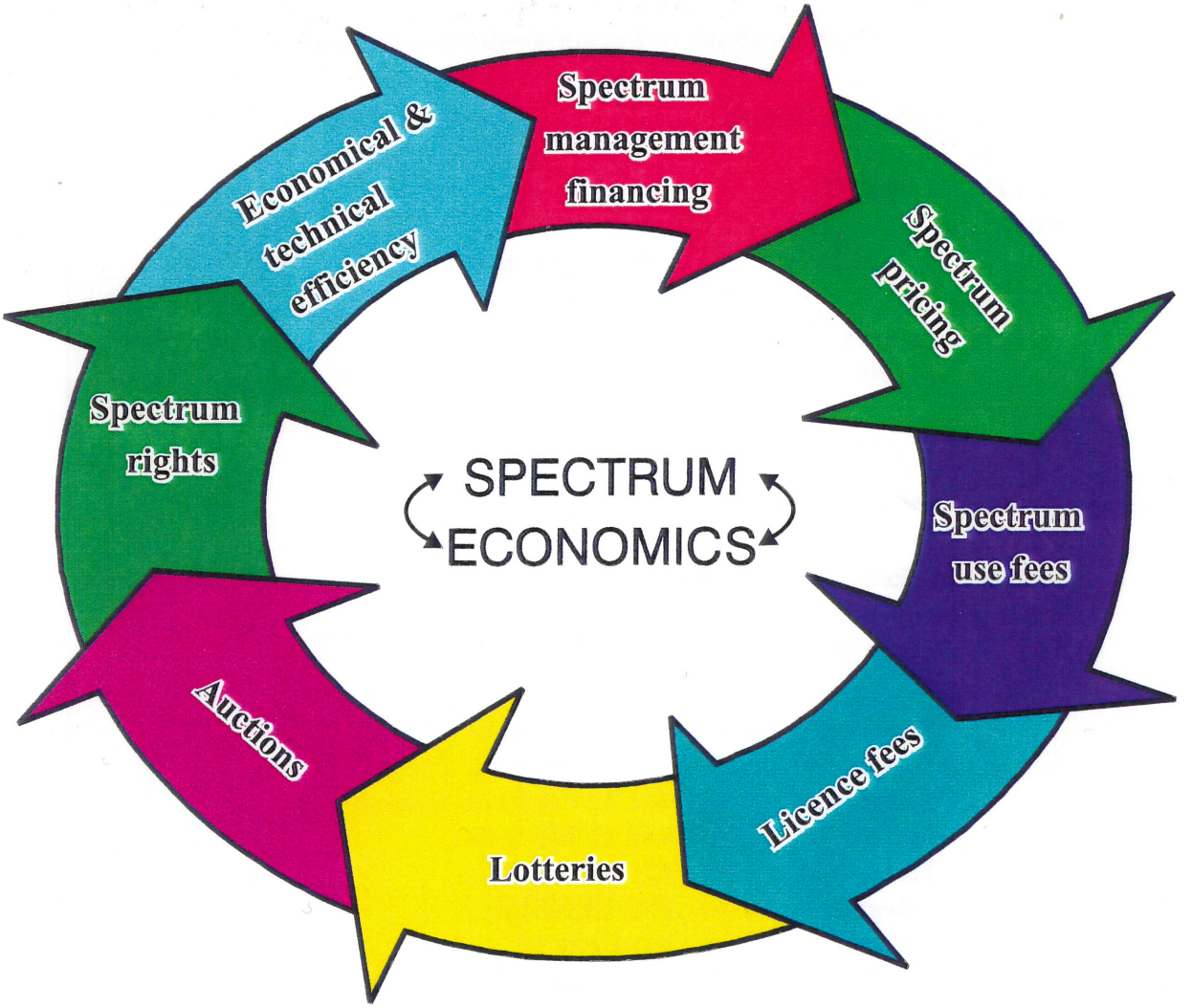
INTERNATIONAL TELECOMMUNICATION UNION

REPORT ITU-R SM.2012

ECONOMIC ASPECTS OF SPECTRUM MANAGEMENT



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SPECTRUM MANAGEMENT

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ITU-R SM SERIES REPORTS

SPECTRUM MANAGEMENT

(Study Group 1)

REPORT ITU-R SM.2012

ECONOMIC ASPECTS OF SPECTRUM MANAGEMENT

PREFACE

Report ITU-R 2012 "Economic Approaches to National Spectrum Management" has been developed by the Group of experts of Radiocommunication Study Group 1 on Spectrum Management.

The Report consists of four Chapters which describe the different economic approaches for spectrum management activities. The Chapters contain detailed explanations and references that can be consulted for additional information.

The Report is intended for the use by administrations of both developing and developed countries in their development of strategies on economic approaches to national spectrum management and to the financing of 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.

Robert W. Jones
Director,
Radiocommunication Bureau

FOREWORD

Radiocommunications have become an increasingly vital part of the telecommunications infrastructure and economy of a country. In order to have effective radiocommunications, a country must have an effective spectrum management system. A number of technical and regulatory procedures need to be implemented for the spectrum management system to be effective. These procedures are described in the ITU handbook on "National Spectrum Management" and, although complex, can be implemented with adequate financial resources, technical expertise and time. The key or starting point for this implementation is to obtain adequate financial resources for the spectrum management system. These financial resources can be obtained from the administration or from fees obtained from the use of the radio spectrum. The collection of fees varies from the fee for the processing of a radio licence to the auctioning of a portion of the radio spectrum.

The 1995 Radio Assembly recommended that Study Group 1 study on a urgent basis "Economic Approaches to National Spectrum Management" and accelerate the development of a report. This report answers many of the questions that were asked by the Radio Assembly and describes economic approaches that promote economic, technical, and administration efficiency and can also help fund a national spectrum system.

The main purpose of the economics report is to describe to developing countries methods of obtaining adequate financial resources to implement an effective national spectrum management system. The development of this report was primarily for the ITU-D sector and was accomplished in cooperation with ITU-D members. The report should be distributed to ITU-D members and comments sought on aspects of this subject that may need further clarification.

The completion of this report on a urgent basis was primarily due to the extra effort of a Rapporteurs group chaired by David Barrett, United Kingdom, Rodney Small and Karl Nebbia, USA, and Ian Munro, Canada. Special appreciation should also go to Alexander Pavliouk, Russia, who organized the completion of the report.

Robert J. Mayher
Chairman, Study Group 1

CHAPTER 1

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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 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. Therefore, every available means including economic means is needed to improve national spectrum management.

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 organisations. Which government bodies or organisations 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 Decision-making process

The processes developed to allocate spectrum, assign frequencies to specific licensees, and monitor compliance with license terms are essential tools for implementing national goals and objectives. Administrative bodies responsible for developing rules and regulations governing the spectrum should develop an organized decision-making process to ensure an orderly and timely spectrum management process. The process should be set up to allow decisions that serve the public interest while reflecting national policies and plans relating to the spectrum, developments in technology, and economic realities. Often such processes will depend on the use of consultative bodies to make appropriate decisions.

1.6 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.

1.6.1 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.

1.6.2 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.

1.6.3 Standards specification, and equipment authorization

Standards provide the basis for equipments to work together and limit the impact of radio use to that which is intended. In many cases, such as aircraft navigation and communications systems, equipment must be capable of operating in conjunction with equipment operated by other users and often other countries. Standards can be used to require design characteristics that will ensure that such operation is possible. The second aspect of standards is their use to ensure electromagnetic compatibility (EMC) of a system with its environment and generally involves limiting transmitted signals to a specified bandwidth or maintaining a specified level of stability in order to prevent interference to other systems. In some cases an administration may choose to set standards for receivers, requiring a certain level of immunity to undesired signals. The establishment of an adequate program of national standards forms a basis for preventing harmful interference and, in some cases, for ensuring desired communications system performance.

1.6.4 Spectrum control (Enforcement inspections and monitoring)

Effective management of the spectrum depends on the spectrum manager's ability to control use of the spectrum through enforcement of spectrum regulations. This control is built primarily on enforcement inspections and monitoring. See the ITU Handbook on Spectrum Monitoring.

1.6.4.1 Enforcement inspections

Spectrum managers must be granted the authority to enforce regulation of spectrum use and set appropriate penalties. For instance, spectrum managers may be granted the authority to identify a

source of interference and to require that it be turned off or to confiscate the equipment under appropriate legal mechanisms. However, the limits of that authority must also be specified.

1.6.4.2 Monitoring

Monitoring is closely associated with inspection and compliance in that it enables the identification and measurement of interference sources, the verification of proper technical and operational characteristics of radiated signals, and detection and identification of illegal transmitters. Monitoring further supports the overall spectrum management effort by providing general measurement of channel usage and band usage, including channel availability statistics and the effectiveness of spectrum management procedures. It obtains statistical information of a technical and operational nature on spectrum occupancy. Monitoring is also useful for planning, in that it can assist spectrum managers in understanding the level of spectrum use as compared to the assignments that are recorded on paper or in data files. Some administrations have chosen to use monitoring in place of licence records.

1.6.5 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.

1.6.6 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.

1.6.7 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.

1.6.8 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.

1.7 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 organisations to support and/or provide part, or all, of specific spectrum management functions.

1.8 Studies on economic aspects of spectrum management

The terms of reference for this economic study are given in Questions ITU-R 206/1, ITU-R 207/1 and ITU-R 208/1. The Radiocommunication Assembly in 1995 approved these Questions and recommended that Study Group 1 study these Questions on an urgent basis. Study Group 1, through Working Party 1B, created a Rapporteurs' Group to address these Questions and accelerate the development of this Report. The decides from these Questions are reproduced in the following to describe the subjects requiring study.

⇒ Question ITU-R 206/1: Strategies for economic approaches to national spectrum management and their financing

decides that the following Question should be studied

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?

⇒ Question ITU-R 207/1: Assessment, for spectrum planning and strategic development purposes, of the benefits arising from the use the radio spectrum

decides that the following Question should be studied

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?

⇒ Question ITU-R 208/1: Alternative methods of national spectrum management

decides that the following Question should be studied

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:

i) the country's infrastructure;

ii) national spectrum management;

iii) regional and international aspects (e.g. notification, coordination, monitoring)?

Note: the focus of this Report in answering Question ITU-R 206/1, decides 1, is placed on approaches to financing national spectrum management rather than underlying principles. Also, no models of the type discussed in Question ITU-R 207/1, decides 2, are presented as no consensus exists on how such models would be represented.

CHAPTER 2

STRATEGIES FOR ECONOMIC APPROACHES TO NATIONAL SPECTRUM MANAGEMENT AND THEIR FINANCING

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 impact of these approaches on financing a national spectrum management program and their impact on economic, technical, and administrative efficiency.

The following material describes the economic approaches to financing national spectrum management. Furthermore, it describes the use of economic approaches to promote efficient national spectrum management. The approaches promoting efficient national spectrum management are subdivided into spectrum assignment methods, both market based and non-market based, and transferable property rights. Finally the economic aspects of various fee mechanisms are discussed.

2.2 Underlying approaches with respect to financing national spectrum management

Each administration must find a way to ensure sufficient revenues to cover the costs of maintaining an effective spectrum management program. Adequate funding of spectrum management can be critical to implementing new spectrum-using services[1] and permitting those services to operate on an acceptable interference-free basis. Further, an adequately-funded spectrum management program creates opportunities for service providers and equipment manufacturers and contributes greatly to the growth of the economy. Inadequate funding of spectrum management, on the other hand, can result in a failure to implement valuable radio services, or delays in implementing such services. In fact, service providers may choose not to serve a country that has an ineffective spectrum management program in order to seek more hospitable spectrum regulatory environments in other countries.

It should be recognized that regardless of which of the following approaches is followed, the use of spectrum and spectrum management have associated costs borne by the population. Even where an administration issues licences without fees, the general population indirectly bears the cost burden for spectrum management through taxation. In that case, the share of spectrum management costs paid through the taxes of individuals that seldom use spectrum services will represent a greater amount than the benefits these individuals receive from spectrum services, while those that use spectrum services receive benefits that are greater than their share of the spectrum management cost burden. The use of licence fees and auctions for the purpose of covering the costs of the spectrum management system does not represent a new tax, but a potentially more appropriate method of distributing the costs of spectrum management to those who actually receive benefits.

[1] In this report the use of the word "service" with a non-capitalised "s" means an end-user service (e.g. cellular radio) and not a Radiocommunication Service.

2.2.1 Approaches

2.2.1.1 Traditional national budget financing

Until recently, virtually all countries have funded their spectrum management programs 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.

2.2.1.2 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 programs in whole or in part through fees. 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.

2.2.1.3 Auctions

Another way of funding spectrum management is through auctions, wherein the percentage of auction revenues necessary to fund a spectrum management program is retained. While no country has directly funded spectrum management through auction revenues, such revenues in the United States have vastly exceeded spectrum management costs in recent years.

2.2.2 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 program. 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,[2] 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.

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

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[2] In the United States, auctions held during 1994-1996 exceeded estimates, whereas recent auctions have fallen short of estimates.

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 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.[3] 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..

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[3] Typically, these criteria might include population to be served, quality of service, and speed of service implementation.

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 applicants' 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 section 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 section 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 minimising 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, 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 licences 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 endeavoring 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 beam-widths 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, potential service providers would likely 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 deter entry and impede the provision of service and the development of new international satellite services under current ITU Radio Regulations.

2.3.4 Experience with auctions and transferable property rights

During the 1990s, some countries have used auctions to assign licences.[4] Additionally, a few of these countries have recently introduced limited systems of transferable property rights, wherein licences to use spectrum may be sold to other parties.

2.3.4.1 Australia

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

- **Making use of price as a tool in assigning licences**

The radio frequency spectrum represents a scarce community resource, and in some frequencies, especially those capable of producing high future revenue for licensees, the possibility exists for high economic rents to be gained by the initial licensees. In attempting to capture these economic rents for the general community the SMA has successfully conducted three price-based assignments using an "open-cry" (English) auction style process. The auctions were used to assign Multipoint Distribution Station (MDS) apparatus licences, which are capable of being used for Pay TV, in the major population areas of the country. The licences, situated in the 2 GHz band, recouped in excess of A$100 million for the Government and the bid prices paid reflect the future revenue gains that the market considered were capable of being achieved by the successful bidders.

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[4] For a discussion of auction types and design, see "Selling Spectrum Rights" by John McMillan in the *Journal of Economic Perspectives*, Volume 8, Number 3, Summer 1994, pp. 145-162.

- **Introducing a new form of licensing: the spectrum licence**

The market system is based on the principle that direct marketing of spectrum will result in more efficient spectrum use. Under the market system, users of spectrum will make decisions on their spectrum access recognizing the pressures of demand and supply. To facilitate a more market oriented approach to spectrum allocation and management, the SMA is introducing a new type of licence, analogous to a property right, called a spectrum licence. Spectrum licensing, instead of focusing on equipment and its uses (which in turn defines the area covered and the frequency bandwidth used), authorizes the use of spectrum within specified limits of frequency bandwidth and coverage area. Under spectrum licensing, licensees will have the flexibility to change their equipment, antenna, siting, in fact any aspect of their use of spectrum, provided they comply with the core technical conditions of the licence, and any coordination requirements. A spectrum licence is tradable and provides explicit rights for a fixed period up to ten years. Users will be able to adjust the amount of spectrum they wish to use and the type of use they make of that spectrum in response to commercial incentives brought about by the price of spectrum access.

This new licence type, which complements rather than replaces traditional apparatus licensing, is to be allocated using price based allocation methods. The SMA recently completed its first simultaneous multiple round auction for spectrum licences in the 500 MHz band.

Together with licence fees, the reforms being implemented by the SMA represent a fundamental shift in spectrum management in Australia. Market forces have been given a much greater role in spectrum assignment and use, and so far the initiatives taken have proven to be successful in promoting the SMA's primary objective of facilitating access to, and use of, the radio frequency spectrum.

2.3.4.2 Canada

The Canadian *Radiocommunication Act* was amended in June 1996 to provide the explicit authority for the use of spectrum assignment auctions in appropriate circumstances. The only auction announced to date is for spectrum in the 28 GHz range for local multipoint communications services (LMCS), to be held in late 1998.

2.3.4.3 New Zealand

Most administrations that have begun applying market-based approaches continue to allocate spectrum based on consideration of national priorities, and have only applied market approaches to licensing within an agreed allocation. New Zealand, however, has applied a broader market-based approach to use of some frequency bands where the impact is limited to a national, rather than an international, scale.

In 1990, New Zealand introduced legislation to establish a regime of spectrum property rights. A "Management Right" to a frequency band enables the owner of that right to create licences to use frequencies within the band. The key differences introduced by this new procedure are that a licence is given a legal status in respect to transmission and interference, it has a tenure up to 20 years, and the licence becomes legally tradable. Though a specific application is not required, the technical limitations of the licence provide inherent limitations on the nature of use. This concept has been applied in the following bands:

526.5-1606.5 kHz	Management Rights retained by the Government and MF-AM broadcast licences created and tendered

	International coordination based on ITU Region 1/3 LF/MF plan
88-100 MHz	Management Rights retained and VHF-FM broadcast licences created and tendered
518-582 MHz and 646-806 MHz	Management Rights retained and UHF-TV broadcast licences created and tendered
825-835 MHz and 870-880 MHz	Management Rights tendered suitable for cellular telephony or other services
835-845 MHz and 880-890 MHz of	Management Rights transferred under transitional provisions the legislation
890-960 MHz	Management Rights tendered in form suitable for two cellular operators or other services
2300 - 2396 MHz	Management Rights tendered in 12 bands of 8 MHz

Work is underway to create Management Rights for Band I and Band III (television). A review of the band 1.7-2.3 GHz is currently being undertaken, with a view to establishing suitable spectrum blocks for PCS development. Concurrent with this will be a move to define this spectrum for ultimate transfer to "Management Rights", using the tendering/auctioning process.

New Zealand has held a number of spectrum auctions, including simultaneous multiple round auctions. In its experience, the auctioning/tendering process requires careful consideration and planning. It should not be seen as the panacea for all spectrum issues and indeed much spectrum cannot be considered in for this process. Consideration should also be given to the need to ensure actual use of spectrum after it has been auctioned by some sort of "use or lose legislation" which might be required to ensure that spectrum is not hoarded to prevent competition taking place.

When developing a suitable auctioning regime, early consideration needs to be given to the extent of possible participants. For example, will it be open to overseas companies/organizations? This decision may impinge on strategic planning, and any exclusion of such entities needs to be clearly stated up front.

2.3.4.4 United States

- **Authority**

In the United States, spectrum management functions are divided between the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA). The FCC is tasked with managing non-Federal Government use of spectrum, including use by the private sector and local and state governments. The NTIA is authorized to manage Federal Government agencies' spectrum use, including the military. The U.S. Congress gave the FCC authority to issue licences via auctions in 1993. This authority is limited to using competitive bidding in instances where mutually exclusive applications have been received and where the principal use of the spectrum is reasonably likely to involve the receipt by the licensee of fees from subscribers in return for enabling those subscribers to receive or transmit communications signals. In granting the FCC auction authority the U.S. Congress sought to promote the following objectives:

"(1) the development and rapid deployment of new technologies, products, and services for the benefit of the public, including those residing in rural areas, without administrative or judicial delays;

(2) promoting economic opportunity and competition and ensuring that new and innovative technologies are readily accessible to the American people by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants, including small businesses, rural telephone companies, and businesses owned by members of minority groups and women;

(3) recovery for the public of a portion of the value of the public spectrum resource made available for commercial use and avoidance of unjust enrichment through the methods employed to award uses of that resource; and

(4) efficient and intensive use of the electromagnetic spectrum."

In granting authority to use competitive bidding, the U.S. Congress also specified that the use of competitive bidding:

"(1) shall not alter spectrum allocation criteria and procedures;

(2) shall not be construed to relieve the FCC of the obligation in the public interest to continue to use engineering solutions, negotiation, threshold qualifications, service regulations, and other means in order to avoid mutual exclusivity in application and licensing proceedings."

The U.S. Congress further specified that the FCC cannot make allocation or service decisions based on the expectation of public revenue from auctions.

The majority of the proceeds from auctions conducted by the FCC are deposited in the general U.S. treasury. The FCC is permitted to retain only that portion of the auction proceeds necessary to pay for the cost of holding the auctions. This portion is well under 1% of the revenues generated by auctions. Generally, the licences that have been issued pursuant to auction are for a ten-year period, and it is intended that after this period the licence would be renewed if the licensee has complied with applicable FCC rules and has provided substantial service.

The following are services that have been licenced in the United States pursuant to auctions.

- **Personal communications services**

Personal Communications Services (PCS) providers are expected to give the public new communications capabilities by providing a variety of mobile services to compete with existing cellular, paging and other land mobile services. These services will be provided via a new generation of communications devices with two-way voice, data and/or message capabilities. These devices include small, lightweight, multi-function wireless phones, portable facsimiles and other devices. PCS is composed of several distinct categories, two of which are Narrowband PCS and Broadband PCS.

The FCC held its first auction in July 1994, auctioning 11 nationwide licences to provide Narrowband PCS in the 900 MHz band. Narrowband PCS can be used to provide new services such as voice message paging, two-way acknowledgment paging in which a subscriber can receive a message and transmit a response back to the sender, and other data services. Licences for Narrowband PCS may cover the entire nation (nationwide licence), large regions (regional licence), or smaller areas. Of the nationwide licences, five are 50/50 kHz paired, three are 50/12.5 kHz paired, and three are 50 kHz unpaired.

From October 26 through November 8, 1994, the FCC auctioned 30 regional Narrowband PCS licence: six licences in each of five regions of the United States. Two licences in each region are 50/50 kHz paired and the remaining four are 50/12.5 kHz paired.

In December 1994, the FCC held its first auction of licences to provide Broadband PCS in the 2 GHz (1850-1990 MHz) band. Broadband PCS encompasses a variety of mobile and/or portable radio services, using such devices as small lightweight, multifunction portable phones, portable facsimile machines, and advanced devices with two-way data capabilities, that are expected to compete with existing cellular, paging and other land mobile services.

The 1850-1990 MHz band was divided into six licence blocks. Licence blocks A, B, and C are each for 30 MHz of spectrum (two paired 15 MHz-wide segments). Licence blocks D, E, and F are each for 10 MHz of spectrum (two paired 5 MHz-wide segments).[5]

Licences for blocks A and B cover regional Major Trading Areas (MTAs). There are 51 MTAs that, combined, cover the entire United States and its territories. Licences for blocks C, D, E, and F cover Basic Trading Areas (BTAs). BTAs are components of MTAs, and there are 493 BTAs that combine to cover the entire United States and its territories. MTAs and BTAs are economic trading areas based on designations contained in the Rand McNally Commercial Atlas and Marketing Guide.

In the auction beginning in December 1994, the FCC auctioned licences in both frequency blocks A and B in 48 MTAs. In the other three MTAs, only the block B licence was auctioned. In those three MTAs (New York, Los Angeles, and Washington-Baltimore), the block A licence was previously awarded under the FCC's pioneer's preference rules. Thus, a total of 99 licences were auctioned. Thirty bidders qualified to bid in the auction and the auction lasted more than 112 rounds before concluding in March 1995.

The FCC began auctioning licences for Broadband PCS block C in the 493 BTAs in December 1995. Unlike the MTA auction, bidding credits and installment payment plans were available to small entities for Block C. The auction concluded in May 1996 after 184 rounds. Auctioning for Broadband PCS blocks D, E and F began in August 1996 for 153 bidders who qualified to participate for 1,479 different licences. Bidding credits and installment payment plans were available for Block F only. The auction concluded in January 1997 after 276 rounds.

Although PCS is a new service, the spectrum that it occupies was previously allocated and licenced to a variety of fixed service (point-to-point) microwave users, including public safety services. As PCS systems begin to occupy the 1850-1990 MHz band, it will be necessary either to move the incumbent microwave systems to another frequency band or to provide for their communications needs through some alternative means, such as cable. In establishing the PCS service, the FCC determined that the fastest and fairest way to make this transition is to have the new PCS licensees pay to move the microwave users out of the band. The FCC therefore established a procedure whereby the new PCS licensees and the incumbent microwave users have a certain period to negotiate the terms of the reaccommodation. In any event, however, the microwave users must vacate the band as of a certain date and cannot therefore prevent implementation of the new services.

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[5] Note that all six blocks combined contain 120 MHz of spectrum. The other 20 MHz (1910-1930 MHz) in the 1850-1990 MHz band is used by unlicensed PCS services.

- **Interactive video data service**

The FCC held its second auction, for 594 Interactive Video Data Service (IVDS) licences, during July 1994. IVDS is a two-way communications service in the 218-219 MHz band. Licences are for a ten-year period, and consist of two 500 kHz licences in each of 297 Metropolitan Statistical Areas (MSAs), which are essentially the urbanized areas of the United States. In each market, both licences were available for auction at the same time, with the highest bidder given a choice between the two available licences and the second highest bidder winning the remaining licence. The FCC auctioned all 594 licences within two days.

- **Specialized mobile radio service**

The Specialized Mobile Radio (SMR) service is a land mobile radio service that provides dispatch, voice, and data services to commercial businesses and specialized users, although licensees are also permitted to provide service to the general public. The SMR service operates in both the 800 MHz and 900 MHz bands.

The FCC established the SMR service in the 800 MHz band in 1974 as a private land mobile radio service intended as a spectrally efficient method to provide dispatch radio service to businesses and other users that qualified as private radio users. Originally, applicants were limited to a relatively small number of channels to be located at a single base station. Coverage and service options were therefore limited. These licences were issued on a first-come, first-served basis, with a lottery used to resolve instances of mutual exclusivity. Over the years, however, the demand for this service increased and the rules limiting eligibility and licensing were gradually reduced. SMR providers today offer a range of services from traditional radio dispatch for local customers to more sophisticated voice and data transmissions for customers over large geographic areas. SMR licensees, in recent years, have been authorized to expand the geographic scope of their services and aggregate large numbers of channels to provide service more directly comparable to cellular radio and PCS. In October 1994, the FCC proposed to issue 800 MHz SMR licences based on FCC-defined service areas and subject to competitive bidding. The 800 MHz band will be the subject of a future auction.

The 900 MHz SMR service consists of 5 MHz of spectrum divided into twenty 10-channel blocks in each MTA. Assignments in the 900 MHz SMR service offer the potential for such competitive services as wireless data, specialized dispatch, two-way paging, and interconnected voice transmission. Licences for this service were initially issued for single transmitter sites in the 50 largest cities in the United States with licensees selected by lottery. Licensing, however, was suspended for a number of years, and the FCC recently restructured the service to issue area-wide licences pursuant to competitive bidding. Original licensees are protected from interference from new licensees; however, they can expand their operations only by obtaining a new licence.

- **Multichannel multipoint distribution service**

Multichannel Multipoint Distribution Service (MMDS) is often referred to as "wireless cable". It offers delivery of video programming to subscribers using MMDS and/or Instructional Television Fixed Service (ITFS) channels. Only MMDS channels at 2150-2160 MHz and 2596-2680 MHz have been auctioned. MMDS resembles cable television, but instead of coaxial cable, "wireless cable" uses microwave transmission and signals. In the past, MMDS licences have been issued for specific coordinates at which the central transmitter was located. However, the FCC recently revised the MMDS licensing procedures so that all licensees will be authorized to operate throughout particular BTAs. New licensees will be required to avoid interference within the protected area of existing MMDS operations (a 35-mile radius). The FCC stated that mutually

exclusive applications that are filed for a particular BTA will be processed using competitive bidding.

- **Direct broadcast satellite**

The Direct Broadcast Satellite Service (DBS) is a radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public. This includes direct reception by both individuals and the community. The FCC held a very limited DBS auction for two orbital slots in January 1996. In adopting auction procedures, the FCC noted that there are characteristics of a national broadcast satellite service, such as the footprint of the satellite falling within the United States, that make DBS different from many other satellite services. One winning bidder received a construction permit for 28 channels and the second winning bidder received a construction permit for use of 24 channels.

- **Satellite digital audio radio**

The Satellite Digital Audio Radio Service (DARS) is a broadcasting-satellite (sound) radiocommunication service located in the 2320-2345 MHz band, in which high-quality audio signals are transmitted to the earth by satellite, either to subscribers or to the general public. The FCC held a satellite DARS auction for two 12.5 MHz licences in April 1997. Both winning bidders plan to offer subscription-based services. Licences are for an eight-year period.

- **Wireless communications**

The Wireless Communications Service (WCS) is a radiocommunication service located in the 2305-2320 MHz and 2345-2360 MHz bands. WCS licensees have the flexibility to offer a variety of fixed, mobile, radiolocation, and broadcasting-satellite (sound) services, except that broadcasting-satellite (sound) and aeronautical mobile services may not be offered at 2305-2310 MHz. The FCC held a WCS auction for two 10 MHz licences for each of 52 Major Economic Areas (MEAs) and two 5 MHz licences for each of 12 Regional Economic Area Groupings (REAGs) in April 1997. MEAs and REAGs consist of groupings of smaller Economic Areas, as defined by the U.S. Department of Commerce. There are 176 Economic Areas that cover the United States and its territories. A large variety of companies won licences in the WCS auction. Licences are for a ten-year period.

2.3.5 Licence fees

Licence fees represent another way which can be used to improve the economic and technical efficiency of national spectrum use, in addition to generating revenues.

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[6]. 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. Similar to auctions, licence fees assign a value to the spectrum and may, if the fee is set at an appropriately high level, oblige radiocommunications users to arbitrate between spectrum and the other inputs, including radiocommunications equipment, that such users employ.

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

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[6] In some Administrations fees may cover concessions, authorisations or permissions.

interest uses, such as by non-profit organizations; however, Australia, Canada, and the United Kingdom, among other countries, do charge government entities.

The basic types of fees are those based on the spectrum management authority's administrative costs of processing licence applications, revenues derived from licensees' use of the frequency spectrum, and incentive fee formulas. Administrative fees are based on direct regulatory costs incurred by spectrum managers in processing applications, and may also reflect indirect spectrum management costs; i.e., overhead costs. Individual licensees are generally grouped into service categories and may be charged fees proportional to bandwidth occupied. Revenue-based fees are proportional to the revenue the licensees generate from use of the spectrum. Incentive fee formulas attempt to take into account to at least some extent the scarcity value of the spectrum. These fees generally reflect the population or area served by the radio station, bandwidth, and in some cases a variety of other factors.

A more complicated solution 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, which has prove to be a very difficult task.

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 substantial improvements in administrative efficiency.

2.3.6 Advantages and disadvantages of fee approaches

2.3.6.1 General

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 what would be paid at auction. 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 what would be paid at auction, economic efficiency will be improved even though excess demand will remain for the spectrum, and revenues to the spectrum management authority will be below those realized in an auction. 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-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.

2.3.6.2 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 administrative 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 fact, 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.

2.3.6.3 Fees based on users' revenues

Establishing a fee based on a certain percentage of revenues related to spectrum use has the advantage of generating 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 revenue increases, which could be viewed as both efficient and equitable. However, there are two major problems with this type of fee. First, it can apply only to users having revenues directly linked to spectrum use, e.g., broadcasters and mobile service providers. It can apply neither to those users whose revenues result only indirectly from spectrum exploitation, e.g., public utilities and telephone companies using microwave links in portions of their fixed network nor to non-commercial services, e.g., defense and national parks. Second, such a fee does not necessarily promote efficient spectrum use or equitable treatment of licensees because user revenues are not directly related to the value of the spectrum. For example, two broadcasters may have identical revenues, 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.

2.3.6.4 Incentive fee formulas

Incentive fee formulas have the advantage of reflecting to at least some extent the scarcity value of the spectrum. By taking into account factors such as population, area, and bandwidth used, such formulas may in some cases approximate the values that would have been realized in an auction. However, the disadvantage of such fees is that no formula, however complex, can take into account all the variations of the market-place. Further, complex formulas may induce a false sense of security among spectrum managers in that they may produce fees that appear "reasonable", but which actually are much lower or higher than would be realized in an auction. For some services, technical factors preclude a reduction in bandwidth and therefore incentive fees based on bandwidth would be inappropriate; for example, radar services.

2.3.6.5 Opportunity cost fee formulas

Opportunity cost fee formulas have the advantage of being directly targeted at the desirable goal of simulating the prices that would be realized in an auction. 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. 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. For example, the three US broadband PCS auctions produced results strikingly different than what had been forecast by almost all analysts.

2.3.6.6 Fee calculation example

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

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

$$F = f(Di, LiI) \quad (2)$$

where F = fee charged to licensee

Di = direct administrative costs of processing licensee's application

Li = licensee's proportion of indirect administrative costs

I = total indirect administrative costs

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

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

where F = fee charged to user

a = proportionate fee established by regulatory agency

R = user revenues

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

$$F = f(B, G, L, E, T) \quad (4)$$

where F = fee charged to licensee

B = bandwidth

G = geographic area covered

L = location

E = exclusivity of use

T = target revenues (Note: this variable is set arbitrarily by the administration)

Opportunity cost fee formulas may also be used. Such fee formulas will resemble incentive fee formulas. However, the target revenues variable (T) 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.

2.3.7 Experience with licence fees

2.3.7.1 Australia's experience with licence fees

In addition to conducting spectrum auctions and implementing a limited system of property rights, the Spectrum Management Authority has attempted to improve the efficiency of the traditional system of licensing. Underpinning the SMA's approach has a been a fundamental restructuring of radiocommunications apparatus licence fees. In April 1995, the SMA, in consultation with industry, moved from a traditional, service based methodology of charging for spectrum usage, to a system which charges on the basis of the amount of spectrum that a particular service denies to other users. Thus, licence fees are calculated in a more consistent and transparent manner, as opposed to the somewhat arbitrary approach that focused predominantly on the characteristics of the radiocommunications service being licenced.

Under the new apparatus licence fee structure, each licence fee generally consists of three identifiable components:

◊ An issue or renewal component, reflecting the cost of issuing or renewing the licence;

◊ A spectrum maintenance component, reflecting the ongoing cost of managing the spectrum, including protection from interference (a fixed percentage of the spectrum access tax, or SAT, described below) and;

◊ A spectrum access tax, which represents a return to the Government for use of a community resource, and is based on a formula involving spectrum location, geographic location, channel bandwidth, and communications coverage area.

The calculation of the SAT represents a market demand based pricing strategy insofar as services operating in higher demand areas of the spectrum (i.e., UHF/VHF) or more densely populated geographic areas (i.e., major capital cities) attract a higher licence fee than those operating in lower spectrum demand or geographic demand areas. Furthermore, in accordance with the spectrum denial methodology, services with larger operating bandwidths attract a higher licence fee than more spectrum efficient services, thereby encouraging users to seek more technically advanced equipment that utilizes narrower operating bandwidths, or alternatively encouraging users to operate in segments of the spectrum that are in greater supply.

The SMA has also introduced measures which allow greater flexibility and certainty for users in the radiocommunications market. Flexibility has been achieved by allowing licensees to transfer their apparatus licences to third parties, while greater certainty has been accomplished by permitting licensees to acquire licences for periods of up to five years.

2.3.7.2 Canada's experience with licence fees

Industry Canada is in the process of overhauling its spectrum licence fee model. The existing fee regime suffers from a number of economic "disconnects" and the goal of a current review exercise is to produce a new system in which fees are equitable among users and contribute to the objectives of economic efficiency and resource rent capture.

The model is based on measuring spectrum consumption in three dimensions: bandwidth, geographic coverage, and exclusivity of use. Larger bandwidths, greater geographic coverage, and exclusive use of a spectrum assignment will all result in higher fees, whereas smaller bandwidths, lesser geographic coverage, and a willingness to share the use of a spectrum assignment will all result in lower fees. Hence, spectrum users will face an incentive to conserve on their spectrum use, consistent with the objective of economic efficiency.

Of course, two licences identical in these three dimensions may have widely divergent real values because of geographic location[7], spectrum in a major city presumably being more valuable than spectrum in the high Arctic, for example. To account for these differences, and given the difficulties inherent in trying to determine true market values in the absence of a functioning market, the concept of spectrum scarcity has been applied as a sort of proxy variable. A grid/cell pattern has been overlaid on the geography of Canada, and in each cell, the volume of spectrum consumed by all users in a given band is divided by the total volume of spectrum existing in that band. It is this ratio that will determine the relative levels of fees across the country. In areas where spectrum use is high, such as major cities, the spectrum scarcity measure, and as a result the licence fee, will also be high. Conversely, where spectrum use is low, such as in the high Arctic, fees will be low. Geographic information software is used to operate the model in a quick, efficient, and user-friendly manner.

2.3.7.3 Israel's experience with licence fees

The Ministry of Communications in Israel has established a fee system intended to exert a market pressure on use of the spectrum. Through the fee system, whereby the fee per 1 MHz decreases with frequency above 960 MHz, higher frequency use is encouraged. Below 960 MHz, the licence fee is about $170,000 ($US) per 1 MHz. This approach has been taken to encourage the use of less occupied bands and to encourage spectrum users to take advantage of the higher frequency reuse associated with high attenuation and lower antenna side-lobes at higher frequencies.

2.3.7.4 United States' experience with licence fees

The FCC began collecting application fees in 1987 that are charged for all FCC-licenced radio services and are intended to cover the direct administrative costs of processing a licence application. Local and state governments and nonprofit entities are generally exempt from application fees. Application fees vary from service to service and are not intended to cover the cost of FCC

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[7] Similarly, the value of spectrum will vary across frequency bands due to differences in propagation characteristics, among other things.

activities that are related to spectrum management, such as domestic and Radio Regulation treaty enforcement, or policy activities that are not directly associated with processing an application.

In 1993, the United States Congress mandated that the FCC must collect regulatory fees to cover its enforcement activities, policy and rulemaking activities, user information services, and international activities. Consequently, regulatory-related fees were implemented in 1994. By statute the total fees collected must cover, but cannot exceed, the amount of money appropriated by Congress to the FCC for these activities. Regulatory fees collected are deposited into an account providing appropriations to the FCC. Each year, the United States Congress mandates a specific amount that must be collected during that fiscal year. Fees are charged (on an annual basis) at the time the service is rendered and vary from radio service to radio service. However, the U.S. Congress has regularly considered and rejected a spectrum access tax.

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, 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 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 programs 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.

Accordingly, national spectrum managers have 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[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[8] arising from the use of the radio spectrum are 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.

3.2 Methods of assessing the spectrum's economic benefits

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

Two methods used for quantifying economic benefits have been identified in the report "The Economic impact of the Use of Radio in the UK[9]" published in 1995. The methods calculate the contribution of radio use to the economy using:

1) Gross Domestic Product GDP and employment;

2) 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

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8 Here the term benefits is not used in its standard economic sense. .

9 Produced by National Economic Research Associates (NERA) and Smith System Engineering Limited in 1995, commissioned by the Radiocommunications Agency (RA) and the Office of Telecommunications (Oftel).

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, see 2.1.1) 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:

i) 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 relatively straightforward. When the radio service provides only part of the business (e.g. Private Mobile Radio - PMR) it can be more difficult;

ii) 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;

iii) 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:

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

ii) 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 UK, 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) x MPE.

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

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.

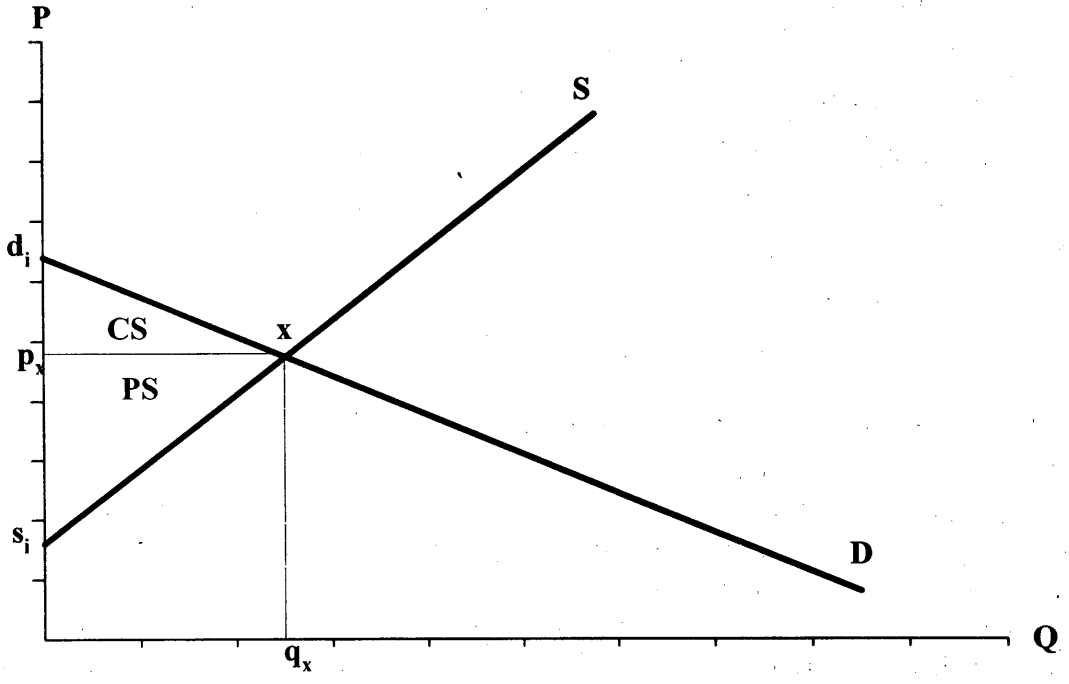
3.2.2 Consumer and producer surplus

Consumer surplus is a measure of the difference between what a customer is willing to pay and the actual price of the product. 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. 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 Figure 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).



P - price axis

Q - quantity axis

D - demand curve

S - supply curve

d_i - demand curve intercept

s_i - supply curve intercept

x - point of intersection between supply curve and demand curve

p_x - price of item

q_x - quantity sold at price p_x

CS - consumer surplus (triangle p_x-x-d_i)

PS - producer surplus (triangle p_x-x-s_i)

FIGURE 1

Consumer and producer surplus

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, radioastronomy.

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 UK, 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 (e.g. in the UK[10] it equates to approximately 2 % of GDP or £13,000m and 410,000 jobs). 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

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10 From "A study to evaluate the economic impact of the use of radio in the UK" by NERA/Smith System Engineering Limited in 1997, commissioned by the Radiocommunications Agency (RA) - estimates based on the 1995/96 Financial Year.

GDP and employment may not include consequential improvements in associated businesses arising from improvements in their efficiency (e.g. cellular telephone users' 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 liberalisation 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 maximise the economic benefits from the utilisation 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 maximised. 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. For example, it has been estimated that a two year delay in providing spectrum for Personal Communications Network (PCN) services in the UK would have cost the economy £410million GDP or £2.5billion consumer surplus a year and 7,600 jobs. 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 optimising 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 organisations. 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 UK a follow up study to the 1993/94 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 1000 jobs a week. Employment[11] 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.

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 radiocommunication 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

[11] 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.

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 characterises 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 administration 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 the potential economic benefits.

Frequency availability is closely linked with coverage area and required bandwidth. The larger the coverage area the lower the frequency re-use 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: 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 UK, 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, determine 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 UK 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 UK'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 UK, 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 UK 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 S5 and individual differences from RR Article S5 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.

3.5 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 two UK studies. In the past, failure to recognise radiocommunications' 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

ALTERNATIVE SUPPORT FOR NATIONAL SPECTRUM MANAGEMENT

4.1 Introduction

Increasing requests for use of the radio spectrum, the need for more efficient and effective frequency assignment strategies, and ever changing radio technologies place an increasing burden on national spectrum managers. Administrations, particularly those in the developing or least developed countries, often have limited financial and human resources that can be applied to spectrum management. In some cases, these limitations can delay or restrict the implementation of communications vital to the national economy, services, and security. Therefore, administrations need to consider alternatives to the traditional centralized, government operated and funded national spectrum management systems. Though national spectrum management remains a primarily governmental effort, alternative approaches using resources outside the national spectrum manager to perform or fund certain spectrum management functions can enhance the efficiency and effectiveness of the national effort.

A number of administrations have made use of spectrum management resources outside the national spectrum manager including:

◊ communication groups with a direct interest in spectrum such as advisory committees, trade associations, professional organizations, and quasi-governmental associations;

◊ frequency coordinators (and coordination groups) and designated spectrum managers; and

◊ spectrum management consultants, and support contractors.

These alternatives can be used to support the national spectrum manager in performing the nine spectrum management functions listed in Chapter 1. Which approach is used may vary with frequency band, radio service, and/or specific radio application, the capability resident within the national spectrum management organization, and the expertise available from other resources. For example, the national spectrum manager may find that sufficient technical expertise and experience to deal with traditional radio applications such as HF radio or FM broadcasting already reside within the national spectrum management organization. On the other hand, new cellular mobile systems may present a complex spectrum management problem beyond the existing capabilities of the national spectrum management office. Furthermore, the national spectrum manager can determine the limits of responsibility and authority granted these groups based on the function to be supported. For example, while consultants can be used to study policy and planning options or support radio conference activities, they cannot be used to make policy and planning decisions or ratify conference agreements. Administrations may also find that a combination of approaches may be required to perform the overall spectrum management function.

The objectives of using groups outside the national spectrum manager to assist in the spectrum management process are:

◊ to save government financial or human resources;

◊ to increase the efficiency of spectrum use;

◊ to improve the efficiency of the frequency assignment and coordination processes; or

◊ to supplement the expertise of the national spectrum manager.

4.2 Approaches

4.2.1 Communications Groups with a direct interest in spectrum

Interested communications groups include organizations established by communications professionals, radio users, and manufacturing or trade associations having an interest in the use of the spectrum. In most cases, these organizations develop by themselves around their shared interests, but the government may need to establish a group, such as a formalized advisory committee, to perform some spectrum management activity. These groups have detailed knowledge of the technical capabilities of their equipment and of their members' needs. They have a good understanding of practical concerns associated with system operations and manufacturing.

Due to the benefit that their members derive from their involvement in standards development, frequency coordination, engineering capability development, and research, they are often willing to participate in spectrum management related activities, frequently at no cost to the government. Though administrations often view inputs from these groups as advisory in nature, the work provided can be invaluable in relieving the national spectrum manager of the need to prepare such advice internally. In some cases, the input of these groups may help to establish a level of voluntary self-regulation among spectrum users.

There may not always be adequate manufacturing or user interest within a single country to justify the establishment of national groups. In these cases, the work of multinational, regional or international bodies may be used to support the national spectrum manager. For example, many countries adopt as national regulations, standards developed within international standards bodies.

4.2.2 Frequency coordinators, designated spectrum managers and system licence holders

4.2.2.1 Frequency coordinators and coordination groups

Frequency coordinators are spectrum management resources outside the national government given the authority to coordinate the selection of frequency assignments within specific parts of the spectrum. This does not necessarily include final authority for the assignment of frequencies. Coordination groups are often created around users with like interests, recognizing that each band is allocated for specific use in which a limited number of parties are interested or permitted.

The frequency coordinator brings together spectrum users concerned with spectrum use in specific bands, performing analysis, selecting frequencies, and in some cases maintaining necessary frequency assignment databases. After selecting a frequency or frequencies the coordinator presents the coordinated request for final approval by the national authority. Having gone through this process, the prospective user can practically be guaranteed access to the spectrum on the frequency coordinated.

The use of frequency coordinators may require financial resources from the government in exchange for the technical expertise provided. More often, however, the national authority grants the coordinator the authority to collect fees for its services from spectrum users. Coordination groups, created by the interested parties to coordinate their spectrum use, can be recognized by the national authority and granted the responsibility to coordinate use in specific bands. In such cases, payment for services is jointly agreed by the members of the group, and generally covers the costs of operating the coordination group.

4.2.2.2 Designated spectrum managers outside the national spectrum manager

Designated spectrum managers are spectrum management resources outside the national

government given the authority to manage the spectrum or parts of the spectrum by the national spectrum management authority. This includes the authority to grant frequency assignments and, in some instances, to establish limitations on the operations or technical characteristics of radio stations. Designated spectrum managers can perform functions including engineering analysis, frequency coordination, monitoring and licensing.

The use of designated spectrum managers requires financial resources from the government or the authority for the spectrum manager to collect fees from spectrum users. In cases where the national spectrum management authority chooses to allow market influence to have its maximum impact, private sector spectrum managers may be charged for the opportunity to perform the management function particularly if they are able to seek profits in providing their service to spectrum users.

4.2.2.3 System licence holders

Many administrations have found that, by providing licences that cover an area and a range of frequencies, the responsibility for managing the spectrum in that geographic area can be turned over to the licence holder. This approach is particularly applicable to cellular, point-to-multipoint and other high density operations. The licence holder can determine the specific channelization, site locations, and other system characteristics. This provides significant relief to the national spectrum manager.

4.2.3 Spectrum management consultants and support contractors

Consultants are individuals that provide various types of service support. They can provide advice to national spectrum managers or in some cases represent the national authority and carry out its policies. Consultants provide services directly to the national spectrum manager or other spectrum users. The consultant may perform engineering analysis, select frequencies, develop policies, or participate for the government in spectrum management fora. No authority is conveyed to the consultant other than to represent the views or policies of the national spectrum manager. Financial support for the private sector consultant comes from the national spectrum manager.

Consultants can support a temporary need of the spectrum management organization, or their use may represent a long term strategy of limiting government staff and increasing staffing flexibility. If the intent is temporary support, these resources may need to be used in part to train the staff of the national spectrum manager. Where they are viewed as a more permanent approach, sufficient expertise must be maintained by the national spectrum manager to select qualified contractors and oversee contracted activities.

In some cases, the national government may find it necessary or advantageous to staff some organizational component or components of the national spectrum management office through the use of staff support contractors. For the most part, these contractors provide various forms of technical support, such as computer or engineering support. Under this type of approach, government staff are used to oversee the overall operation.

While most consultant and support contractors are provided through private sector companies, many administrations have used government technical organizations to support spectrum management. Though this approach does not directly result in a net financial savings, it can lead to efficiencies through the focusing of technical expertise.

4.2.4 Costs and benefits of the approaches

While these approaches can assist the national spectrum manager in managing the growing workload or technical complexity of the work, the government may lose some of its control.

Although some of this loss of control may in fact be positive and result in greater initiative from interested parties, the national spectrum manager will need to ensure against undesired losses. Furthermore, the use of groups outside the national spectrum manager may result in some administrative or organizational inefficiencies.

4.2.4.1 Financial

Where their services are provided free of charge to the national spectrum manager, interested communications groups, frequency coordinators and designated spectrum managers provide a direct savings to the administration. Financial benefit derived from the national spectrum manager paying consultants is not clear since such payments represent a full cost or near full cost replacement for government staffing. Similarly, the government contracting a private sector spectrum management support contractor as a replacement for government staff will not necessarily result in cost savings. The financial benefit gained from these support resources depends on the manner in which the service is funded. Instability in consultant or contractor groups and the ongoing need to develop, review and monitor contracts may often result in significant additional costs. Consultants and support contractors can provide short term support that is terminated when an assignment ends. However, the overall spectrum management effort may be affected by a lack of cohesiveness. These potential negative aspects may be able to be overcome by giving adequate attention to their transition plans.

4.2.4.2 Staff

When there is a lack of qualified personnel available to perform spectrum management tasks, saving money may not be as crucial as identifying sources of staff support. In some administrations, government policy stipulates limits on government staffing levels. Each of the support approaches provides assistance to alleviate the staff requirements of the national spectrum manager.

4.2.4.3 Control

Anytime the national spectrum manager delegates responsibilities to an outside group some of its control is lost. The use of private sector resources having their own interests and often a profit motive can create a conflict of interest. Thus the government spectrum manager must remain close to any private sector activities to ensure that biases do not have a negative impact. Care must be taken in the use of these resources to protect non-profit, public-interest services. A number of specific problems with such a system may be anticipated. Interested communications groups may create compatibility standards, for example, that give greater consideration to their own costs than to the requirements of other spectrum users. In such a case, all of the users dealt with by frequency coordinators and managers might not agree with decisions that are made. Some may object to the fees involved. Others may feel that they are not adequately represented. Others may believe that their investment is put at risk by the judgement of a coordinator or manager. These groups often emphasize the need for government control of the national resource, demanding appeal procedures or government review of decisions.

Government oversight of coordinator or manager activities to ensure that treatment of the users is fair and equitable, represents a management burden derived from turning over control to another group. A potential method of keeping the coordination process fair would be to have more than one certified coordinator for each sub-band. This "marketplace" approach to coordination raises the problem of database management. For coordination to be equitable, each coordinator must have equal access to an up-to-date database of licensees. They must share a single database or have simultaneously updated databases. This may necessitate operation of the database by the

government or an agreed third party.

4.2.4.4 Process efficiency

Frequency coordination groups are highly familiar with the specialized spectrum needs of the user groups they represent. Because of this familiarity, they can provide fast, efficient, conflict-free assignments to users. Because of their unique status, private sector coordination groups are in a position to provide a highly efficient and rapid method of frequency coordination that is not usually available to either the end user or the national spectrum manager. Private sector spectrum managers are likely to employ market techniques in selecting between prospective users. Such a process can speed the process of approval, eliminating the debate associated with an administrative process (often referred to as "comparative hearings") to compare user requirements. Licencing systems in an area and over a range of frequencies speeds the licencing process by granting one licence to what amounts to many transmitters, locations and frequencies.

4.2.4.5 Spectrum use efficiency

Because private sector spectrum managers and coordinators and system licence holders have a vested financial interest in the bands they oversee, increased efficiency in the use of those bands may result as compared to oversight by a government regulator. Private sector spectrum managers and system licence holders may be motivated financially to develop techniques to maximize the number of assignments and thereby maximize their profit. Coordinators representing user groups work to the benefit of all those within the user group. Maximizing assignments maximizes benefit to the user group. Though designated spectrum managers, coordinators or system licence holders may increase the efficiency of the bands that they oversee, they have no motivation to decrease the total amount of bandwidth that their users occupy. If a user group has more than enough spectrum for its use, there is no motivation to move toward more efficient technology or assignment procedures. Thus, having entrenched frequency coordinators or designated spectrum managers may make it more difficult for the national spectrum manager to make larger scale allocation or allotment changes. The use of these groups may decrease the national spectrum manager's overall flexibility, possibly leading to a decrease in spectrum efficiency.

4.2.4.6 Flexibility and sharing

When spectrum is turned over to frequency coordinators or coordination groups, sharing flexibility may be lost. Generally, each coordination group has one service with which it deals. Therefore, management or coordination by one group may prevent sharing a band with other services. However, in some cases, coordination groups have successfully been used to coordinate use by different radio services within shared spectrum.

4.2.4.7 Technical expertise

National spectrum managers sometimes find it difficult to focus available technical expertise on each of the myriad of services, bands, users, and technologies needing spectrum access in a country. System licence holders have direct experience from managing their own systems. Interested communications groups and frequency coordination groups generally originate from the groups they manage. Therefore, they have the expertise and information directly at hand to perform their tasks. The use of consultants allows the selection of individuals or groups with the skills matched to tasks. Designated spectrum managers carrying out general duties similar to the national spectrum manager experience the same difficulties in covering all spectrum issues.

4.3 Experience

Many administrations have used alternative resources to support national spectrum management for a number of years. The following information reviews some of this experience.

4.3.1 Country experience

4.3.1.1 Canada

- **Consultation Process**

In Canada, the Radio Advisory Board of Canada (RABC) is the main body in the private sector that provides advice to the Canadian Administration on a wide variety of issues related to spectrum management. The RABC is basically an association of associations with a large number of members representing the service provider, equipment manufacturer and radio user sectors of Canada. The RABC is organised in a number of committees, such as the mobile and personal communications, the fixed wireless communications, broadcasting, electromagnetic compatibility, etc. Committees. The Administration participates in these meetings as observer. The Board advises the Administration on matters related to policy, standards, technical and procedures development. Engineering analyses on channelling plans, interference calculations, sharing scenarios are often conducted in the RABC and have provided significant inputs to the Canadian spectrum management process. Once every two years, the RABC and the Administration jointly organise a high-level conference, called the Spectrum 20/20 Symposium, bringing together industry and government officials to discuss long term as well as short term issues of spectrum management including spectrum economics. The RABC has been recognized as a very successful co-operation between government and the private industry in Canada.

- **Frequency Coordination Process**

The Canadian national spectrum management organization makes use of frequency coordinators in a number of cases.

In the case of Fixed Service and the Fixed Satellite Service frequency applications, while the Department of Industry is responsible for processing licence applications, including the examination of interference potential, international coordination, etc., domestic coordination is the responsibility of the applicant. The fixed service users maintain their own data bases from which they coordinate with each other. The majority of the coordination is done within the Frequency Coordination System Association which is a non-profit Canadian corporation, with major telephone companies as its members. It operates and administers a computerized Microwave Information and Coordination System.

- **Licensing Process**

In the Amateur Service, while a license is required to operate the radio equipment in the Amateur bands, no interference analysis is conducted. However, an examination is required of the Amateur operators, which has been delegated to Amateur organizations.

- **Information Dissemination**

In order to facilitate the dissemination of information the assigned frequency records are made available to the general public through Internet access or on a CD-ROM format.

4.3.1.2 Germany

In Germany, user associations perform spectrum management function for essential private mobile

radio (PMR) use. Spectrum has been allotted to specific user associations. These associations have been successfully involved, as private sector frequency coordinators, in licensing frequency assignment for more than 25 years.

The experts of these associations advise their members in all aspects of PMR use. They explain national regulations and support user planning of PMR networks. The association recommends to the regulatory authority characteristics of a PMR network such as frequency, coverage area, antenna height, call sign, etc. Normally, all relevant technical standards, rules for frequency planning and other licensing conditions are taken into account in the recommendation of the user association. The regulatory authority is able to follow these recommendations in almost all cases and grants a license accordingly. In this way, the national technical coordination is carried out de facto by the user association within their allotment (international coordination is always carried out by the regulatory authority).

The users associations are financed by contributions from their members and work for the benefit of the PMR users and the regulatory authority. Beside the day-to-day frequency coordination, they contribute to the medium and long-range planning process for the frequency spectrum representing the spectrum requirements of their members to the regulatory authority. They provide a valuable link between the regulatory authority and the users.

4.3.1.3 Israel

Israel takes advantage of private sector resources to perform many spectrum management functions. The Administration is not rich in human resources, and the private sector is very familiar with what is needed for communications. The optimal usage of spectrum is important for the Administration and for the industry. The operator (and the supplier) are interested in maximum usage of the spectrum.

Private industry assists the Administration in many ways. The industry designs the assignments of two-way radio and paging in 136-174 MHz 450-470 MHz bands, trunking and cellular in 800-900 MHz. Operators can share the same frequency band without the intervention of the authorities. In some cases, the Ministry of Communications decides on the ratios between channels, and the operators among themselves choose the specific assignments. The Administration determines only the rules, and the operators apply them optimally.

Furthermore, the Administration contracts the following support from a private sector communications company:

◊ Spectrum Monitoring;

◊ Development of spectrum management systems and software programs;

◊ Consultation, spectrum information, training and courses.

4.3.1.4 Russia

In Russia great support to governmental spectrum management activities is provided through various scientific, development and design organizations, which play the role of frequency coordinators and spectrum management consultants. While administratively these organizations may belong to different ministries and other governmental bodies, they are actually providing independent expertise in many fields of radiocommunications, and particularly of spectrum management, to the Russian telecommunication administration, as well as to private radio operators and various commercial organizations supporting their activities. Due to close collaboration with the Russian telecommunication administration on the one hand and with radio operators on the

other hand, and through active participation in relevant regional and international activities, they are very familiar with what is needed for the development and improvement in different radio services and in spectrum management issues at the national, regional and international levels.

Such spectrum management organisations include research institutes, particularly the Radio Research and Development Institute (NIIR) together with its branches, type-approval testing laboratories, private operator associations and consulting firms operating on a commercial basis.

The main assistance to the telecommunication administration provided by these organizations are:

- conducting, at the request of the administration, systematic interference analysis for Fixed (microwave) and Fixed Satellite Service frequency applications including issues of domestic and international coordination;
- conducting frequency-site planning of radio transmitters for sound and TV Broadcasting Services;
- conducting experimental investigations of the potential for allocating additional TV and sound broadcasting channels for areas with specific terrain problems. Based on conclusions provided, the administration issues relevant frequency permissions and licences for operational activities.
- developing various draft standards, specifications, recommendations, etc. concerning radiocommunication networks and equipment development, EMC analysis and frequency planning, frequency sharing criteria and conditions to be approved by the administration; recently these activities more and more concern relevant regulatory and legislative matters as well.

As far as it concerns assistance to radio operators, the main issues are the following:

- explanation of national, regional and international regulations in their implementation with respect to various radio services;
- assistance in user planning of relevant radio networks particularly cellular, trunking etc., using all relevant technical standards, rules for frequency planning and other licensing conditions;
- preliminary analysis of interference-free broadcasting channels for commercial sound and TV broadcasters, calculation of service areas etc.;
- assistance in preparation of relevant licence application and bid documentation;
- assistance to various state and commercial enterprises in the field of industrial interference limitation.

4.3.1.5 United States

The United States makes wide use of frequency coordinators, interested communications groups, and private sector spectrum management consultants.

- **U.S. use of interested communications groups**

The U.S. spectrum management organizations also make significant use of advisory committees. The FCC for instance develops its radio conference proposals through an open advisory committee process. Furthermore, the National Telecommunications and Information Administration, as the manager of U.S. government agency use of radio systems, relies heavily on the Inter-department Radio Advisory Committee (IRAC), its subcommittees (planning, technical, and radio conference), and ad hoc committees for advice on regulation and policy development. This committee is the longest standing advisory committee in the U.S. government. Though this is not a private sector body, it represents an excellent example of using advisory bodies or collections of experts. NTIA also seeks the advice, with regard to spectrum management policy, from a joint government/private

sector group, the Frequency Management Advisory Committee (FMAC).

The FCC has also successfully employed a technique known as "negotiated rulemakings" whereby it has placed system developers and spectrum advocates in a position of jointly developing the very regulations and standards which will be used to regulate their activities.

- **U.S. use of frequency coordinators**

Under FCC rules, prior to applying for a station licence for certain services, an applicant must provide technical coordination information or evidence of "prior coordination" of the station with existing stations. Private groups often perform this prior coordination function.

In the Private Land Mobile Radio Services (PLMRS), the FCC has certified groups for specific sub-allocations (e.g., public safety, industrial, and land transportation services) to coordinate frequency assignments prior to their application for the actual licence. Under this system, applicants proposing new stations or modifying existing licences send their completed applications to the appropriate certified coordinator. The coordinator checks the application for completeness, accuracy, and compliance with the FCC's rules, recommends the most suitable frequency for the applicant, and forwards the completed application to the FCC, which issues the licence directly to the applicant upon approval. The FCC oversees the performance of these coordinating committees. Performance consistently below FCC standards could lead to an inquiry and eventual decertification of the coordinator. In cases of disagreement between the applicant and the coordinator, the FCC has final authority to resolve the problem.

Prior coordination takes place in other services, such as the FCC's Point-to-Point Microwave Radio Service and the Private Operational Fixed Microwave Service. Prior to obtaining a licence, applicants for these services are required to engineer their proposed systems to avoid interference and to coordinate with existing applicants and licensees who could potentially experience interference from these proposed systems. Coordination in these bands is typically done by the applicant or their private frequency coordination consultant and depends largely upon industry cooperation. There are no certified coordinators for these bands. The applicant must certify that the coordination process has been completed before the application is accepted for filing. Private frequency coordinators charge a fee for their services.

Through this requirement for prior coordination, the FCC attempts to ensure that interference conflicts are resolved through private negotiations before applications are filed. Successful coordination through this method lessens the need for federal government administrative processes to resolve conflicting private claims to the spectrum. Since the FCC established requirements for frequency coordination within the microwave bands in 1975 and implemented the certified frequency coordinator program for the PLMRS bands in 1986, the speed of service has improved and the FCC's licensing burden has been reduced. Further, the first recourse of action for licensees involved in interference problems is to seek the assistance of the coordinator. In most cases, the coordinator can find a solution to the problem without the FCC ever being involved.

- **U.S. use of spectrum management consultants**

While NTIA and the FCC currently make limited use of spectrum management consultants, federal agencies with significant communications interests but limited staff resources make extensive use of technical consultants and functional support contractors. These groups play an active role in the wide array of advisory and ad hoc committees performing engineering analysis and preparing committee documents. In many cases, they represent government agency interests in delegations to international bodies.

4.3.2 Other experiences

4.3.2.1 Amateur services

Generally, amateur stations are not assigned specific frequencies by government spectrum managers but are free to select operating frequencies according to current band occupancy and propagation conditions. National, regional and local band plans are established by informal agreement to arrange compatible intra-service uses, principally by class of emission, such as telegraphy, data and voice.

The major exceptions to stations selecting frequencies in real-time are VHF/UHF voice repeaters, packet radio relay stations and propagation research beacons, which use specific frequencies on a long-term basis. Some administrations have regulations that encourage the establishment of private sector frequency coordinators, particularly to maintain user databases and, by recommendation rather than assignment, coordinate the selection of voice repeater frequencies to minimize interference within their geographic areas.

Amateur-satellite frequencies are international in nature and are coordinated through amateur-satellite organizations known as AMSAT.

The three International Amateur Radio Union (IARU) regional organizations also establish informal band plans. The IARU and AMSAT organizations cooperate in matters concerning frequency usage.

4.3.2.2 Area and high density systems

Most administrations have experience with authorising area systems to a range of frequencies. This has been done primarily for cellular, PCS and other area and high density systems.

4.4 Application in developing countries

The spectrum management organizations of developing countries frequently suffer from inadequate funding for spectrum management, insufficient training of spectrum management staff to perform technical engineering and computer tasks, unclear spectrum management procedures and mechanisms, and a lack of spectrum management experience. Though in most cases increased funding and staff are crucial to upgrading their spectrum management capability, short-term significant increases are not often possible and long-term increases via the normal national budget allotments may not be sufficient. Spectrum management approaches must be considered that minimize the need for government funding increases. Growth of the spectrum management unit should be incremental; however, funding increases alone will not provide results. As with the general national economy, free and secure capital investment is essential for the national telecommunications infrastructure and a portion of that capital investment may be needed to support the national spectrum management system.

Because spectrum users and service providers are often the most qualified to deal with technical issues and have a great deal of motivation for resolving issues, they represent the most readily available source of active support. In many cases, a significant difference in private and government salaries has caused many of the qualified experts to gravitate toward private enterprise. Because spectrum management is essential to the success of their enterprises, private companies are highly motivated to use their resources to establish and support a sound spectrum management process.

These resources can be drawn together in organized bodies to provide advice or in many cases voluntary support to include everything from frequency coordination, to site inspection, regulation

drafting, and research. Coordination groups can be established to coordinate frequencies for some services. Groups for broadcasting, fixed, and mobile are often a good starting point. Coordination groups can perform tasks under government oversight but using primarily private sector participation. The members of these groups are motivated by the fact that they want to use the spectrum. Advisory committees can develop initial drafts for national regulations and spectrum management procedures as well as positions on international issues.

Where monetary resources from spectrum fees or market approaches to spectrum management have been used to increase funding but technical expertise is deficient in the government, the government spectrum manager can employ consultants or contractors to provide support. Such groups are excellent for providing database and engineering support. In some cases, they have been successfully used to support national representation in international bodies.

Whether by voluntary or contract support, government staff requirements can be lowered, but other considerations, such as security and government control, may impact government implementation of these approaches. However, most approaches discussed above can be used without relinquishing the government's primary leadership and oversight role.

4.5 Implementation measures

The approaches described above are intended to decrease the national spectrum manager's work load without necessarily decreasing the spectrum manager's level of authority. They also take advantage of the expertise of the spectrum users and service providers. However, the measures that are required to implement these approaches depend on the level of authority that is granted to groups outside the national spectrum manager. Because most administrations have used traditional centralized approaches to spectrum management, some legal authorization may be required to implement any of these approaches. Actual delegation of government authority, for example licensing authority, to groups outside the national spectrum manager will require additional legal provisions. As these approaches deal with spectrum management support in conjunction with the national spectrum management authority, as opposed to national government operation of radio services, implementation of these approaches requires no changes to the national industrial infrastructure. Many of the significant changes to national processes are legal or administrative. Others may involve shifts in the types of skills maintained by the national spectrum manager. Developing private sector support for the national spectrum manager can be accomplished regardless of the national position with regard to privatization of national phone companies. Separation of the national spectrum management role from that of a government run telecommunications operator is not dealt with in this report .

A legal basis, including rules of conduct, may have to be created for the establishment of government recognized advisory bodies. For frequency coordinators or designated spectrum managers to charge fees, their authority to do so may need to be established. In cases where a group outside the government is delegated authority to actually perform a spectrum management function, this authority must be clearly presented to the spectrum user community. Rules for conduct of such a group would have to be established. These rules would necessarily include provisions that prevent a group from exercising management authority in bands or services where it has a direct financial stake in those users under its authority. In dealing with contracted support, laws concerning contract bidding and award have to be developed and applied. For international activities, national authorities would have to accredit groups that participate on their behalf and ultimately, administrations must be represented by those authorized to make national treaty commitments.

Arranging a multitude of counsellors does not necessarily make decision-making easier. In some

cases, the ideas of interested groups may be in conflict with one another. Therefore, while more detailed and expert advice may become available, the national spectrum manager will still have to sort out issues and make decisions.

Approaches where responsibilities are delegated through contracting or use of spectrum coordinators or managers require a new set of skills related to development and oversight of these resources. While there may be a specific need for contract processing or other administrative skills, the national spectrum manager must maintain a sufficient level of technical capability to select and oversee support resources. Furthermore, the national spectrum manager will need to develop and maintain methods to monitor and evaluate how well these approaches are working.

4.6 Summary

A number of administrations have implemented and gained experience with various forms of support to the national spectrum managers. These methods have potential for saving government financial or human resources, increasing the efficiency of spectrum use, improving the efficiency of the frequency assignment and coordination, and supplementing the expertise of the national spectrum manager. Therefore, in seeking ways to provide an effective national spectrum management system, administrations should consider these approaches.

GLOSSARY

Terms defined in this glossary are printed in *italics*.

Administrative pricing A form of *spectrum pricing* in which *equipment licence* fees or charges for *spectrum rights* are set by the spectrum manager. Administrative pricing may include such variants as:

- *shadow pricing* (see below);
- *incentive pricing*, where fees are set with the intention of promoting efficient spectrum use;
- *regulatory pricing*, where fees are set unrelated to market considerations, for example, to recover spectrum management costs.

Apparatus licence A permission to install and use radio equipment. This will specify the frequency or frequency band to be used and may also impose terms and conditions restricting matters such as the type of apparatus to be used, power, coverage area, geographical location or service to be provided. The extent and specificity of the restrictions will depend on circumstances and the characteristics of the service in question.

Auction A form of *spectrum pricing* - as well as a spectrum assignment mechanism - in which *apparatus licences* or *spectrum rights* are assigned to the winner(s) of a competitive process selected on the basis of price. (In some countries, other factors, such as quality of service, speed of roll-out and financial viability, may also be taken into account, either in the assessment of the bids or as pre-qualification criteria.) *Auctions* may take various forms, including:

- the *English auction*, where the auctioneer increases the price until a single bidder is left;
- the *first-price sealed bid auction*, where bidders submit sealed bids and the highest wins;
- the *second-price sealed bid auction*, where bidders submit sealed bids and the highest bidder wins but pays the second highest amount bid;
- the *Dutch auction*, where the auctioneer announces a high price and reduces it until a bidder shouts "mine";
- the *simultaneous multiple round auction*, as first practiced by the Federal Communications Commission in the USA. This involves multiple rounds of bidding for a number of lots that are offered simultaneously. The highest bid on each lot is revealed to all bidders before the next round when bids are again accepted on all lots. The identity of the high bidder may or may not be revealed after each round, but is revealed at the auction's close. The process continues until a round occurs in which no new bids are submitted on any lots. This variant is more complex than single-round auctions but offers bidders greater flexibility to combine lots in different ways, and, because it is more open than a sealed bid process, limits the impact of the *winner's curse*, allowing bidders to bid with more confidence.

Auctions are commonly considered to have advantages of economic efficiency, transparency and speed compared to alternative assignment methods and also capture the market value of spectrum rights for the administration holding the auction. They can give rise to anti-competitive outcomes if they result in large operators acquiring an undue concentration of the available spectrum but various safeguards against this can be introduced, for example restrictions on the amount of spectrum an individual bidder may win or 'use it or lose it' provisions to prevent hoarding.

Bidding credit A discount given to certain bidders to promote socially desirable goods. Bidding credits were given to smaller, entrepreneurial firms in some FCC auctions. For example, a 25% bidding credit would mean that if an entrepreneurial firm submitted a winning bid of $1,000,000, it would pay only $750,000. Originally, bidding credits were also proposed for women and racial minorities; however, the FCC dropped this proposal after the U.S. Supreme Court's *Adarand* decision, which declared that such preferences were discriminatory, and therefore illegal.

First-come, first-served An assignment procedure in which spectrum is assigned to applicants until it is exhausted, subject only to compliance with minimum technical or financial criteria. This procedure has tended to be used for small scale assignments, such as individual private business radio and fixed links licences. It works best where spectrum is not scarce.

Gross Domestic Product (GDP) The sum of the value of all final goods and services sold within the geographic borders of a country in a year.

Lottery A process for assigning *apparatus licences* or *spectrum rights* to applicants selected at random. *Lotteries* have the advantage of speed and simplicity but they are unlikely to lead to an economically optimum outcome and can give rise to speculative applications because of the prospect of windfall gains.

Mutual exclusivity A situation in which two or more applicants are competing for the same spectrum assignment.

Oligopoly A situation in which only a small number of firms are supplying a product or service. This situation may be contrasted with a monopoly situation, in which there is only one firm supplying a product or service.

Opportunity cost The benefits foregone by not putting a resource to its best alternative use. For example, the best alternative use of a frequency band currently used for a broadcast service might be for a mobile service. In an auction, the bidder with the highest willingness to pay will generally win, with a bid that is just above the valuation of the bidder with the second highest willingness to pay. This second highest valuation represents the opportunity cost.

Resource rents The term economists use to categorize the value of a resource. The rent accruing to a resource right, such as a spectrum right, can be quantified by the price that the right would sell for in an open market.

Secondary trading Buying and selling of *apparatus licences* or *spectrum rights* after initial assignment by the spectrum manager. Dealing may take place directly between the parties or through an intermediary.

Shadow pricing A form of administrative pricing in which the price is set according to a predetermined formula intended to mimic the effect of market forces. Parameters commonly used include bandwidth, frequency location, geographical location and coverage area.

Spectrum pricing A generic term currently used to denote the denoting the use of pricing as a spectrum management tool. It covers both *administrative incentive pricing* and *auctions* of either *apparatus licences* or *spectrum rights*. Under *spectrum pricing*, charges are not set by reference to the fully allocated costs of spectrum management attributable to particular user categories but are intended to balance supply of and demand for spectrum or to achieve other spectrum management policy objectives, such as facilitating the introduction of new services or promoting competition.

Spectrum right The right, analogous to a property right, to use a specified frequency or range of frequencies in a particular location or throughout a nation or region for a particular time period within ITU Radio Regulations. Where such rights have been introduced, restrictions on the type of equipment

to be used or service to be provided may be minimal apart from technical non-interference conditions in relation to adjacent *spectrum rights*. It may be possible to assemble *spectrum rights* to provide increased bandwidth or coverage area or both.

Threshold qualifications Qualifications that are a prerequisite to participate in some process, such as a lottery or auction. Threshold qualifications may include financial and technical viability, and a service plan that satisfies certain social goals.

Unjust enrichment An award, such as the award of a valuable frequency assignment, to a person or company that exceeds that person's or company's entitlement to the award.

Winner's curse A possible effect of an auction, most commonly a sealed-bid auction. Assuming that some bidders will over-estimate the value of the lot, the winner may be the most optimistic rather than the most skilful in assessing the value of the lot. In a sealed-bid auction, auction proceeds may be reduced as bidders attempt to minimise this effect. *Winner's curse* can be reduced or eliminated by careful design, particularly by using multiple round auctions (see *simultaneous multi-round auction*).

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