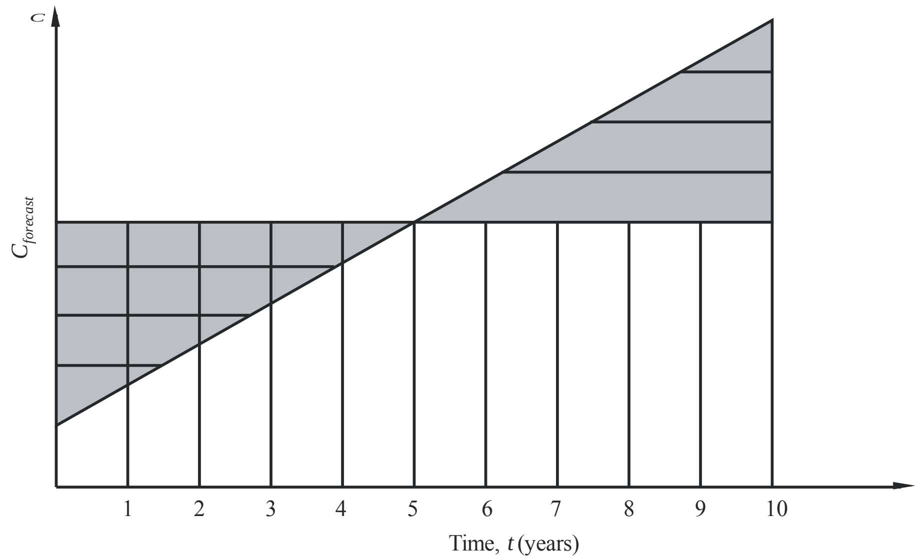
The Kyrgyz Republic, like the majority of new and developing countries, experienced difficulties in funding a modern system of spectrum management. The greatest difficulty was the funding of the national automated radio monitoring system, which can ensure effective spectrum management. Such a system is necessary, but its cost is high. The condition of the State budget does not allow funding of such a system.

One of the ways to fund such a system is a loan on preferential terms from international financial organizations or from other countries. The principal could be included in the amount of the annual payment and gradually returned to the creditor. The mechanism of return of the principal is shown in Fig. 13. It is possible to return the principal in equal payments each year. However, the payment (principal and interest) would be very high in the first years of return of the principal.

Such payments would result in substantial growth of expenses of the telecommunication operators and a rise in price of their services. Accordingly development would be impaired and in some cases operators would fail. The delay of expansion of telecommunication services would cause not only reduction of tax receipts, but a recession, as has happened in the past.

FIGURE 13

Mechanism of return of the principal



A different approach is possible. Based on the experience of other countries, the number of the spectrum users will grow. Therefore, it is possible within reasonable limits to increase the price for the unit of the spectrum and to support it in hard currency until the annual total fee has reached the forecast size, $C_{forecast}$, n the middle of an amortization period (for example, 5 years after installation of the equipment, assuming the loan is for 10 years).

The total amount of the taxes for 10 years (including the principal, which it is necessary to return within 10 years) is equivalent to the area shaded by vertical lines. For the first 5 years there would be a shortage, equivalent to the area shaded with vertical and horizontal lines, whereas in the next 5 years there would be a surplus (area shaded with horizontal lines). The main advantage of such policy would be price stability, which would allow the telecommunication operators to plan their incomes, expenditures and development of services.

Of course, the above would be only the initial approach to price policy. If it will possible to forecast more accurately and to determine more precisely the price policy based on actual conditions, it would be possible to make faster payments.

The above technique would allow to determine the Republic tariff policy regarding spectrum use in view of conditions of loan repayments, thus keeping a non-discriminatory approach to the various spectrum users.

5.2.7 The Russian Federation's experience with licence fees

With a view to ensuring more efficient use of the radio-frequency spectrum, the Government of the Russian Federation adopted a decree in June 1998 on the "Introduction of charges for use of the radio-frequency spectrum". Under this decree, with effect from September 1998, businesses, individual entrepreneurs and other persons using the radio-frequency spectrum in the Russian Federation for the provision of telecommunication services to commercial ends are charged for such use, pursuant to the "List of telecommunication services for whose provision use of the radio-frequency spectrum shall be on a paid basis" set forth in the decree.

Operators providing the following types of service are required to pay for use of the spectrum:

– mobile telephony;
– cellular telephony;
– radio paging;
– radio paging with VHF FM channel multiplexing;
– global mobile personal communications by satellite;
– distribution of television programmes using MMDS, LMDS and MVDS type systems.

For implementation of the fees for use of the spectrum, regulations were also adopted on "Payment for use of the radio-frequency spectrum in the Russian Federation". The regulations set out the basic principles and general conditions for payment for the use of radio channels by all organizations – irrespective of their type of ownership – and individual entrepreneurs that use the radio-frequency spectrum in the territory of the Russian Federation for the provision of commercial telecommunication services. Charges for use of the spectrum are set separately for each category of service, depending on the service area, number of channels used and the bandwidth used.

The amount of the charge levied for use of the spectrum is set annually. Annual charges for use of the spectrum are payable to Russia's national frequency management authority, in equal quarterly instalments, not later than the fifth day of the first month of each quarter.

The payment is distributed as follows:

– 50% to cover the expenses of the national spectrum management authorities;
– 50% as income to the federal budget.

Failure to respect the procedures for payment for use of the spectrum constitutes grounds for withdrawal of the licence for provision of the telecommunication services for which the spectrum is used.

5.2.8 The United Kingdom's experience with licence fees

Administered Incentive Pricing (AIP) was first introduced in the UK in 1998. AIP aims to set licence fees to reflect the opportunity cost of spectrum denied to other uses and users, rather than just the costs of managing the radio spectrum. As a new and fundamentally different approach to fee-setting, it has to date been applied in a conservative manner: implementation has been rolled out to different users of spectrum slowly, and fee levels have generally been set at most at around 50% of the estimated full opportunity cost. Significant fee increases have also been phased in over a number of years.

AIP is intended to provide long term signals of spectrum value to spectrum users. These long-term value signals are intended to help spectrum users (and their suppliers) make more efficient decisions concerning their use of spectrum and investment in radio technology. At the same time, given the significant investment that many users have tied up in radio equipment which in most cases cannot easily and quickly be returned to different frequencies and has a lifetime of many years it cannot be expected that AIP will lead to significant changes to spectrum use in the short term. AIP is not intended to achieve any specific short term spectrum reallocation goals.

UK had carried out an evaluation of the policy of charging spectrum fees based on AIP. The full policy document is available in:

http://www.ofcom.org.uk/research/radiocomms/reports/policy_report/evaluation_report_AIP.pdf

The overall conclusions of this report are:

– In the main, AIP has met its primary objective in helping to incentivize spectrum users to consider more carefully the value of the spectrum they use alongside that of other inputs, and to take decisions that are more likely to lead to optimal use of the available spectrum. Because each individual users decisions reflect their particular circumstances and objectives, improvements in spectrum allocation are difficult to attribute, with confidence, solely to the influence of AIP. However in the course of this evaluation a number of important actions by users were identified, in the period since AIP has been implemented, where it was believe that AIP may have contributed to incentivizing more efficient use.
– In particular:
  – the removal of legacy fixed links in the 4 GHz band, generally regarded as technically inefficient due to the age of the equipment deployed;
  – the removal of constraints on active services in spectrum bands, used by the Radio Astronomy Service, following the introduction of AIP fees for grants of Recognized Spectrum Access (RSA);
  – the return of some UHF2 spectrum used by the police in Scotland;
  – no evidence was found to suggest that the application of AIP has given rise to material adverse consequences for spectrum efficiency. In particular it has not resulted in demand for spectrum falling off significantly where AIP has been applied.

5.2.9 United States of America's experience with licence fees

The FCC regulates both spectrum and wired services for the civilian sector and charges application fees (also known as filing fees) and regulatory fees (information is included here for wired services only for background and completeness). The FCC process of imposing and collecting fees is mandated by statute of the U.S. Congress solely as a means to reimburse costs of issuing licences and of associated regulatory services.

In 1987, the FCC began collecting application fees that are charged for all FCC-licensed radio services and are intended to cover the direct administrative costs of processing a licence application. They are paid when a licence is obtained or renewed. Local and state governments and non-profit entities are generally exempt from application fees. Application fees vary from service to service.

The authority to impose and collect application fees was not assumed independently by the FCC, but was established by the U.S. Congress and is contained in Title III, Section 3001 of the Omnibus Budget Reconciliation Act of 1989 (Public Law 101-239), Section 8, revising 47 U.S.C. 158, which directs the FCC to prescribe charges for certain types of application processing or authorization services it provides to communications entities over which it has jurisdiction. Funds collected as application or filing fees pursuant to Section 8 of the Act are deposited into the General Fund of the U.S. Treasury as reimbursement to the United States of America Federal Government. They do not offset funds appropriated to the FCC (47 U.S.C. 158(a)). Section 8(b) of the Communications Act, as amended, requires that the FCC review and adjust its application fees every two years after 1 October 1991 (47 U.S.C. Section 158(b)). The adjusted or increased fees reflect the net change in the Consumer Price Index for all Urban Consumers (CPI-U).

Since 1990, the FCC has collected application fees averaging about USD 39 million annually. The programme encompasses over 300 different fees with the vast majority collected at the time an original licence application, renewal or request for licence modification is filed with the FCC.

Most fees are assessed as a one-time charge on a per-application basis, although there are certain exceptions. Local (state, county, city, etc.) government, non-profit, non-commercial broadcast and amateur licence applicants are exempt from the fees.

The schedule of charges is exactly as reviewed and approved by Congress. The charges represent the best estimate of the FCC's actual direct administrative costs of processing a licence application.

In 1993, Congress mandated that the FCC must collect regulatory fees to cover its enforcement activities, policy and rule-making activities, user information services, and international activities. Consequently, regulatory-related fees were implemented in 1994.

The requirement to collect annual regulatory fees is contained in Public Law 103-66 "The Omnibus Budget Reconciliation Act of 1993". These regulatory fees, which may change yearly, are used to offset costs associated with the FCC's enforcement, public service, international, policy and rulemaking activities. These fees are in addition to any application processing fees associated with obtaining a licence or other authorization from the FCC.

Without regulatory fees to offset the FCC's costs, the agency would have required a Congressional appropriation of USD 189 million for fiscal year 1997 (1 October 1996 to 30 September 1998). When offsetting regulatory fees (USD 152 million) were taken into consideration, only USD 37 million had to be appropriated from the U.S. Treasury to fund the FCC.

By statute, the total fees collected should cover, but cannot exceed, the amount of money appropriated by Congress to the FCC for these activities. Regulatory fees collected are deposited into an account providing appropriations to the FCC.

Some of the activities included in the regulatory fees are considered below.

5.2.9.1 Policy and rulemaking

Formal inquiries, rulemaking proceedings to establish or amend the FCC's rules and regulations, action on petitions for rulemaking, and requests for rule interpretations or waivers; economic studies and analyses; spectrum planning, modelling, propagation interference analyses, and allocation; and development of equipment standards. This also includes policy direction, programme development, legal services, and executive direction, as well as support services associated with policy and rulemaking activities.

5.2.9.2 Enforcement

Enforcement of the FCC's rules, regulations and authorizations, including investigations, inspections, compliance monitoring, and sanctions of all types. This also includes the receipt and disposition of formal and informal complaints regarding common carrier rates and services, the review and acceptance/rejection of carrier tariffs, and the review, prescription and audit of carrier accounting practices. It also includes policy direction, programme development, legal services, and executive direction, as well as support services associated with enforcement activities.

5.2.9.3 Public information services

The publication and dissemination of FCC decisions and actions, and related activities; public reference and library services; the duplication and dissemination of FCC records and databases; the receipt and disposition of public inquiries; consumer, small business, and public assistance; and public affairs and media relations. This activity also includes policy direction, programme development, legal services, and executive direction, as well as support services associated with public information activities.

The following licensees and other entities regulated by the FCC must pay regulatory fees:

Common carrier regulatees: inter-exchange carriers (long-distance companies), local exchange carriers (local telephone operating companies), competitive access providers (companies other than the traditional local telephone companies that provide interstate access services to long-distance carriers and other companies), operator service providers (carriers that enable customers to make away from home calls and to place calls with alternative billing arrangements), pay telephone operators (owners of pay telephones), resellers (companies that obtain lines from facilities-based carriers and sell service to others, but does not include mobile resellers governed by the commercial wireless radio services), and other interstate providers (e.g., calling card providers).

Commercial mobile radio services (CMRS) regulatees: specialized mobile radio services (Part 90); public coast stations (Part 80); public mobile radio, cellular, 800 MHz air-ground radiotelephone, and offshore radio services (Part 22); and PCS broadband services (Part 24). The CMRS messaging services category includes all one-way paging (Parts 22 and 90), two-way paging, qualifying interconnected business radio services, 220-222 MHz land mobile systems (Part 90), and PCS narrow-band services (Part 24). All other private wireless regulatory fees are paid in advance for the full licence term and submitted along with the appropriate application fee.

Mass media licensees: commercial AM and FM radio stations, commercial TV stations, low power television and television translator and booster licensees, broadcast auxiliary, FM translator and FM booster licensees, and multipoint distribution service licensees (includes multichannel multipoint distribution service). Non-commercial educational licensees are exempt from regulatory fees as are licensees of auxiliary broadcast services such as low power auxiliary stations, television auxiliary service stations, remote pickup stations and aural broadcast auxiliary stations where such licences are used in conjunction with commonly owned non-commercial educational stations. Emergency alert system (EAS) licences for auxiliary service facilities are also exempt as are instructional television fixed service (ITFS) licensees. In the event that there has been a change in ownership of a system after the effective date, but before the date payment is due, responsibility for payment of the regulatory fees rests with the owner of record on the effective date noted.

Cable television systems: cable television systems operating on 31 December 1996, were requested to pay regulatory fees per subscriber in the fiscal year 1997. All cable television systems were requested to pay regulatory fees of USD 0.54 per subscriber for each community unit in which they operate. Additionally, each system operating on 1 October 1996, was requested to pay a USD 65.00 fee for each community antenna relay service licence held and, if applicable, a USD 25.00 fee for each broadcast auxiliary service licence held. In the event that there had been a change in ownership of a system after the effective dates above, but before the date payment was due, responsibility for payment of the regulatory fees rested with the owner of record on the appropriate effective date noted above.

International public fixed licensees (Part 23), international (HF) broadcast licensees (Part 73), providers of international bearer circuits, earth station regulatees (Part 25), geosynchronous space station regulatees (Part 25) and direct broadcast satellite licensees (Part 100), and low-Earth orbit system licensees (Part 25).

Local governments and non-profit entities are not required to pay regulatory fees. However, the FCC is considering a proposal which would require that each exempt entity submit, or have on file with the FCC, a current internal revenue service determination letter documenting its non-profit status, a certification of local governmental authority, or certification from a local governmental authority attesting to its exempt status. Under the proposal, a regulatee would be relieved of its fee payment requirement if its total fee due, including all categories of fees, amounts to less than USD 10.

For the fiscal year 1997, the FCC adjusted the estimated regulatory payment units for each service from the fiscal year 1996 fees. The FCC obtained its estimated payment units through a variety of means, including its licensee databases, actual prior-year payment records, and industry and trade group projections. Whenever possible, the FCC verified these estimates from multiple sources to ensure their accuracy.

The FCC multiplied the revised payment units for each service by its fiscal year 1996 fee amounts in each fee category to estimate how much revenue the FCC would collect in the fiscal year 1997 without any change to the existing schedule of regulatory fees. The amount of revenue the FCC would have collected was approximately USD 137.3 million. This amount was approximately USD 15.2 million less than the amount the FCC was required to collect in the fiscal year 1997. The FCC therefore adjusted the revenue requirements for each fee category on a proportional basis, consistent with Section 9(b)(2) of the Act, to obtain an estimate of revenue requirements for each fee category necessary to collect the USD 152 million required by Congress for the fiscal year 1997.

On 1 October 1995, the FCC implemented, in accordance with 47 U.S.C. § 159(i), a cost accounting system designed, in part, to provide the FCC with useful data, in combination with other information, to help ensure that fees closely reflected the FCC's actual costs of regulation.

In order to utilize actual costs derived from the FCC's cost accounting system for fee development purposes, indirect support costs contained in the cost accounting system had to be added to direct costs (see Note 1) and the results adjusted further to approximate the amount of revenue that Congress required the FCC to collect in the fiscal year 1997 (USD 152 million) (see Note 2). Thus, the FCC proportionally adjusted the actual cost data related to regulatory fee activities recorded for the period 1 October 1995, through 30 September 1996, among the fee categories so that total costs approximated the USD 152 million.

The FCC's next step was to determine whether reliance on actual costs to develop fiscal year 1997 regulatory fees would result in fees which were too disparate from the corresponding fiscal year 1996 fees. As a result of this analysis, the FCC proposed establishing a ceiling of 25% on the increase in the revenue requirement of any service over and above the Congressionally mandated overall increase in the revenue requirement and after taking into consideration changes in payment unit counts (see Note 3).

Because Congress, for the fiscal year 1997, increased the FCC's overall fee collection requirement, the FCC was required to collect substantially more than it collected in the fiscal year 1996. Nevertheless, capping each service's revenue requirement at no more than a 25% increase enabled the FCC to begin the process of realigning fees to account for differences in regulatory costs. The 25% increase was over and above the revenue which was required after adjusting for the projected fiscal year 1997 payment units and the proportional share of the 21% increased in the amount that Congress requires the FCC to collect. Thus, the fiscal year 1997 fees increased by more than 25% over the fiscal year 1996 fees. Under this methodology, fees actually increased by as much as 40%.

An important consideration in establishing a revenue ceiling is the impact on other fee payers. Because the FCC was required to collect USD 152 million in the fiscal year 1997 regulatory fees, the additional revenue that would have been collected from classes of licensees subject to a revenue ceiling, instead needs to be collected from licensees not subject to the ceiling. This results in a certain amount of cross-subsidization between fee payer classes (see Note 4). The FCC asserted, however, that the public interest would best be served by adopting a revenue ceiling because, otherwise, several entities would be subjected to unexpected, substantial increases which could severely impact the economic well being of these licensees.

Regulation of interstate telephone service providers accounts for approximately 36% of all FCC costs. Therefore, any methodology which employs a subsidization feature, such as the FCC's proposed revenue ceiling, will impact these regulatees to a greater extent than others, at least in the short term. As other fee payers' fees approach amounts that bring their revenues closer to their actual costs, as the FCC's phased-in revenue ceiling technique would do, the amount of subsidization required of fee payers below their revenue ceilings (such as those common carriers providing interstate telephone service) will steadily decrease. Thus, in the long term, cross-subsidization will decrease and revenue requirements for all services will approach actual costs (assuming other factors, such as the total amount that Congress requires the FCC to collect, remain constant).

The FCC adopted the 25% revenue ceiling as proposed. Application of the 25% ceiling was accomplished by choosing a "target" fee revenue requirement for each individual fee category. This "target" was either the actual calculated revenue requirement (for those categories at or below the 25% ceiling) or, in cases where the calculated revenue exceeded the ceiling, an amount equal to the ceiling. The shortfall created by reducing the revenue requirement of those whose revenue requirement exceeded the revenue ceiling was proportionately spread among those fee categories whose revenue requirements were below the ceiling. This computation required more than one round of adjustment because the allocation of this revenue, in a few instances, caused the new revenue requirement amount to exceed the 25% ceiling. After two iterations (rounds), all the revenue requirements were at or below the revenue ceiling.

Once the FCC determined the amount of fee revenue needed to be collected from each class of licensee, the FCC divided the individual revenue requirements by the number of associated payment units (and by the licence term, if applicable, for "small" fees) to obtain actual fee amounts for each fee category. These calculated fee amounts were then rounded to an even amount.

NOTE 1 – One feature of the cost accounting system is that it separately identifies direct and indirect costs. Direct costs include salary and expenses for:

a) staff directly assigned to the FCC's operating Bureaus and performing regulatory activities;

b) staff assigned outside the operating Bureaus to the extent that their time is spent performing regulatory activities pertinent to an operating Bureau.

These costs include rent, utilities and contractual costs attributable to such personnel. Indirect costs include support personnel assigned to overhead functions such as field and laboratory staff and certain staff assigned to the Office of the Managing Director. The combining of direct and indirect costs is accomplished on a proportional basis among all fee categories.

NOTE 2 – Congres's estimate of costs to be recovered through regulatory fees is generally determined at least twelve months before the end of the fiscal year to which the fees actually apply. As such, year-end actual activity costs will not equal exactly the amount Congress designates for collection in a particular fiscal year.

NOTE 3 – For example, the regulatory cost associated with the Aviation (Aircraft) service is USD 934 905. If no change were made to this service's fiscal year 1996 regulatory fee (USD 3 per year), the total revenue collected from licensees in this service would have been only USD 70 634 in the fiscal year 1997, a shortfall of USD 864 271. Application of the proposed 25% revenue ceiling to this service resulted in a capped revenue ceiling of USD 88 293 (USD 70 634 × 125%).

NOTE 4 – Revenues from current fee payers already offset significant costs attributable to regulatees exempt from payment of a fee or otherwise not subject to a fee pursuant to Section 9(h) of the Act or the Commission's rules. For example, CB and ship radio station users, amateur radio licensees, governmental entities, licensees in the public safety radio services, and all non-profit groups are not required to pay a fee. The costs of regulating these entities are borne by those regulatees subject to a fee requirement.

5.2.10 Brazil's experience with spectrum fees

The Brazilian General Telecommunication Law, issued in 1997, established that the use of radio frequency for any service would always be charged. The value of the charge should alternatively be:

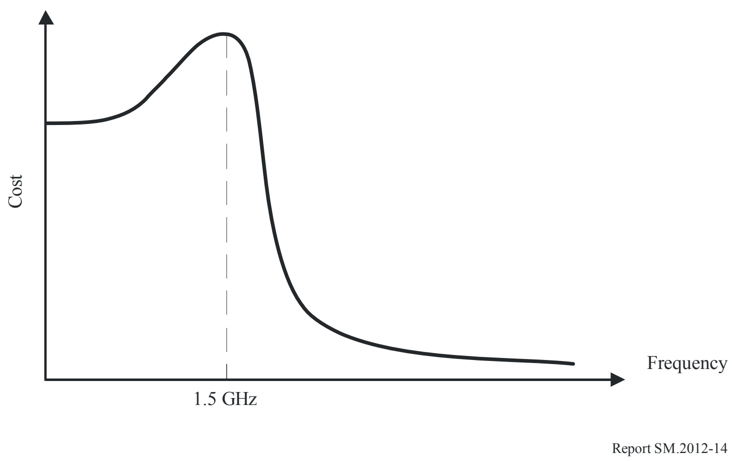
– determined by the regulations or the tender invitation document; or

– established as per the winning proposal, when it becomes a judgment item or established in the concession contract or license act, in the cases where bidding is not required.

In 2004, the National Telecommunication Agency reviewed the regulation on the collection of public fees for the right to use radio frequencies. The main premise of such rules was kept, i.e., the price should be based on how one precludes the use of a specific radio frequency to other users. So the following aspects were considered: time, space (geographic area), bandwidth and frequency band.

It was considered that the frequency bands around 1.5 GHz were, from the economic point of view, more important than any other, and so they should have a higher value. Consequently, two functions were defined to describe such idea, which is illustrated in the Fig. 14.

FIGURE 14



For a centre frequency *f* (kHz) less than, or equal to, 1.5 GHz:

$$F(f) = 0.05 + 0.011 \times 10^{-6\left(\log\left(\frac{f}{1\,500\,000}\right)\right)^2}$$

For a centre frequency *f* (kHz) greater than 1.5 GHz:

$$F(f) = 0.001 + 0.06 \times 10^{-6\left(\log\left(\frac{f}{1\,500\,000}\right)\right)^2}$$

It is important to note that the procedure described for the calculation of the public fee applies to the authorization of use of any frequency within the entire radio frequency band.

The reference value, *P*

A reference value for the right to use radio frequencies is obtained by applying the following formula:

$$P = K \cdot B \cdot A^{0.1} \cdot T \cdot F(f)$$

where:

B: bandwidth to be authorized (kHz)

A: geographic area in which the frequency shall be used (km^2)

T: factor related to the time period of use

$F(f)$: frequency factor, according to the expression given above

f: centre frequency of the operating frequency band (kHz)

K: cost factor of radio frequency.

The value of frequency, *f*, to be used in the formula shall be the average value of the minimum and maximum authorized frequencies, and, in the case that a specific channel is used, such value shall be equal to that of the carrier frequency of the mentioned channel.

The bandwidth, *B*

As regards exclusive use, the value of bandwidth *B* to be used in the formula is that of the total authorized band, whereas as regards non-exclusive use, the value to be considered is that of the authorized bandwidth, according to the emission designation.

The area, *A*

As regards exclusive use, the value of area *A* to be used in the formula is that of the region for which the service was authorized, or the designated area covered by the station. Whereas as regards non-exclusive use, the value of area *A* shall be that which is indicated in the license. If no such indication exists, the value of the area shall be that of the surface defined by the circular sector of radius *d* and antenna aperture α, that is:

$$A = \pi \cdot d^2 \cdot \frac{\alpha}{360°}$$

For point-to-point systems, *d* is the distance (km) between the stations involved and α is the half-power angle (degrees) of the radiating system. For point-area systems, the distance, *d*, to be considered is the farthest distance (km) covered by the nodal station.

Under any circumstances, the surface to be considered in the calculation of the area shall be limited to the national territory, including the Brazilian territorial waters.

The minimum value of the area shall be 1 km^2.

With respect to Earth-space feeder links for satellite communications systems, the value of area *A* to be considered shall be that of the coordination area, determined in accordance with the procedures described in RR Appendix 7.

The Time, *T*

The factor T takes into consideration both the number of hours of use per day T_1 and the term T_2, in years, of the authorization to use the radio frequency, and shall be calculated by the following formula:

$$T = \left(\frac{T_1}{24}\right) \cdot \left(\frac{T_2}{20}\right)$$

For periods of use per day of less than one hour, the value of T_1 to be considered shall be 1 h.

For authorizations granted for a term of less than one year, the value of T_2 to be considered shall be one year.

The cost factor, *K*

The cost factor K is defined by taking into consideration the mode of use of the spectrum, whether exclusive or non-exclusive, and the nature of the interest in the service, whether collective or restricted, as shown in Table 23:

TABLE 23

Mode of use	Nature of interest	Cost factor *K*
Non-exclusive	Collective	20
	Restricted	25
Exclusive	Collective	50

The value to be paid, *V*

For the use of radio frequencies, V, shall be obtained by applying the following formula:

$$V = P \cdot C \cdot D \cdot E$$

where:

P: reference value for the rights to use radio frequencies

C: 0.6 for stations of mass media services and stations of radio broadcasting services, and 1.0 for stations of other services

D: 0.3 for stations intended for services of a scientific nature, and 1.0 for stations intended for other services

E: 1 for point-to-point systems and, in accordance with Table 24, for point-area systems.

TABLE 24

Population (inhabitants)	Value of *E*
Up to 50 000	0.10
From 50 001 to 100 000	0.15
From 100 001 to 150 000	0.20
From 150 001 to 200 000	0.35
From 200 001 to 250 000	0.40
From 250 001 to 300 000	0.50
From 300 001 to 350 000	0.60
From 350 001 to 400 000	0.75
From 400 001 to 450 000	0.90
Above 450 000	1.00

The value to be paid for the use of radio frequencies, *V*, shall not be less than ($T_2 \times$ R$ 20.00).

For the following cases a fixed value of *V* is applicable: amateur radio and citizen band services; coastal stations, stations aboard ships, and port stations; stations aboard aircraft, and aeronautical stations; and stations of the community broadcasting services.

For purposes of the regulation, the following systems shall be subject to the payment of the appropriate utilization charges:

– point-to-point – upon assignment of each transmit frequency;

– point-area – upon assignment of each radio frequency, whether receive or transmit, to nodal stations, base stations, or space stations. For direct communication between terminal stations, the payment is due upon assignment of each radiofrequency to be used collectively by the terminal stations set. For unidirectional point-area systems, the payment is due upon assignment of each radio frequency to the transmitter station.

Whenever applicable, upon issuance or renewal of an authorization for the utilization of a radio frequency, such authorization will be charged.

The following are exempt from spectrum fees: frequency usage by certified short range devices; frequency usage by Armed Forces in frequencies allocated to exclusively military usage; temporary spectrum use by Diplomatic Missions, Representations of International Organizations and Consular Offices, including military vessels and aircraft in foreign official visits in Brazil.

5.2.11 Experience with spectrum fees – Republic of Korea

Radio spectrum is public assets rather than private properties and spectrum users gain economic benefits by using radio spectrum. It means that users taking advantage of public assets through radio station operation. Therefore, spectrum users have to pay adequate amount of spectrum fees equivalent to economic value of radio spectrum.

Spectrum fees provide the Government with practical information such as spectrum preference in the market, radio service's qualities and can measure proper volume of spectrum demand. The demand for spectrum has been rapidly increasing with growth in telecommunications services and radio technology. More importantly, spectrum fees can not only suppress over-utilization of radio spectrum but also induce radio spectrum users to withdraw unused radio spectrum to the Government.

The Administration of the Republic of Korea implemented spectrum fees in 1993 in accordance with Radio Wave Act in order to create revenue for effective spectrum management and radio technology development programs. The assessment and collection of spectrum fees is prescribed in the Presidential Decree of the Radio Wave Act.

No fees are imposed on radio stations that are:

– used for government affair;
– for non-profit broadcasting or paying broadcasting promotion fund;
– used by subscribers of common carrier service;
– used for emergency, experimental, amateur communications;
– used for standard radio frequency/time signalling;
– used by the Korean Red Cross Association;
– installed in tunnels and other underground areas for relaying subscriber-based communications and broadcasting services;
– used for the purpose of disaster alarming and relief (such as flood warnings);
– installed by common carriers but used for official use;
– covered by the criteria in Table 25.

TABLE 25

Type of station	Frequency band (MHz)	Bandwidth (kHz)	Maximum power supplied to antenna (W)
Ship	2 20	2.8 2.8	50 25
Aircraft	100	6	10
General purpose	146	8.5	5

Additionally, no fees are imposed in cases the calculated fee would be less than 3 000 KRW (Korean Currency Unit).

The spectrum fees are calculated using the parameters such as frequency band, bandwidth, power and number of subscribers. The Spectrum fee categories can be classified in four categories.

Category 1: Subscriber-based facilities (except for fixed wireless access (FWA) and microwave links) are based on the number of subscribers.

Category 2: Subscriber-based FWA and microwave link facilities and non-subscriber-based facilities of common carriers.

Category 3: Private fixed and land mobile radio facilities.

Category 4: Other mobile radio facilities.

NOTE 1 – All fees are imposed quarterly.

Assessment criteria of spectrum use fees

Category 1 fee: Subscriber based facilities (except for FWA and microwave links):

Spectrum fees (SF) are imposed on the operator based on the following equation:

$$(SP) = N_s \times U_p \times \{1 - (F_s + R_f + E_f) \times C\} \quad (61)$$

where:

- N_s: number of subscribers
- U_p: unit price
- F_s: facilities sharing factor
- R_f: roaming factor
- E_f: use efficiency factor.
- C: frequency weighting factor.

Described as follows:

a) Number of subscribers

The average number of subscribers is calculated using the following equation:

{(the number of subscribers on the first day of a quarter (season)) +
(the number of the subscribers on the last day of the quarter)}/2

b) Unit price

Services	Unit price (KRW/subscriber/quarter)
Mobile phone service (Cellular, PCS, IMT)	2 000
WiBro (Broadband wireless internet)	1 200
Radio pager/Trunked radio service	150
Location based service	50
Wireless data service	30

c) Common facilities and roaming factors

Facility sharing and roaming ratio (%)	< 10	10 ~ 20	20 ~ 30	30 ~ 40	40 ~ 50	> 50
Facilities sharing factor	0.01	0.02	0.04	0.06	0.08	0.10
Roaming factor	0.05	0.10	0.15	0.20	0.25	0.30

Facility sharing ratio: Ratio of the number of stations served by an operator that share radio facilities to the total number of stations served by that operator.

Roaming ratio: Ratio of the number of stations served by an operator that use roaming technology to the total number of stations served by that operator.

Facilities sharing ratio: Ratio of the number of stations served by an operator that share radio facilities to the total number of stations served by other operator.

d) Use efficiency factor

Frequency use efficiency (%)	< 100	100 ~ 150	150 ~ 200	200 ~ 250	> 250
Frequency use efficiency factor	0.01	0.02	0.03	0.04	0.05

Frequency use efficiency: Ratio of the average number of subscribers per frequency assignment to the basic capacity of the number of subscribers (which is 500 000 subscribers per frequency assignment for mobile phone and PCS service, 1 500 000 for IMT and 700 000 for WiBro service).

NOTE 1 – The frequency use efficiency factor does not apply to the radio pager, trunked radio system (TRS), location based system (LBS) and wireless data services.

e) Radio characteristic factor

Frequency band	Radio characteristic factor
< 1 GHz	1.16
1 GHz ~ 3 GHz	0.81

NOTE 1 – For radio pager, TRS, LBS and wireless data services, this factor does not apply.

NOTE 2 – For the station operating in the frequency licensed by payment basis, this factor does not apply.

Category 2 Fee*:* Spectrum fee for subscriber-based fixed wireless access (FWA), microwave link facilities and non-subscriber-based facilities of common carriers and satellite broadcasting relaying stations.

The spectrum fee (SF) is imposed on the facility according to the equation:

$$(SF)_{station} = C_B \times U_f \times S_f \times (1 - F_S) \quad (62)$$

where:

C_B: basic price

U_f: designated spectrum amount

S_f: service factor

F_S: facility sharing factor.

Described as follows:

Basic price, C_B: 250 000 KRW/station

The amount of designated bandwidth, U_f: the value in the cell at the intersection of the column “amount of designated bandwidth”, and the row, frequency bands, in Table 26.

TABLE 26

Frequency bands \ Amount of designated bandwidth (MHz)	< 0.1	0.1 ~ 0.3	0.3 ~ 1.5	1.5 ~ 4	4 ~ 7	7 ~ 10	10 ~ 15	15 ~ 20	20 ~ 30	30 ~ 40	40 ~ 60	60 ~ 80	80 ~ 110	110 ~ 150	> 150
< 1 GHz	1	2	3	5	7	9	12	15	19	23	28	33	28	44	50
1 ~ 3 GHz	7	1.4	2.1	3.5	4.9	6.3	8.4	10.5	13.3	16.1	19.6	23.1	26.6	30.8	35
3 ~ 15.4 GHz	0.3	0.6	0.9	1.5	2.1	2.7	3.6	4.5	5.7	6.9	8.4	9.9	11.4	13.2	15
> 15.4 GHz	0.2	0.4	0.6	1	1.4	1.8	2.4	3	3.8	4.6	5.6	6.6	7.6	8.8	10

NOTE 1 – If analogue technology is used, the fee is tripled in the land mobile service.

Service factor, S_f

Radio stations	Factors
Fixed stations: – for microwave link – for local loop – for communications with islands – for other applications	 0.5 0.25 0.05 1
Other stations	1

Facility sharing factors, Fs: Ratio of the number of stations served by an operator that share radio facilities(antenna tower, transmitter and/or receiver) to the total number of stations served by other operator.

Facilities sharing ratio and roaming ratio (%)	**< 10**	**10 ~ 20**	**20 ~ 30**	**30 ~ 40**	**40 ~ 50**	**> 50**
Facilities sharing factor	0.01	0.02	0.04	0.06	0.08	0.10

Category 3 Fee: Private fixed and land mobile radio facilities:

The spectrum fee (SF) is imposed on each transmitter, according to the equation:

$$(SF)_{station} = C_B \times \left(\sqrt{P + B_W}\right) \times P_f \times T_f \times O_f \times (1 - F_s) \qquad (63)$$

where:

- C_B: basic price
- P: antenna power
- B_W: bandwidth
- P_f: preference factor
- T_f: frequency sharing factor
- O_f: operating purpose factor
- F_s : facility sharing factor.

Described as follows:

Basic price, C_B: 2 000 KRW/designated frequency

Antenna power, P (W)

Bandwidth, B_W (kHz). The value of 1 kHz is used for a bandwidth of less than 1 kHz at a frequency of less than 960 MHz, and the value of 1 MHz is used for a bandwidth of less than 1 MHz at a frequency above 960 MHz.

Preference factor P_f :

Frequency bands		Factor
MF/HF	< 28 MHz	1
VHF	28 ~ 300 MHz	1.3
UHF	300 ~ 960 MHz	1.5
Sub microwave	960 ~ 3 GHz	0.1
Microwave	3 ~ 15.4 GHz	0.03
	15.4 ~ 30 GHz	0.02
Millimeter wave	> 30 GHz	0.01

Frequency sharing factor F_S :

Frequency type	Factor
Exclusive use	1
Common use	0.1

NOTE 1 – *Exclusive use* occurs when an operator uses a frequency exclusively over a country or region and *common use* occurs when an operator uses a frequency non-exclusively over a country or region.

Operating purpose factor $\boldsymbol{O_f}$:

Operating purpose	Factor
Radionavigation services (radar, transponder, distance estimator, radio altimeter)	0.5
Radiotelemetry (including detection and beacon) services	0.1
Other services	1

Facility sharing factors, Fs: Ratio of the number of stations served by an operator that share radio facilities(antenna tower, transmitter and/or receiver) to the total number of stations served by other operator.

Facilities sharing ratio and roaming ratio (%)	< 10	10 ~ 20	20 ~ 30	30 ~ 40	40 ~ 50	> 50
Facilities sharing factor	0.01	0.02	0.04	0.06	0.08	0.10

Category 4 Fee: Spectrum fees for other mobile radio facilities:

The spectrum fee (SF) shall be imposed on each mobile station as follows:

Type of mobile stations	SUF (KRW)
Earth stations installed on vehicles (such as ships or automobiles)	20 000
Telecommunication operator's earth stations for lease	20 000
Other stations	3 000

5.3 Experience with using alternative resources

Many administrations have used alternative resources to support national spectrum management for a number of years. The following information reviews some of this experience.

5.3.1 Canada

5.3.1.1 Consultation process

In accordance with the Statutory Instruments Act and the Statutory Instruments Regulations, federal departments and agencies are required to demonstrate that Canadians have been consulted and that they have had an opportunity to participate in developing or modifying regulations and regulatory programmes. In Canada the *Canada Gazette* contains formal public notices, official appointments, proposed regulations, regulations and public Acts of Parliament from government departments and agencies. All consultations and notices are posted on the Industry Canada's Web site, providing an opportunity for the public to provide comments and reply comments.

The Government of Canada also consults with industry members via the Radio Advisory Board of Canada (RABC). The RABC is the main body in the private sector that provides advice of a technical nature regarding the management and use of the radio frequency spectrum to the Government of Canada. The RABC represents most sectors of the radiocommunication business in Canada, including manufacturers, wireless carriers and service providers, network operators, broadcasters, public safety and national security radio network operators and users. The RABC is organized in a number of committees, such as the mobile and personal communications, fixed wireless communications, broadcasting and electromagnetic compatibility. The Canadian Administration participates in these meetings as observer. The RABC advises the Administration on matters related to policy, standards, technical and procedures development. Engineering analyses on channelling plans, interference calculations, sharing scenarios are often conducted in the RABC and have provided significant inputs to the Canadian spectrum management process.

5.3.1.2 Frequency coordination process

The Canadian national spectrum management organization makes use of frequency coordinators in a number of cases.

In the case of fixed service and the fixed-satellite service frequency applications, while the Department of Industry is responsible for processing licence applications, including the examination of interference potential, international coordination, etc., domestic coordination is the responsibility of the applicant. The fixed service users maintain their own databases from which they coordinate with each other. The majority of the coordination is done within the Frequency Coordination System Association which is a non-profit Canadian corporation, with major telephone companies as its members. It operates and administers a computerized Microwave Information and Coordination System.

5.3.1.3 Information dissemination

In order to facilitate the dissemination of information the assigned frequency records are made available to the general public through Internet access or on a CD-ROM format.

5.3.2 Germany

In Germany, user associations perform some limited spectrum management functions for private mobile radio (PMR) systems. These associations have been successfully involved in the frequency assignment procedure for more than 25 years and are today invited to support their member within the assignment procedure.

The experts of these associations advise their members in all aspects of PMR use. They explain national regulations and support user planning of PMR networks. The association could recommend to the regulatory authority characteristics of a PMR network such as frequency, coverage area, antenna height, call sign, etc. Normally, all relevant technical standards, rules for frequency planning and other licensing conditions are taken into account in the recommendation of the user association. The regulatory authority is able to follow these recommendations in almost all cases and assigns the frequency accordingly. International coordination is, however, always carried out by the regulatory authority.

The users associations are financed by contributions from their members and work for the benefit of the PMR users. They contribute to the medium and long-range planning process for the frequency spectrum representing the spectrum requirements of their members to the regulatory authority. They provide a valuable link between the regulatory authority and the users.

5.3.3 Israel

Israel takes advantage of private sector resources to perform some spectrum management functions.

In the past there were some operators who assisted the administration by assigning their own frequencies in a specified band. Today this is done only with trunking operators, cellular operators and in some cases for point-to-point microwave links.

The Administration still receives support from operators and the industry in participating in ITU work, like World Radiocommunication Conferences and the Radiocommunication study groups (examples: TADIRAN in Radiocommunication Study Group 1, Motorola Israel in Radiocommunication Study Group 8).

5.3.4 Russian Federation

In the Russian Federation great support to governmental spectrum management activities is provided through various scientific, development and design organizations, which play the role of frequency coordinators and spectrum management consultants. While administratively these organizations may belong to different ministries and other governmental bodies, they are actually providing independent expertise in many fields of radiocommunications, and particularly of spectrum management, to the Russian Federation telecommunication Administration, as well as to private radio operators and various commercial organizations supporting their activities. Due to close collaboration with the Russian Federation telecommunication Administration on the one hand and with radio operators on the other hand, and through active participation in relevant regional and international activities, they are very familiar with what is needed for the development and improvement in different radio services and in spectrum management issues at the national, regional and international levels.

Such spectrum management organizations include research institutes, particularly the Radio Research and Development Institute (NIIR) together with its branches, type-approval testing laboratories, private operator associations and consulting firms operating on a commercial basis.

The main assistance to the telecommunication Administration provided by these organizations are:

– conducting, at the request of the Administration, systematic interference analysis for fixed (microwave) and fixed-satellite service frequency applications including issues of domestic and international coordination;
– conducting frequency-site planning of radio transmitters for sound and TV broadcasting services;
– conducting experimental investigations of the potential for allocating additional TV and sound broadcasting channels for areas with specific terrain problems. Based on conclusions provided, the administration issues relevant frequency permissions and licences for operational activities;
– developing various draft standards, specifications, recommendations, etc. concerning radiocommunications networks and equipment development, EMC analysis and frequency planning, frequency sharing criteria and conditions to be approved by the Administration; recently these activities more and more concern relevant regulatory and legislative matters as well.

As far as it concerns assistance to radio operators, the main issues are the following:

– explanation of national, regional and international regulations in their implementation with respect to various radio services;
– assistance in user planning of relevant radio networks particularly cellular, trunking etc., using all relevant technical standards, rules for frequency planning and other licensing conditions;
– preliminary analysis of interference-free broadcasting channels for commercial sound and TV broadcasters, calculation of service areas, etc.;
– assistance in preparation of relevant licence application and bid documentation;
– assistance to various state and commercial enterprises in the field of industrial interference limitation.

5.3.5 United States of America

The United States of America makes wide use of frequency coordinators, interested communications groups, and private sector spectrum management consultants.

5.3.5.1 Use of interested communications groups

The United States of America spectrum management organizations also make significant use of advisory committees. The FCC for instance develops its radio conference proposals through an open advisory committee process. Furthermore, the National Telecommunications and Information Administration (NTIA), as the manager of United States of America government agency use of radio systems, relies heavily on the Inter-department Radio Advisory Committee (IRAC), its subcommittees (planning, technical, and radio conference), and ad hoc committees for advice on regulation and policy development. This committee is the longest standing advisory committee in the United States of America government. Though this is not a private sector body, it represents an excellent example of using advisory bodies or collections of experts. NTIA also seeks the advice, with regard to spectrum management policy, from a joint government/private sector group, the Frequency Management Advisory Committee (FMAC).

The FCC has also successfully employed a technique known as negotiated rulemakings whereby it has placed system developers and spectrum advocates in a position of jointly developing the very regulations and standards which will be used to regulate their activities.

5.3.5.2 United States of America use of frequency coordinators

Under FCC rules, prior to applying for a station licence for certain services, an applicant must provide technical coordination information or evidence of prior coordination of the station with existing stations. Private groups often perform this prior coordination function.

In the private land mobile radio services (PLMRS), the FCC has certified groups for specific sub-allocations (e.g., public safety, industrial, and land transportation services) to coordinate frequency assignments prior to their application for the actual licence. Under this system, applicants proposing new stations or modifying existing licences send their completed applications to the appropriate certified coordinator. The coordinator checks the application for completeness, accuracy, and compliance with the FCC's rules, recommends the most suitable frequency for the applicant, and forwards the completed application to the FCC, which issues the licence directly to the applicant upon approval. The FCC oversees the performance of these coordinating committees. Performance consistently below FCC standards could lead to an inquiry and eventual decertification of the coordinator. In cases of disagreement between the applicant and the coordinator, the FCC has final authority to resolve the problem.

Prior coordination takes place in other services, such as the FCC's point-to-point microwave radio service and the private operational fixed microwave service. Prior to obtaining a licence, applicants for these services are required to engineer their proposed systems to avoid interference and to coordinate with existing applicants and licensees who could potentially experience interference from these proposed systems. Coordination in these bands is typically done by the applicant or their private frequency coordination consultant and depends largely upon industry cooperation. There are no certified coordinators for these bands. The applicant must certify that the coordination process has been completed before the application is accepted for filing. Private frequency coordinators charge a fee for their services.

Through this requirement for prior coordination, the FCC attempts to ensure that interference conflicts are resolved through private negotiations before applications are filed. Successful coordination through this method lessens the need for federal government administrative processes to resolve conflicting private claims to the spectrum. Since the FCC established requirements for frequency coordination within the microwave bands in 1975 and implemented the certified frequency coordinator program for the PLMRS bands in 1986, the speed of service has improved and the FCC's licensing burden has been reduced. Further, the first recourse of action for licensees involved in interference problems is to seek the assistance of the coordinator. In most cases, the coordinator can find a solution to the problem without the FCC ever being involved.

5.3.5.3 United States of America use of spectrum management consultants

While NTIA and the FCC currently make limited use of spectrum management consultants, federal agencies with significant communications interests but limited staff resources make extensive use of technical consultants and functional support contractors. These groups play an active role in the wide array of advisory and ad hoc committees performing engineering analysis and preparing committee documents. In many cases, they represent government agency interests in delegations to international bodies.

5.3.6 China's experience with alternative resources

In China, the Advisory Committee of Experts on Radio frequency Planning provides advices to the China's Radio Administration on a wide variety of issues related to policies, standards and technical development of spectrum management. The advisory committee, which was established in 2000, basically comprises famous and experienced experts in mobile communication and satellite communication fields.

The main assistance provided by Advisory Committee of Experts on Radio frequency Planning is:

– Follow-up researches on revision of Radio Regulation of ITU, the study results of frequency sharing, the trends and the developments of radio spectrum planning in other countries, putting forward the advices on China's radio spectrum allocation, allotment and assignment.
– Follow-up studies on the international trends and developments of new radio applications and technologies, bringing forward the strategic spectrum planning of new radio applications and technologies in China.
– Providing advices to the exploitation and utilization of spectrum and satellite orbits.
– Deliberating on the draft of national Regulations on Radio Frequency Allocation.
– Deliberating on the scientific research projects related to radio frequency planning, the methods and criteria of radio frequency sharing.

In China, different experts are invited to join the advisory committee every five years, upon issuance of the formal letter of appointment. Every five years, there may be some adjustments to the members list. Usually, the Advisory Committee of Experts on Radio frequency Planning, under which a secretary office is established to be responsible for the daily affairs, consists of experts from Chinese research institutes, universities, enterprises, and science and technology commission belonging to different ministries and other government bodies and so on. The members of the committee, working by letter or email during daily time, actually provide broadly based, independent, objective, unbiased and technical expertise in different fields. If necessary, a conference will be convened for some special topics for discussion.

From 2000 until now, the Advisory Committee of Experts on Radio frequency Planning has discussed many topics related to national frequency planning, and provided some important and significant advices to the national spectrum management, which plays an important role in deeply studying national frequency and satellite orbit planning and management, promoting the application of new radio technologies, and following up the international trends and developments on radio spectrum management. Especially in the revision of national Regulations on Radio Frequency Allocation, issuance of frequency planning for 3G mobile communication systems, the study of the items of WRC and so on, the advices from Advisory Committee of Experts on Radio frequency Planning are the important factors that the administration would consider when making policies.

5.4 Other experiences

5.4.1 Amateur services

Generally, amateur stations are not assigned specific frequencies by government spectrum managers but are free to select operating frequencies according to current band occupancy and propagation conditions. National, regional and local band plans are established by informal agreement to arrange compatible intra-service uses, principally by class of emission, such as telegraphy, data and voice.

The major exceptions to stations selecting frequencies in real-time are VHF/UHF voice repeaters, packet radio-relay stations and propagation research beacons, which use specific frequencies on a long-term basis. Some administrations have regulations that encourage the establishment of private sector frequency coordinators, particularly to maintain user databases and, by recommendation rather than assignment, coordinate the selection of voice repeater frequencies to minimize interference within their geographic areas.

Amateur-satellite frequencies are international in nature and are coordinated through amateur-satellite organizations known as Radio Amateur Satellite Corporation (USA) (AMSAT).

The three International Amateur Radio Union (IARU) regional organizations also establish informal band plans. The IARU and AMSAT organizations cooperate in matters concerning frequency usage.

5.4.2 Area and high density systems

Most administrations have experience with authorizing area systems to a range of frequencies. This has been done primarily for cellular, PCS and other area and high density systems.

5.4.3 Space services, orbital use and spectrum fees

Continued access to satellite spectrum requires a balance approach in the administrations' revenue generating policies that does not affect the long-term viability of satellite services and the industry as a whole. The impact of fees, auctions and other revenue generating approaches, taken as a whole from all countries in which satellite resources are provided, can make deployment of this critical infrastructure economically unfeasible. As an example, a lack of harmonized national approaches on the fee structures of planned integrated MSS and complementary ground component systems that may contribute to more efficient use of spectrum could impede development of such integrated systems. Economic options may help in improving the efficient use of the orbit and spectrum resources. It could limit coordination filings to "serious" and more carefully tailored ones, it may increase resources to BR. On the other hand, it might be seen as an extension of ITU regulatory competence and consequential reduction in national sovereignty, not mentioning the difficulty of agreeing to fee levels and the disadvantage to entities in developing countries. Fees may not be a deterrent to major players and could decrease competition.

This topic is not within the competence of ITU, because fee structures are within the sovereignty of national administrations. Nevertheless, this topic could serve as a means of thought leadership and focusing attention on a substantial issue that is affecting the satellite community and may be one of the potential instruments guaranteeing efficient use of satellite spectrum.

A coordinated approach with respect to models for satellite fees could lead to a more efficient use of satellite spectrum globally and facilitate cost estimations by satellite operators. In this respect, ITU may provide an excellent platform for discussions on models for satellite spectrum fees, it may study and suggest calculation methods and criteria and undertake benchmarking i.e. compare spectrum models applied by administrations for comparable satellite services.

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GLOSSARY

Terms defined in this glossary are printed in *italics*.

For convenience and in the interests of clarity, the following definitions have been used and are specific to this document. The definitions of the terms "allotment" and "assignment" differ slightly from those given in Nos 1.17 and 1.18, respectively, of the Radio Regulations.

1. A*ssignment*: any authorization to use a frequency at a given site and under identified conditions. Such a frequency is referred to as an *assigned frequency*.
2. *Allocation surface* of an assignment: that part of the territory within which the assigned frequency may be used.
3. *Allotment*: any authorization to use a block of frequencies within a given geographic area. Such frequencies are known as *allotted frequencies*.

Administrative pricing: A form of *spectrum pricing* in which *equipment licence* fees or charges for *spectrum rights* are set by the spectrum manager. Administrative pricing may include such variants as:

– *shadow pricing* (see below);

– *incentive pricing*, where fees are set with the intention of promoting efficient spectrum use;

– *regulatory pricing*, where fees are set unrelated to market considerations, for example, to recover spectrum management costs.

Apparatus licence: A permission to install and use radio equipment. This will specify the frequency or frequency band to be used and may also impose terms and conditions restricting matters such as the type of apparatus to be used, power, coverage area, geographical location or service to be provided. The extent and specificity of the restrictions will depend on circumstances and the characteristics of the service in question.

Auction: A form of *spectrum pricing* – as well as a spectrum assignment mechanism – in which *apparatus licences* or *spectrum rights* are assigned to the winner(s) of a competitive process selected on the basis of price. (In some countries, other factors, such as quality of service, speed of roll-out and financial viability, may also be taken into account, either in the assessment of the bids or as pre-qualification criteria.) *Auctions* may take various forms, including:

– the *English auction*, where the auctioneer increases the price until a single bidder is left;

– the *first-price sealed bid auction*, where bidders submit sealed bids and the highest wins;

– the *second-price sealed bid auction*, where bidders submit sealed bids and the highest bidder wins but pays the second highest amount bid;

– the *Dutch auction*, where the auctioneer announces a high price and reduces it until a bidder shouts "mine";

– the *simultaneous multiple round auction,* as first practiced by the Federal Communications Commission (FCC) in the United States of America. This involves multiple rounds of bidding for a number of lots that are offered simultaneously. The highest bid on each lot is revealed to all bidders before the next round when bids are again accepted on all lots. The identity of the high bidder may or may not be revealed after each round, but is revealed at the auction's close. The process continues until a round occurs in which no new bids are submitted on any lots. This variant is more complex than single-round auctions but offers bidders greater flexibility to combine lots in different ways, and, because it is more open than a sealed bid process, limits the impact of the *winner's curse*, allowing bidders to bid with more confidence.

Auctions are commonly considered to have advantages of economic efficiency, transparency and speed compared to alternative assignment methods and also capture the market value of spectrum rights for the administration holding the auction. They can give rise to anti-competitive outcomes if they result in large operators acquiring an undue concentration of the available spectrum but various safeguards against this can be introduced, for example restrictions on the amount of spectrum an individual bidder may win or "use it or lose it" provisions to prevent hoarding.

Bidding credit: A discount given to certain bidders to promote socially desirable goods. Bidding credits were given to smaller, entrepreneurial firms in some FCC auctions. For example, a 25% bidding credit would mean that if an entrepreneurial firm submitted a winning bid of USD 1 000 000, it would pay only USD 750 000. Originally, bidding credits were also proposed for women and racial minorities; however, the FCC dropped this proposal after the United States of America Supreme Court's *Adarand* decision, which declared that such preferences were discriminatory, and therefore illegal.

Differential rent: Rent attributable to varying characteristics of a resource, e.g., more desirable propagation characteristics in one frequency band than another frequency band.

First-come, first-served: An assignment procedure in which spectrum is assigned to applicants until it is exhausted, subject only to compliance with minimum technical or financial criteria. This procedure has tended to be used for small scale assignments, such as individual private business radio and fixed links licences. It works best where spectrum is not scarce.

Gross domestic product (GDP): The sum of the value of all final goods and services sold within the geographic borders of a country in a year.

Lottery: A process for assigning *apparatus licences* or *spectrum rights* to applicants selected at random. *Lotteries* have the advantage of speed and simplicity but they are unlikely to lead to an economically optimum outcome and can give rise to speculative applications because of the prospect of windfall gains.

Mutual exclusivity: A situation in which two or more applicants are competing for the same spectrum assignment.

Oligopoly: A situation in which only a small number of firms are supplying a product or service. This situation may be contrasted with a monopoly situation, in which there is only one firm supplying a product or service.

Opportunity cost: The benefits foregone by not putting a resource to its best alternative use. For example, the best alternative use of a frequency band currently used for a broadcast service might be for a mobile service. In an auction, the bidder with the highest willingness to pay will generally win, with a bid that is just above the valuation of the bidder with the second highest willingness to pay. This second highest valuation represents the opportunity cost.

Resource rents: The term economists use to categorize the value of a resource. The rent accruing to a resource right, such as a spectrum right, can be quantified by the price that the right would sell for in an open market.

Scarcity rent: Rent attributable to a resource demand exceeding supply at zero price.

Secondary trading: Buying and selling of *apparatus licences* or *spectrum rights* after initial assignment by the spectrum manager. Dealing may take place directly between the parties or through an intermediary.

Shadow pricing: A form of administrative pricing in which the price is set according to a predetermined formula intended to mimic the effect of market forces. Parameters commonly used include bandwidth, frequency location, geographical location and coverage area.

Spectrum pricing: A generic term currently used to denote the denoting of the use of pricing as a spectrum management tool. It covers both *administrative incentive pricing* and *auctions* of either *apparatus licences* or *spectrum rights*. Under *spectrum pricing*, charges are not set by reference to the fully allocated costs of spectrum management attributable to particular user categories but are intended to balance supply of and demand for spectrum or to achieve other spectrum management policy objectives, such as facilitating the introduction of new services or promoting competition.

Spectrum rights: The right, analogous to a property right, to use a specified frequency or range of frequencies in a particular location or throughout a nation or region for a particular time period within the ITU Radio Regulations. Where such rights have been introduced, restrictions on the type of equipment to be used or service to be provided may be minimal apart from technical non-interference conditions in relation to adjacent *spectrum rights*. It may be possible to assemble *spectrum rights* to provide increased bandwidth or coverage area or both.

Threshold qualifications: Qualifications that are a prerequisite to participate in some process, such as a lottery or auction. Threshold qualifications may include financial and technical viability, and a service plan that satisfies certain social goals.

Unjust enrichment: An award, such as the award of a valuable frequency assignment, to a person or company that exceeds that person’s or company’s entitlement to the award.

Winner’s curse: A possible effect of an auction, most commonly a sealed-bid auction. Assuming that some bidders will overestimate the value of the lot, the winner may be the most optimistic rather than the most skilful in assessing the value of the lot. In a sealed-bid auction, auction proceeds may be reduced as bidders attempt to minimize this effect. *Winner’s curse* can be reduced or eliminated by careful design, particularly by using multiple round auctions (see *simultaneous multi-round auction*).

Annex 1

A.1.1 Spectrum Fees Regulations of the United Arab Emirates

ARTICLE (1)

Purpose

1.1 In accordance with the Federal Law by Decree No. 3 of 2003 as amended and its Executive Order, these Regulations sets the spectrum Fees schedule for Frequency Spectrum and Wireless Equipment Authorization. The spectrum Fees shall be collected in advance for applying, registering, authorizing, issuing or renewing Authorization, unless exempted in these Regulations.

ARTICLE (2)

Definitions

2.1 In applying these Regulations, the following terms shall have the following meanings unless the context requires otherwise, whereas any term undefined in the following shall be defined in line with the Federal Law by Decree No. 3 of 2003 as amended and its Executive Order:

2.1.1 **"Applicant"** means any Person who has applied for a License or an Authorization in accordance with the Telecom Law or other Regulatory Instruments issued by the TRA.

2.1.2 **"Application"** means the request for issuance of a License or an Authorization, received at the TRA on prescribed forms as per the procedure in vogue.

2.1.3 **"Assigned Frequency"** means the centre of the frequency band assigned to a station by the TRA.

2.1.4 **"TRA"** means the General Authority for Regulating the Telecommunications Sector known as Telecommunications Regulatory Authority (TRA) established pursuant to the provisions of Article 6 of the UAE Federal Law by Decree No. 3 of 2003.

2.1.5 **"Authorization"** means a valid Frequency Spectrum Authorization granted by the TRA.

2.1.6 **"Authorized User"** means a Person that has been granted an Authorization by the TRA.

2.1.7 **"Class Authorization"** means the Authorization which permits the operation of Wireless Equipment by any Person within designated frequency bands subject to the terms and conditions stipulated by the TRA.

2.1.8 **"National Spectrum Plan"** means Radio Frequency Allocation plan for the UAE and any modifications thereof.

2.1.9 **"Person"** will include "juridical entities" as well as "natural persons".

2.1.10 **"Radiocommunication Service"** means the transmitting or receiving of Radio Frequency which may be used for the conveyance of data, or messages or voice or visual images, or for the operation or control of machinery or apparatus.

2.1.11 **"Radio Frequency"** means radiated electromagnetic energy measured in Hz or cycles/sec.

2.1.12 **"Frequency Spectrum Authorization"** means an authorization, which permits the use of Radio Frequency subject to terms and conditions as stipulated by the TRA.

2.1.13 **"Regulatory Instruments"** means any instrument issued by the Authority under its powers, and includes without limitation; Regulations, violation decisions, directives, instructions, guidance and recommendations and regulatory policies.

2.1.14 **"Station"** means an installation operated by an Authorized User, for carrying on a Radiocommunication Service.

2.1.15 **"Temporary Authorization"** means an Authorization issued by the TRA which permits the use of Assigned Frequency for a period up to 90 days.

2.1.16 **"UAE"** means the United Arab Emirates including its territorial waters and the airspace above.

2.1.17 **"Wireless Equipment"** means a category of Telecommunication Apparatus used for Radiocommunication Service.

ARTICLE (3)

Application processing Fees

3.1 Each Application for the Frequency Spectrum Authorization shall require an advance non-refundable payment of Five Hundred (500) Dirhams for processing the Application, irrespective of the final status of the Application towards grant or rejection of the Application. The TRA may advise certain Governmental Entities, licensed operators or any major user to accumulate the Application processing Fees for payment along with the spectrum Fees. The invoice and receipt for the Application processing Fees shall only be issued upon request from the Applicant. The Application shall only be considered for processing upon the proof of the payment provided by the Applicant. The Application processing Fee for modification of an Authorization will be raised with the annual spectrum Fees invoice.

ARTICLE (4)

Application processing Fees Exemption

4.1 The following Applications shall be exempted from the Application processing Fees:

a) Application for Small Fishing Boats. (Fishing Trawls.)

b) Application for Amateur Authorization.

c) Application for personal use of Private Mobile Radio for Camel jockeys and Hunting.

d) Application by non-commercial clubs for hobbies like Aeromodelling.

e) Application by research and educational institutions for private use.

f) Application by Foreign Missions, Consulates and Embassies for official correspondence or visits of dignitaries when submitted through the UAE Ministry of Foreign Affairs.

ARTICLE (5)

Spectrum Fees for New Application

5.1 The Spectrum Fees shall be payable in advance. Upon successful processing of a new Application, the TRA shall inform the Applicant of the spectrum Fees, calculated for the period of validity of the Authorization, starting from the date of invoice. The Applicant shall submit to the TRA, the proof of payment immediately and not later than thirty (30) days from the date of issuing of Invoice. The receipt of the Fees by the TRA based on verification by the TRA shall be considered as completion of the payment for issuance of the Authorization. If payment is not received, the TRA shall cancel the Application and if the Applicant requires pursuing such Application, the Applicant shall be required to re-submit the Application with new Application processing Fee.

ARTICLE (6)

Spectrum Fees for renewal of Authorization

6.1 The Authorized User shall be responsible to apply to the TRA for renewal of the Authorization, within the period, thirty (30) days before the expiry of the Authorization. A grace period of fifteen (15) days after expiry may be given to the Authorized User by the TRA to pay the Spectrum Fees for renewal without any additional Fees.

ARTICLE (7)

Additional Fees for delayed renewal of Authorization

7.1 The TRA shall raise a new invoice (superseding the unpaid invoice) with an additional Fee of 10% of the amount due for Spectrum Fees after 15 days of the expiry of the Authorization up to a maximum of 45 days from the expiry of Authorization after which the TRA will cancel such Authorization.

ARTICLE (8)

Authorization reproduction Fees

8.1 In case the Authorization is damaged or lost, the Authorized User shall have to apply to the TRA for reproduction of the Authorization. A non-refundable payment of One Hundred (100) Dirhams shall be charged in advance for the reproduction of each Authorization requested.

ARTICLE (9)

Authorization modification Fees

9.1 The Authorized User can apply for modification of an Authorization. A non-refundable payment of One Hundred (100) Dirhams shall be charged for the modification of the Authorization requested. Modifications of contact details in the Authorization shall require the reproduction Fees as mentioned in Article 8 above before issuing of an Authorization. The request of modification of any site data or addition of Wireless Equipment or change of technical data shall require payment of Application processing Fees as mentioned at Article 3 above. In case the modification is approved by the TRA, the annual Spectrum Fees shall be calculated on prorate basis. The Authorized User shall pay the difference in advance to the TRA. If the difference is in favour of the Authorized User, no reimbursement shall be made by the TRA and the annual Spectrum Fees for subsequent year shall be calculated based on the revised Fees. The Application processing Fee for modification or reproduction of an Authorization will be raised with the annual spectrum Fees invoice.

ARTICLE (10)

Authorization cancellation Fees

10.1 The Authorized User can apply for cancellation of the Authorization. There will be no Fees for cancellation and no reimbursements shall be made by the TRA for any balance amount.

ARTICLE (11)

Spectrum Fees for Public Land Mobile (Cellular) Service

11.1 The Annual Spectrum Fees for the Public Land Mobile (cellular) services (including GSM, UMTS and IMT) shall be calculated as follows:

Spectrum Price = [FF x CF x P x BW] / 4 000

where:

FF = Frequency Factor which will be determined as follows:

Frequency Range	Frequency Factor (FF)
900 MHz or less	1.00
1800 MHz	0.75
2.1 GHz	0.60
2.5 GHz	0.50

NOTE 1 – The TRA shall have the sole discretion to determine the Frequency Factor (FF) for any other frequency range not mentioned above, requested for Public Land Mobile or similar services.

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai 1.000 for other Emirates	4.000

P = Price per MHz, presently set at 978,560 AED (Nine Hundred Seventy Eight Thousands Five Hundred and Sixty Only) per year. The TRA may conduct a study at appropriate intervals to review this price.

BW = Assigned Bandwidth in MHz where for duplex assignment of 2x20 MHz shall be taken as 40 MHz.

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

ARTICLE (12)

Spectrum Fees for Private Mobile Radio, Paging, Trunking and PAMR

12.1 The Annual Spectrum Fees for Private Mobile Radio (in the frequency range of 30 MHz to 700 MHz) shall be calculated as follows:

Spectrum Fees = NC x CF + SUM (WE x 500 x PF)

where:

NC = Number of Channels (6.25 kHz bandwidth equivalents each) that will be assigned to the Applicant.

WE = Wireless Equipment (including handhelds) will be included in the calculation.

SUM (WE x 500 x PF) = Total sum of (each Wireless Equipment multiplied by 500 multiplied by Power Factor).

PF = Power Factor depending on the authorized radiated power (e.i.r.p.) for the Equipment which will be determined as follows:

Power	Less than 1 W	1 – 5 W	> 5 – 10 W	> 10 – 20 W	> 20 W
PF	0.25	1	2	3	4

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai 1.000 for other Emirates	4.000

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

NOTE 2 – Private Mobile Radios Onboard Vessels shall be charged with **CF** = 100.

12.2 The Annual Spectrum Fees for Private Mobile Radio (vehicles only) which are not localized (i.e. not connected to a base station) shall be calculated as follows:

Spectrum Fees = NC x CF

where:

NC = Number of Channels (12.5 kHz bandwidth equivalents each) that will be assigned to the Applicant.

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai and 1.000 for other Emirates	4.000

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

12.3 The Annual Spectrum Fees for Private Mobile Radio used by the Taxi companies shall be calculated for the base station in accordance with the Article 12.2 and separate Fees of 300 AED for each Taxi fitted with a radio.

12.4 The Annual Spectrum Fees for Private Mobile Radio used in the Camel Race Tracks shall be calculated as follows:

Spectrum Fees = NC x 50 + WE x 100

where:

NC = Number of Channels (6.25 kHz bandwidth equivalents each) that will be assigned to the Applicant.

WE = Wireless Equipment (including handhelds) will be included in the calculation.

12.5 The Annual Spectrum Fees for Public Paging shall be calculated for the base station in accordance with the Article 12.1 with no additional Fees for handheld pagers.

12.6 The Annual Spectrum Fees for Analog Trunking (like MPT 1327) shall be calculated in accordance with the Article 12.1 above.

12.7 The Annual Spectrum Fees for Digital Trunking (like TETRA, TETRAPOL, EDACS, APCO, etc.) shall be calculated as follows:

Spectrum Fees = NC x CF

where:

NC = Number of Channels (25 kHz unpaired bandwidth equivalents each) that will be assigned to the Applicant.

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai 1.000 for other Emirates	4.000

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

ARTICLE (13)

Spectrum Fees for Fixed (point to point) links

13.1 The Annual Spectrum Fees for each fixed point to point link above 2 GHz shall be calculated as follows:

Spectrum Fees = F x 2 000 + BW x 1000

where:

F = Frequency range factor as follows:

Frequency Range	F Factor
2 GHz – 3 GHz	4
> 3 GHz – 14 GHz	3
> 14 GHz – 40 GHz	2
Above 40 GHz	1

BW = Bandwidth factor as follows:

Bandwidth	BW Factor
7 MHz or less	1
> 7 MHz – 28 MHz	2
> 28 MHz – 56 MHz	3
More than 56 MHz	4

13.2 The bandwidth for each Fixed Point to Point link above 2 GHz shall be calculated based on the channel bandwidth (e.g. frequency pair with each frequency of 3.5 MHz + 3.5 MHz = 7 MHz shall be having BW factor of 1). The frequency diversity shall be charged as a separate link but space diversity and hot standby operations shall not add to the Fees.

13.3 For unidirectional links and links using the same carrier frequency for transmit and receive, the bandwidth factor will be the assigned bandwidth.

13.4 In exceptional cases, as decided by the TRA, where frequency pairs are assigned for all UAE point-to-point links above 2 GHz, the annual spectrum Fees shall be ten times the annual spectrum Fees for one link (same parameters) based on a re-use factor of 10.

13.5 The Annual Spectrum Fees for each fixed point to point link below 2 GHz with capacity less than 64 kbps shall be calculated as follows:

$$\text{Spectrum Fees} = \text{BW x 1 000}$$

where:

BW is the total bandwidth in kHz for all channels of that link.

13.6 The Annual Spectrum Fees for Fixed Point to Point link below 2 GHz with high capacity equal or above 64 kbps shall be calculated as follows:

$$\text{Spectrum Fees} = \text{BW x 2 000}$$

where:

BW is the total bandwidth in MHz for all channels of that link.

ARTICLE (14)

Spectrum Fees for FWA (PMP, WLL), SCADA, Telemetry, Mesh Networks

14.1 The Annual Spectrum Fees for Fixed Wireless Access (including Wireless Local loop and Point to multipoint), SCADA, Telemetry and Mesh networks below 2 GHz shall be calculated as follows:

$$\text{Spectrum Fees} = \text{BW x CF x 10}$$

where:

BW = Total Bandwidth in kHz.

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai, 1.000 for other Emirates	4.000

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

14.2 The Annual Spectrum Fees for Fixed Wireless Access (including Wireless Local loop and Point to multipoint), SCADA, Fixed Broadband and mesh networks above 2 GHz shall be calculated as follows:

Spectrum Fees = BW x CF x FF

where:

BW = Total Bandwidth in MHz.

***Note 1** – For networks (including vehicles) using both 2.4 and 5.8 GHz, total bandwidth of both bands will be added.*

CF = Coverage Factor depending on the geographical area which will be determined as follows:

Area	Rural area or within premises	Urban city area within one Emirate	Emirate wide	More than Three Emirates
CF	100	500	2.000 for Abu Dhabi or Dubai and 1.000 for other Emirates	4.000

FF = Frequency Factor which will be determined as follows:

Frequency Range	Frequency Factor (FF)
2 GHz < $f \leq$ 6 GHz	5
6 GHz < $f \leq$ 11 GHz	4
11 GHz < $f \leq$ 14 GHz	3
14 GHz < $f \leq$ 40 GHz	2
40 GHz < f	1

f = Assigned Frequency.

NOTE 1 – The TRA shall have the sole discretion to determine the Coverage Factor for an Application.

ARTICLE (15)

Spectrum Fees for Optical and Laser links

15.1 The Annual Spectrum Fees for free space Optical and Laser links shall be fifty (50) Dirhams.

ARTICLE (16)

Spectrum Fees for WLAN and Cordless Telephony

16.1 The indoor use of WLAN and DECT based Cordless Telephony if operated as per the TRA regulations, shall be exempted from the Spectrum Fees.

ARTICLE (17)

Spectrum Fees for GMPCS

17.1 The Annual Spectrum Fees for Global Mobile Personal Communication by Satellite (GMPCS) Service (including its land based, aeronautical and maritime use) shall be calculated as follows:

Spectrum Fees = BW x 5 000

Where **BW** = Bandwidth Factor based on 2 x 1 MHz Bandwidth used and shall be determined as follows:

Bandwidth	BW Factor
Less than 2 x 1 MHz	3
2 x 1 MHz – Less than 4 x 1 MHz	6
4 x 1 MHz – Less than 6 x 1 MHz	9
6 x 1 MHz – Less than 8 x 1 MHz	12
8 x 1 MHz – Less than 10 x 1 MHz	15
10 x 1 MHz	18
For each additional 2 x 1 MHz	3

ARTICLE (18)

Spectrum Fees for Amateur

18.1 The Annual Fees for Amateur license shall be Two Hundred (200) AED payable in advance.

ARTICLE (19)

Spectrum Fees for Aeronautical Radio Stations

19.1 The Annual Fees for each aircraft and helicopter license shall be One Thousand (1 000) Dirhams. This shall include all Wireless Equipment onboard.

19.2 The Annual Fees for gliders and balloons shall be Three Hundred (300) Dirhams.

19.3 The Annual Fees for ground to air links shall be in accordance with Article (12).

19.4 The ground to air HF links shall be charged in accordance with Article (13).

ARTICLE (20)

Spectrum Fees for Maritime Radio Services

20.1 Spectrum Fees for each small fishing boat license shall be Two Hundred (200) Dirhams for two years.

20.2 The Annual Spectrum Fees for each pleasure boat license shall be Five Hundred (500) Dirhams.

20.3 The Annual Spectrum Fees for each Coastal Ship (within domestic water and without MMSI) license shall be Five Hundred (500) Dirhams.

20.4 The Annual Spectrum Fees for each Ship (going outside domestic water or with MMSI) license shall be One Thousand (1 000) Dirhams.

NOTE 1 – The Article 21.3 & 21.4 shall be subject to the use of International Marine Frequency Channel as per the ITU Radio Regulations otherwise the Application will be treated as Private Mobile Radio.

ARTICLE (21)

Spectrum Fees for Space and Ancillary Services

21.1 The Annual Spectrum Fees for each private VSAT shall be Five Thousand (5 000) Dirhams.

21.2 The Annual Spectrum Fees for each Earth Station antenna shall be Fifty Thousand (50 000) Dirhams.

21.3 The TVRO (Television receive only) shall not be charged.

21.4 The Annual Spectrum Fees for each DSNG shall be Five Thousand (5 000) Dirhams.

21.5 The Annual Spectrum Fees for offering Aeronautical Mobile Satellite Service shall be Ten Thousand (10 000) Dirhams.

21.6 The Annual Spectrum Fees for offering Maritime Mobile Satellite Service shall be Ten Thousand (10 000) Dirhams.

21.7 The Annual Spectrum Fees for offering Earth Exploration Satellite service shall be Ten Thousand (10 000) Dirhams.

21.8 The Annual Spectrum Fees for HAPS shall be determined by the TRA based on the purpose of use.

ARTICLE (22)

Spectrum Fees for Radionavigation stations

22.1 The Annual Spectrum Fees for each Radionavigation Station shall be One Thousand (1 000) Dirhams.

ARTICLE (23)

Spectrum Fees for Radio Astronomy stations

23.1 The Annual Spectrum Fees for each Radio Astronomy Station shall be Five Hundred (500) Dirhams.

ARTICLE (24)

Spectrum Fees for Radiolocation stations

24.1 The Annual Spectrum Fees for each maritime coastal radar, weather radar, ground based radar, aeronautical surveillance, approach control, oceanic, surface movement and tracking shall be Five Thousand (5 000) Dirhams.

ARTICLE (25)

Spectrum Fees for Broadcasting Service

25.1 Terrestrial Sound and Television Broadcasting

Annual Spectrum Fees for one individual Broadcasting Station shall be calculated as follows:

Spectrum Fees (per Station) = B + (P x ST x SZ x H x C)

where:

B = **Basic Fee =** 40.000 (Forty Thousands) Dirhams.

P = **Power Factor** shall be the power; expressed in kilowatts [KW] equals the transmitter output power (in case of LW, MW or SW transmissions) and Effective Radiated Power (e.r.p.) in all other cases.

ST = **Service Type Factor** shall be calculated as follows:

NOTE 1 – In case of using Single Frequency Network (SFN) the complete network shall be treated as one single transmitter and the Basic Fee shall be charged once for that SFN whereas the remaining part of Spectrum Fees shall be charged per station basis.

TABLE 1

Definition of Service Type Factors (ST) for Sound Broadcasting Services

Sound Broadcasting Service			
Service Type	**Frequency Range**	**Bandwidth**	**Service Type Factor (ST)**
LF/MF Sound Broadcasting	148.5-283.5 kHz	9 kHz	4.5
	526.5-1,606.5 kHz	9 kHz	
VHF Sound Broadcasting	87.5-108 MHz	200 kHz	11
	174-230 MHz	1.536 MHz	21

TABLE 2

Definition of Service Type Factors (ST) for TV Broadcasting Services

TV Broadcasting Service			
Service Type	**Frequency Range**	**Bandwidth**	**Service Type Factor (ST)**
Terrestrial Analogue TV	47-68 MHz	7 MHz	12
	174-230 MHz		
	470-862 MHz	8 MHz	14
Terrestrial Digital TV Broadcasting	174-230 MHz	7 MHz	60
	470-862 MHz	8 MHz	68
Terrestrial Mobile TV Broadcasting	174-230 MHz	7 MHz	119
	470-862 MHz	8 MHz	136

NOTE 1 – The Service Type Factor for Terrestrial Analog TV shall be applicable till December 2015. Afterwards, the Service Type Factor for Terrestrial Digital TV Broadcasting shall be applied for Terrestrial Analog TV.

NOTE 2 – Service Type Factor can be calculated on prorate basis with respect to above mentioned bandwidth and closest frequency range if similar Broadcasting Service is required to be authorized in any frequency band not mentioned above.

SZ = Service Zone Factor as follows:

TABLE 3

Definition of Service Zones Factors (SZ)

Service Zone Factor (SZ)	**Service Zone**	**Polygon Corners**
1.00 (high)	City and environs of Abu Dhabi	54° 30’ E – 24° 45’ N 55° 15’ E – 24° 40’ N 55° 00’ E – 24° 05’ N 54° 00’ E – 24° 20’ N
	Cities and environs of Dubai, Sharjah, Ajman and Umm Al Quwein	55° 30’ E – 25° 40’ N 55° 55’ E – 25° 20’ N 55° 15’ E – 24° 40’ N 54° 30’ E – 24° 45’ N

TABLE 3 (*end*)

Service Zone Factor (SZ)	Service Zone	Polygon Corners
0.75 (medium)	Area between Abu Dhabi and Al Ain	55° 00’ E – 24° 20’ N 55° 30’ E – 24° 20’ N 55° 30’ E – 24° 00’ N 55° 00’ E – 24° 05’ N
	City and environs of Al Ain	55° 30’ E – 24° 20’ N 55° 50’ E – 24° 20’ N 55° 50’ E – 24° 00’ N 55° 30’ E – 24° 00’ N
	City and environs of Fujairah	56° 15’ E – 25° 15’ N 56° 25’ E – 25° 15’ N 56° 25’ E – 25° 00’ N 56° 15’ E – 25° 00’ N
	City and environs of Ras Al Khaimah	55° 50’ E – 25° 55’ N 56° 05’ E – 25° 55’ N 56° 05’ E – 25° 40’ N 55° 50’ E – 25° 40’ N
	Area between Umm Al Quwein and Ras Al Khaimah	55° 30’ E – 25° 40’ N 56° 05’ E – 25° 40’ N 55° 55’ E – 25° 20’ N
0.50 (low)	All remaining areas	

NOTE 1 – Any transmission from a certain location having medium or low Service Zone Factor into (partly or entirely) a higher Service Zone will upgrade this particular station in Service Zone Factor to the higher level which may be also a two step increase and the decision of the TRA shall be final in this regard. The TRA shall have the sole discretion to determine Service Zone for an Application.

NOTE 2 – For Broadcasting Services in the HF and lower frequency bands, the Service Zone Factor **SZ** = 1.

H = **Antenna Height Factor** is the Antenna Height above ground level in meters including building, tower and a hill.

C = **Correction Factor as follows:**

a) For Governmental Broadcasting Stations which are operating on a non-commercial basis, a Correction Factor **C** = 0.5 shall be applied.

b) For promoting digital switchover, digital terrestrial audio and video broadcasting transmitters (excluding Terrestrial Mobile TV Broadcasting – Handheld) shall be granted a reduction of 50% during the period before 30th December 2015; (i.e. Correction Factor **C** = 0.5). This reduction is only limited to the above specified period and may be accompanied with other conditions as determined by the TRA.

c) For all other assignments, the value of Correction Factor **C** = 1.

25.2 HF Seasonal Sound Broadcasting:

For HF Seasonal Sound Broadcasting Services, the Spectrum Fee shall be charged per transmitter basis and for each transmitter the Annual Spectrum Fees shall be:

Spectrum Fees for each HF transmitter = AED 20.000/-

25.3 Satellite Radio and Television Broadcasting:

Uplinking of DAB, DVB-S and DVB-SH shall be charged at 200.000 AED per multiplex unit and DVB-RCS by 400.000 AED per multiplex unit.

NOTE 1 – A multiplex unit is defined as one channel (signal) with appropriate bandwidth containing several programmes combined by digital multiplexing. The TRA shall have the sole discretion to determine Multiplex Unit for an Application.

ARTICLE 26

Short Range Devices

26.1 All Wireless Transmission equipment meeting the criteria of the Short Range Devices as determined by the TRA shall be exempted from the annual Spectrum Fees.

26.2 Low Power Transmitting Devices meeting the criteria of the Low Power Transmitting Devices as determined by the TRA shall be charged as follows:

TABLE 4

Annual Fee for Low Power Equipment

Radiated Power	Annual Fee
≤ 10 mW	100 AED
10 mW ≤ 100 mW	200 AED
100 mW ≤ 1 W	400 AED

ARTICLE 27

Emergency and disaster frequencies

27.1 All emergency, distress and safety of life frequencies identified within the National Spectrum Plan and the National Table of Frequency Allocation shall not be charged. All Wireless Transmission equipment made exclusively for safety of life and accepted by the TRA as falling within this category shall be exempted from the spectrum Fees.

ARTICLE 28

Temporary Authorization

28.1 The Annual Spectrum Fees for Temporary Authorization will be calculated on prorate basis of the annual Spectrum Fees in accordance to the Radiocommunication Service. However, a minimum of 100 AED will be charged as Spectrum Fees in case the amount is less than 100 AED. The Spectrum Fees for Temporary Authorization will be in addition to the Application processing Fees.

ARTICLE 29

Other Radio Services

29.1 The Annual Spectrum Fees for an Authorization which is not covered above shall be as determined by the TRA and shall be applicable on approval by the Director General of the TRA, even before inclusion in the revised issue of these Regulations.

ARTICLE 30

Interference complaints processing and monitoring Fees

30.1 The TRA does not charge for attending the interference complaints and monitoring.

ARTICLE 31

Fees for the Foreign Embassies, Consulates and Diplomatic Missions

31.1 The Foreign Embassies, Consulates, Diplomatic Missions and the State visits of dignitaries shall be exempted from the Spectrum Fees provided the same exemption is available for the UAE Embassy, Consulate and Mission in the country of origin. This exemption shall be applicable for official correspondence which falls within the scope of the Vienna Convention for diplomatic correspondence and the Applications forwarded to the TRA through the Ministry of Foreign Affairs of the UAE.

ARTICLE 32

Fees for Site Surveys

32.1 The following Fees shall be charged for the site survey conducted by the TRA upon request from the Applicant or the Authorized User for technical assistance:

Site Survey Fee = 2,500 AED per day for each visit.

ARTICLE 33

Obligation to pay

33.1 The Spectrum Fees shall be payable in advance by all without any exemption except as determined in these Regulations. The Spectrum Fees shall not be construed as Federal Tax or any Local Tax and shall be considered as charge for the use of a scarce national resource of radio spectrum. Authorized Users shall have to pay the full dues within the stipulated time, even in cases where the Authorized User contests the amount either wholly or partially.

ARTICLE 34

Methods of payments

34.1 The TRA accepts spectrum Fees and other associated charges in any of the following methods:

– E-Dirham.

– Cheque or cash deposit into the TRA's bank account.

– Cash.

– Wire transfer.

– E-payment (when available).

ARTICLE 35

Penalties

35.1 The penalties of the Federal Law by Decree No. 3 of 2003 as amended shall apply to any violation to these Regulations.

A.1.2 Fees Policy of Cote D'Ivoire

REPUBLIC OF COTE D'IVOIRE

UNITY-DISCIPLINE-WORK

Ministry of Economic Infrastructures	Ministry of Economy and Finances
....	....

ORDER N°…….. OF…. FIXING AMOUNT OF FEES, TAXES AND CHARGES ON RADIOCOMMUNICATIONS

THE MINISTER OF ECONOMIC INFRASTRUCTURES

THE MINISTER OF ECONOMY AND FINANCES

Considering Law N° 95-526 of 7 July 1995 on Telecommunications Code.

Considering Decree N° 95-554 of 19 July 1995 organizing and fixing the functioning of a Public Entity called Agence des Télécommunications de Côte d'Ivoire (ATCI).

Considering Decree N° 96-PR/002 of 26 January 1996 appointing members of Government, and modified by Decree N° 96-PR/10 of 10th August 1996.

Considering Decree N°… defining fees, taxes and charges on radiocommunications.

Considering the necessity of service.

ORDERS

Article 1

The amount for fees, taxes and charges on radio electricity to be paid in conformity with the rules and regulations in force are fixed in the annex to this Order.

Article 2

The Agence des Télécommunications de Côte d'Ivoire is charged with the responsibility of implementing this Order which will take effect from the date of signature and its publication in the Official Gazette of the Republic of Côte d'Ivoire.

Done in Abidjan on ……..

The Minister of Economic Infrastructures	The Minister of Economy and Finances
AKELE Ezan	N'Goran NIAMIEN

AMOUNT OF FEES, TAXES AND CHARGES ON RADIOELECTRICITY

A. TERRESTRIAL RADIOCOMMUNICATION SERVICES

NETWORKS OR STATIONS	Fees for compilation of file	Fees for visiting or control of stations in CFA	Contribution to management costs	Charges for use of frequency or radioelectric channel
FIXED NETWORKS AND INDEPENDENT MOBILE TERRESTRIAL NETWORKS FOR PRIVATE USE (Non profitable services)	11 600			
1.1 – VHF/UHF Radioelectric network (Bandwidth = 12.5 KHz)				
a1. Transmitter power equal or less than 10 W		87 000		
a2. Transmitter power between 10 and 25 W		14 500		
a3. Transmitter power above 25 W		58 000		
b1. Local links with no relay (less than 10 km)				1 450 000
b2. Local links with relay (less than 25 km)				362 500
b3. Local links in Abidjan				Double above taxes
c1. Network with less than 10 sets in Abidjan			290 000	
c2. Network with 10 to 50 sets in Abidjan			145 000	
c3. Network with more than 50 sets in Abidjan			58 000	
c4. Network outside Abidjan			58 000	
1.2 – Radioelectric Network in MF/HF (with bandwidth equal to 3 KHz)	11 600			
a1. Transmitter less than 50 W		14 500		
a2. Transmitter between 50 and 150 W		17 400		
a3. Transmitter above 150 W		58 000		
b1. Regional links (average 100 km)				348 000
b2. Inter-regional links (average 250 km)				870 000
b3. National Links (average 500 km)				1 740 000
c1. Network with less than 5 stations			58 000	
c2. Network with 5 to 10 stations			87 000	
c3. Network with more than 10 stations			145 000	
1.3 – Research radio/ Message radio networks (Paging) (bandwidth = 12.5 KHz)				
a1. Local network (urban)	116 000			
a2. Regional network (interurban)	290 000			
a3. National network	580 000			
b1. Base station				

NETWORKS OR STATIONS	Fees for compilation of file	Fees for visiting or control of stations in CFA	Contribution to management costs	Charges for use of frequency or radioelectric channel
c1. Locally available frequency				
c2. Regional available frequency				
c3. Frequency available throughout the national territory		34 800		
				1 044 000
1.4 – Shared resources network (Trunking) (with bandwidth of 12.5 KHz)				3 480 000
				5 800 000
a1. Local network				
a2. Regional network				
a3. National network				
b1. Base station				
	116 000			
c1. Locally available duplex channel	290 000			
c2. Duplex channel available on regional plan	580 000			
c3. Duplex channel available throughout the national territory				
1.5 – Microwave Links above 1 GHz		34 800		
a1. Trunk or local network				1 740 000
a2. Trunk or regional network				5 800 000
a3. Trunk or national network				
				8 700 000
b1. Terminal station				
b2. Relay station				
c1. Links between 1 to 24 telephone channels or from 2.1 Mbits/s				
	116 000			
c2. Links between 25 to 120 telephone channels or from 2.1 to 8 Mbits/s	290 000			
	580 000			
c3. Links from 121 to 600 telephone channels or from 8 to 34 Mbits/s				
c4. Links with more than 600 telephone channels or more than 34 Mbits/s		34 800 29 000		
II. FIXED AND TERRESTRIAL MOBILE NETWORKS OPENED TO THE PUBLIC (Profitable business)				1 160 000
				1 450 000
II.1. Research and Message networks (Paging) (With 12.5 KHz bandwidth)				
				1 740 000
a1. Local (urban) network				
a2. Regional (interurban) network				

NETWORKS OR STATIONS	Fees for compilation of file	Fees for visiting or control of stations in CFA	Contribution to management costs	Charges for use of frequency or radioelectric channel
a3. National network				2 900 000
b1. Base station				
c1. Locally available frequency				
c2. Regionally available frequency				
c3. Nationally available frequency				
II.2. Shared Resources networks (Trunking) With channels = 12.5 KHz)	1 160 000			
a1. Local network (urban)	1 740 000			
a2. Regional network (interurban)		34 800		
a3. National network	3 770 000		5 800 000	
b1. Base station			14 500 000	3 480 000
			29 000000	5 800 000
c1. Locally available frequency				
c2. Regional available frequency				8 700 000
c3. Frequency available throughout the national territory				
II.3. Cellular Network				
a1. Base station		34 800		
b1. For duplex channel available throughout the national territory (with bandwidth = 200 KHz)	1 160 000			
	1 740 000			
II.4. Microwave Links above 1 GHz	3 770 000			
				5 800 000
a1. Local links				8 700 000
a2. Regional Links		34 800		10 440 000
a3. National Links				
b1. Terminal station				
b2. Terminal station				
c1. Links of 120 telephone channels or 8 Mbits/s				
c2. Links from 121 to 600 telephone channels or from 2.1-8 Mbits/s				10 440 000
c3. Links up to 1200 telephone channels or more than 70 Mbits/s				

NETWORKS OR STATIONS	Fees for compilation of file	Fees for visiting or control of stations in CFA	Contribution to management costs	Charges for use of frequency or radioelectric channel
III. TERRESTRIAL RADIOMARITIME SERVICE			29 000 000	
		34 800		
III.1. Private coastal station (non profitable)		29 000	10 440 000	
a1. Radioelectric links VHF (25KHz)				
a2. Radioelectric links MF/HF (less than 1 KHz)	1 160 000			
a3. Radioelectric links MF/HF (3KHz)	1 740 000			
	3 770 000			
			5 800 000	5 800 000
			14 500 000	10 440 000
III.2. Coast Station opened to the public (commercial service)				14 500 000
		87 000	29 000 000	17 400 000
a1. Radioelectric links VHF (25KHz)				
a2. Radioelectric links MF/HF (less than 1 KHz)				
a3. Radioelectric links MF/HF (3KHz)				
III.3. Commercial ship stations				
a1. Ports operations				
III.4. Fishing ship stations				174 000
				139 200
a1. Of less than 150 tons	580 000	580 000		417 600
a2. Of more than 150 tons				
b1. Ports operations				
III.5. Tourists / Pleasure ships			3 480 000	
III.6. Maritime transmitter (receivers of 55 channels				
IV. Aeronautic mobile Stations	1 450 000			
IV.1. Private aeronautic station (unofficial)				174 000
a1. Link land to air				
a2. Link land to land		34 800	8 700 000	
		34 800		
IV.2. Public Civil aviation transport system				174 000
IV.3. Private civil aviation transport				
				174 000

NETWORKS OR STATIONS	Fees for compilation of file	Fees for visiting or control of stations in CFA	Contribution to management costs	Charges for use of frequency or radioelectric channel
V. AMATEUR STATIONS		34 800		
				Nothing
a1. Radiotelephone station VHF				
a2. Radiotelephone MF/HF		11 600		
	11 600			
	11 600			
		87 000		
			116 000	
	11 600		174 000	116 000
				145 000
	11 600			
				Nothing
		58 000	58 000	
				Nothing
		34 800		
			58 000	
	116 000			
				Nothing
		8 700		Nothing
		17 400	580 000	
	17 400			
	11 600		290 000	
			58 000	
	5 800			
	5 800		Nothing	
			Nothing	

B. SATELLITE RADIOCOMMUNICATIONS

NETWORKS OR STATIONS	Tax for compiling files	Control or visit charges	Contributions towards management costs	Charges for use of radio frequency or radioelectric channels
PRIVATE NETWORKS AND EARTH STATIONS (Non commercial services)				
I.1. National network (Fixed or Mobile)				
	1 044 000		8 700 000	
a1. Master station				
a2. Secondary station		87 000		
		34 000		
b1. Links between 1 to 24 telephone channels or less than 2.1 Mbits/s				
				1 160 000
b2. Links between 25 to 120 telephone channels or 2.1 to 8 Mbits/s				
b3. Links between 121 to 600 telephone channels or 8 to 34 Mbits/s				1 450 000
				1 740 000
b4. Links over 600 telephone channels or more than 34 Mbits/s				
				2 900 000
I.2. International Independent Earth station				
I.3. International secondary micro earth stations (VSATs)	116 000	34 800	580 000	348 000
I.4. Portable or Mobile Earth station				
I.5. Individual reception earth station	58 000	34 800	174 000	145 000
	58 000	29 000	145 000	116 000
II. STATIONS AND TERRESTRIAL NETWORKS OPENED TO THE PUBLIC (Commercial services)	11 600	14 500	Nothing	Nothing
II.1. National network opened to the public				
a1. Terrestrial aeronautic station-coastal or terrestrial	3 770 000		29 000 000	
a2. Terrestrial aeronautics- ship or terrestrial		87 000		
b1. Links between 1 to 120 telephone channels or 2 to 8 Mbits/s		58 000		
b2. Links between 121 to 600 telephone channels or 8 to 34 Mbits/s				5 800 000
b3. Links between 601 to 1200 telephone channels or 34 to 70 Mbits/s				10 440 000
b4. Links above 1200 telephone channels or more than 70 Mbits/s				14 500 000
II.2. Terrestrial earth stations linked to international public networks				17 400 000
II.3. Terrestrial stations linked to international independent networks	1 740 000	87 000	11 600 000	3 480 000
II.4. Community reception earth stations				

NETWORKS OR STATIONS	Tax for compiling files	Control or visit charges	Contributions towards management costs	Charges for use of radio frequency or radioelectric channels
a1. Reception of less than 5 programmes a2. Reception of 5 to 10 programmes a3. Reception of more than 10 programmes	870 000 580 000 29 000 58 000 145 000	34 800 34 800 14 500 29 000 58 000	5 800 000 29 900 000 1 450 000 5 800 000 1 160 000	1 740 000 580 000 1 450 000 5 800 000 11 600 000

C. TEMPORAL UTILIZATION OF RADIOELECTRIC STATIONS

NETWORKS OR STATIONS	FEES FOR COMPILING FILES	Control or visit tax	Contribution for management costs	Charges for use of frequencies or Radioelectric spectrum
Terrestrial services a1. Fixed station or base a2. Mobile station a3. Portable station Spatial services a1. Aeronautic, coastal or earth stations a2. Mobile earth station a3. Portable or mobile earth stations	 Nothing Nothing Nothing Nothing, Nothing, Nothing	 11 600 8 700 5 800 29 000 17 400 11 600	 Calculated for the whole month on the prorate of utilization	 Calculated for the entire month on the prorate of utilization

D. OTHER FEES AND TAXES

I. SPECIAL EQUIPMENTS.

1. Transmitters and Receivers with low power or CB sets

– Annual forfeitary charge 23 200 F

2. Installation of reduced command radio

– Special tax for 5 years 23 200 F

II. LICENCE FEES/CERTIFICATE

	Establishing	Renewal	Duplicata
1. Amateur station aeronautic or ship	5 800	5 800	11 600
2. Amateur Earth Station aeronautic/Ship	11 600	11 600	23 200
3. Operator's certificate	5 800	–	11 600

III. EXAM FEES FOR THE ISSUE OF OPERATOR'S CERTIFICATE

1. Radiotelegraphic operator for ship station	
a. General certificate for radiocommunications operator	58 000F
b. First class radiotelegraphic operator	29 000F
c. Second class radiotelegraphic operator	29 000F
d. Special radiotelegraphic operator certificate	29 000F
2. Radiotelegraphist for aeronautic or ship stations	
a. General certificate	14 500F
b. Restricted certificate	14 500F
3. Operator's certificate for Radio amateur station	
a. Radiotelegraphist	14 500F
b. Radiotelephonic operator	14 500F

IV. FEES FOR THE ISSUANCE OF AUTHORIZATIONS

	Fees for compiling file	Authorization charge
1. Private installer	58 000F	348 000F
2. Reseller	58 000F	145 000F
3. Simple Terminal Equipment	5 800F	58 000F
4. Complex Terminal Equipment	11 600F	116 000F

V. TAX FOR INTERVENING IN THE NETWORKS

1. Interference	116 000F
2. Non conformity of installations	145 000F
3. Miscellaneous	58 000F

VI. LABELLING

1. Fixed set	2 900F
2. Mobile set	1 740F
3. Handheld set	1 160F

REPUBLIC OF COTE D'IVOIRE

CONCESSIONARY CONVENTION

ANNEX 15

DRAFT DECREE FIXING FEES, TAXES AND CHARGES ON RADIOCOMMUNICATIONS

REPUBLIC OF COTE D'IVOIRE

Unity-Discipline-Work

Ministry of Economic Infrastructure

Ministry of Economy and Finances

ORDINANCE N° 97/173/ of 19/03/97 DEFINING FEES, TAXES AND CHARGES IN RADIOCOMMUNICATION SERVICES

THE PRESIDENT OF THE REPUBLIC

Considering the joint report of the Ministry of Economy and Finances and the Ministry of Economic Infrastructure.

Considering the Constitution.

Considering law N° 95-526 of 7 July 1995 on Telecommunications Code.

Considering Decree N° 85-1089 of 16th October 1985 fixing Private Radioelectricity regulations in Côte d'Ivoire.

Considering decree N° 95-554 of 19 July 1995 fixing organization and functioning of a Special Public entity here-after named Agence des Télécommunications de Côte d'Ivoire.

Considering decree N° 96-PR/002 of 26th January 1996 appointing members of Government; as modified by decree N° 96-PR/10 of 10th August 1996.

Considering decree N° 96-179 of 1st March 1996 fixing attributions of members of Government.

THE MINISTER'S COUNCIL HAVING CONSIDERED:

DECREES

CHAPTER I

GENERAL PROVISIONS: EXTENT OF APPLICATION

Article 1: In application of the provisions of Articles 6, 8, 20, 24 and 51 of Law N° 95-526 of 7 July 1995 fixing Telecommunications Code, this decree defines fees, taxes, charges and contributions payable to Agence des Télécommunications de Côte d'Ivoire (ATCI) by applicants or holders of authorizations in radiocommunications matters.

CHAPTER II

FEES, CHARGES AND CONTRIBUTIONS APPLICABLE TO RADIOELECTRIC NETWORKS AND STATIONS

Section_1: Radioelectric networks of fixed and mobile services, networks and earth stations of fixed satellite services and mobile satellite services.

Article 2: The applicants or holders of authorizations relating to radioelectric networks for fixed and terrestrial mobile services, as well as networks and earth stations for fixed and mobile satellite services are liable to the payment of fees, charges and contributions as follows:

– fees for compiling file;
– fees for controlling radioelectric stations;
– contribution to management costs;
– charges for using radioelectric frequencies.

Section II: Community Earth Stations for Reception only.

Article 3: Applicants or holders of authorizations relating to installation of radio broadcasting for collective reception or reception from redistribution in conformity with the provisions of Article 20 of Law N° 95-526 of 07 July 1995 fixing Telecommunications Code, are entitled to pay fees, charges and contributions stipulated in Article 2 above.

Section III: Amateur Stations.

Article 4: Applicants or holders of authorizations for amateur stations are entitled to pay the following fees:

– Fees for compiling the file.
– Charges for controlling the stations.

Section IV: Temporary utilization of radioelectric stations.

Article 5: Terrestrial radioelectric stations as well as spatial earth stations which are used on temporal basis are entitled to pay the following charges and fees:

– control charge;
– fees for contribution towards management costs and charges for the use of radioelectric frequencies calculated on monthly basis.

Section V: Low power Transmitters and Receivers or CBs sets.

Article 6: The use of transmitters and receivers sets which operate on simple channels called CB sets, is submitted to the payment of a forfeitary charge, which is not refundable at the time of awarding the authorization.

Not subject to this fees are CB sets with a maximum of 40 channels operating exclusively in angular modulation and having a maximum of 4 W.

Section VI: Installation of reduced command radio.

Article 7: The use of reduced transmitters and receivers sets with less than five (5) watts meant for command radio, except for those authorized with full right, is submitted to the payment of taxes for a period of five (5) years, which is collected upfront and non refundable.

Section VII: Rates and the modality of payment of radioelectric fees and charges.

Article 8: The modalities for payment of fees, charges and contributions as stipulated in Sections I to IV stipulated above is as follows:

– fees for the compilation of files, forfeitary and non refundable charges are paid upfront before the authorization is issued;
– control charge for stations and contributions for management costs are paid in advance and due payable on annual basis and non refundable;
– charges due for the use of electric frequencies is on annual basis and the first year starts from the date of putting into service of the stations while the subsequent years start from the 1st of January.

Article 9: Payment of fees and charges is testified with the issue of a label which is gummed on the equipment, vehicles or ship for mobile stations.

CHAPTER III

FEES AND OTHER CHARGES

Section I: Exam Fees.

Article 10: For the obtention of a certificates for radiotelegraph operator, radio telephone operator or a certificate for the two, exams fees are paid before the examinations start. The same fees will be paid for issuing a certificate (s) for those having military attestations as operators.

Article 11: In the course of issuing or renewing or establishing a duplicate of a radio amateur, air or ship licence and a certificate of an operator, forfeitary and non refundable fees are paid.

Section II: Intervention fees.

Article 12: Exceptional fees are paid for radioelectric interference on frequency which is in regular use or installations which have not respected the norms as stipulated in chapter II above and this leads to payment of a forfeitary charge for each intervention. This tax is paid by the owner of the station which is either interfering with other stations or by the owner of a non conformity installation.

Section III: Commissioning Charges.

Article 13: The commissioning of terminal equipments and an authorization of private radiocommunications installers are entitled to payment of non refundable charges as follows:

1) **For equipments**: A fee for compiling a file and a fee for technical control of the equipment.
2) **For private installers**: A fee for compiling a file and a charge for commissioning which are paid during the issue or renewal of authorization.

CHAPTER IV

PENAL PROVISIONS

Article 14: Any infringement to the provisions of this decree will be sanctioned by Articles 14 and 35 of Law N° 95-526 of 7 July 1995 on Telecommunications code.

Article 15: In addition, failure to pay the required fees, charges and contributions will lead to the suspension of the authorization and the sealing of the radioelectric equipment.

CHAPTER V

FINAL PROVISIONS

Article 16: The amount of fees, charges and contributions to be paid in accordance to the provisions of this decree are fixed by a joint Ministerial Order of the Minister of Economy and Finances and the Minister in charge of Telecommunications.

Article 17: All other former provisions contrary to this decree are cancelled notably Articles 16, 17, 18, 19, 20, 21 and 22 of decree N° 85-1089 of 16 October 1985 fixing regulations on private radioelectricity.

Article 18: This decree shall enter into force from the date of signature and will be published in the Official Gazette of the Republic of Côte d'Ivoire.

Article 19: The Minister in charge of Telecommunications and the Minister in charge of Economy and Finances are responsible as it concerns each of them in the implementation of this decree.

Done in Abidjan

Henri KONAN BEDIE