



Report ITU-R SM.2012-3
(09/2010)

Economic aspects of spectrum management

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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 *spectrum fees* (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:

$$F = D_i \quad (1)$$

$$F = f(D_i, L_i I) \quad (2)$$

where:

F: fee charged to licensee

D_i: direct administrative costs of processing licensee's application

L_i: 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:

$$F = f(a, G) \quad (3)$$

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:

$$F = f(B, C, S, E, F_R, F_C) \quad (4)$$

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 interference¹.

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.

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 UK², 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

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 = $(DE + FL + BL - DPE) \times MPE$ (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.

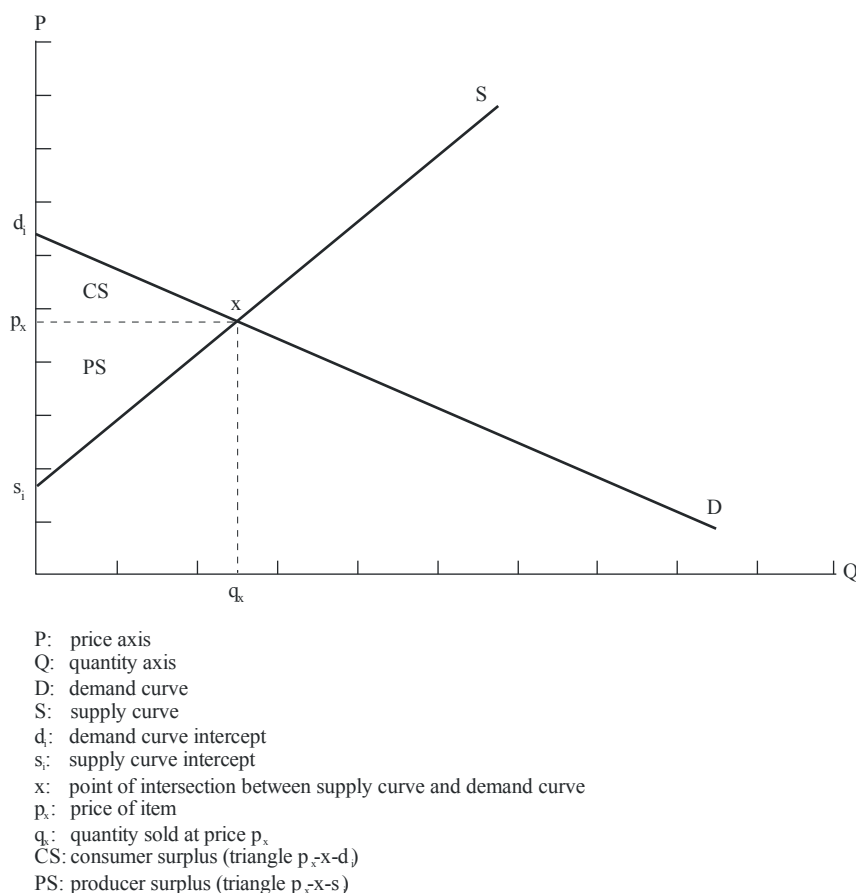
Producer surplus is the difference between what a producer actually earns and the amount it needs to earn to continue in business. Producer surplus is related to the consumer surplus. It can be defined as the revenue received by a supplier of any particular good or service over the minimum amount he 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).

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FIGURE 1
Consumer and producer surplus



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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.

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

Socio-economic factors in the countries under consideration	Remarks
GDP or GDP/inhabitant	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.
Total population; population density	Operator's propensity to pay fees increases in line with population size since, generally speaking, the potential turnover increases with population size.
Geographic distribution of the population (concentrated in a few areas, dispersed, ...)	Operator's propensity to pay fees increases with concentration since, generally speaking, the cost of network deployment decreases with concentration.
Country size, relief and degree of insularity	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.
Characteristics of authorizations or licences	
Period of validity of authorizations	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.
Stability of operating conditions	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.
Renewability of authorizations	The influence of this factor is similar to that of the period of validity.
Content of authorized operator terms of reference	
Coverage of the territory in question	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.
Quality of service	
Participation in universal service	
Participation in research and development efforts in the telecommunication sphere	
Other obligations (free calls to certain numbers, number portability, spectrum monitoring,...)	

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:

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

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:

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

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 fees³:

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.

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:

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

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:

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

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:

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

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