Radio Spectrum Management

Module 5

ICT Regulation Toolkit

EXECUTIVE SUMMARY

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Module 5 of
ICT Regulation Toolkit

www.ictregulationtoolkit.org

January 2007

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Acknowledgements

Both Module 5 of the ICT Regulation Toolkit on Radio Spectrum Management and this Executive Summary were commissioned by *info*Dev and drafted by Adrian M. Foster of McLean Foster and Co. Other project team members included Prof. Martin Cave (Warwick Business School, University of Warwick) and Robert W. Jones (ITU). The authors wish to acknowledge with thanks the valuable input of the review team comprising staff from the World Bank, *info*Dev and ITU, and in particular from Björn Wellenius, Zaid Safdar, Doreen Bogdan-Martin, Susan Schorr and Nancy Sundberg.

The full module is available online at:
http://www.ictregulationtoolkit.org/en/Section.1247.html

For more information, please see:
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1. INTRODUCTION

Historically, accessing and using radio spectrum has been highly regulated, in order to prevent interference amongst various users in adjacent frequency bands. In the last decade, there have been significant innovations in the theory and practice of spectrum regulation. There is now a growing consensus that past and current regulatory practices have delayed the introduction and growth of beneficial technologies and services or have artificially increased costs. As a result, there is a renewed emphasis on striking the best possible balance between the certainty of administrative approaches and the flexibility of more light-handed market-based regulation.

The Radio Spectrum Management Module is one of the seven new modules that constitute the online ICT Regulation Toolkit project, a joint initiative of the International Telecommunication Union (ITU) and the World Bank's Information for Development Program (*info*Dev). The Spectrum Management Module gives readers a foundation of spectrum management concepts and issues. It includes a review of the differences between traditional spectrum management methods and recent innovations and practices. The module uses an approach that is more descriptive than prescriptive, allowing readers to make up their own mind on various perspectives.

This executive summary gives the reader an overview of the many topics and issues addressed in the eight sections of the Radio Spectrum Management Module. Important topics addressed in this Executive Summary include: Regional Cooperation and Planning, Regulatory Framework, Market-based Assignments, Market-based and Administrative Spectrum Pricing, Secondary Markets, and Spectrum Monitoring. The online toolkit, itself, provides a deeper discussion of the trends, issues, and options available for change and includes numerous examples and references. It is available at www.ictregulationtoolkit.org.

2. IMPORTANT CONCEPTS AND TRENDS IN SPECTRUM MANAGEMENT

The first section of the Radio Spectrum Management Module provides an overview of the important fundamental concepts. It begins by explaining in basic terms what is a radio spectrum and why is it necessary to regulate this important natural resource. The objectives for regulating spectrum and regulatory frameworks at the international and national levels are described, along with descriptions of key spectrum management regulatory functions. The first section also addresses the important trends that affect spectrum management use. It explains actions taken by regulators and stakeholders in response to changing market conditions and changing technologies.

The Radio Spectrum as a Resource

The radio spectrum is used for a wide range of economic, social, cultural, scientific and developmental purposes with an enormous number of end-user services: communications for firms, households and public bodies, including critical safety and security communications used by defense forces, emergency services and air traffic control; various kinds of radar; broadcasting; scientific research; and so on. From an economic viewpoint, the spectrum is a resource used by a wide range of entities, including public bodies such as defense or emergency services, and for a number of applications, including narrow and broadband mobile telecommunications, broadcasting, aeronautical and marine communications, and scientific applications such as radio astronomy and environmental sensing.

From a technical viewpoint, the radio spectrum is the portion of the electromagnetic spectrum that carries radio waves. The boundaries of the radio spectrum are defined by the frequencies of the transmitted signals, and are usually considered to range from 9 kHz (kilohertz; thousand cycles per second) to 3000 GHz (gigahertz; billion cycles per second). The key characteristics of the spectrum are the propagation features and the amount of information which signals can carry. In general, signals sent using higher frequencies reach shorter distances but have a higher information-carrying capacity. These physical characteristics of the spectrum limit the currently identified range of applications for which any particular frequency band is suitable.

The spectrum as an economic resource is unusual in that it is both non-exhaustible and non-storable. Unlike oil and water, the spectrum will never run out, although it may become increasingly congested. Also, it cannot be accumulated for later use. These factors put a premium on a streamlined process for making spectrum available for purposes which are useful to society. In fact, because spectrum has so many uses, arbitrating among them in cases of shortage can be difficult.

Effective spectrum management can make a big difference to a country's prosperity, especially as wireless technologies have become the main means of connecting businesses and households to voice, data and media services[1]. It is becoming increasingly evident that as developing countries address broader issues of communication and information policy and regulatory reform, wireless services are outpacing wireline connectivity and the spotlight is focusing on current modes of spectrum management. In a globalizing world with rapid technological innovation and increasing demand for radio frequencies, effective spectrum policy should therefore promote the roll-out of services, reduce barriers of entry, and promote innovation.

As a resource, the spectrum has both technical and economic dimensions: Section I of the Module provides more details to the following brief definitions:

- Economically, efficient use of spectrum, as a starting point, means the maximization of the value of outputs produced from available spectrum including the valuation of public outputs provided by the government or other public authorities.
- Technically, efficient use of spectrum, at a basic level, implies the fullest possible use of all available spectrum. Two measures of technical efficiency are occupancy and data rate. Time, for example, can be used as a measure of technical efficiency, in the sense of how constant or how heavy the usage of spectrum is over time. Data rate, means how much data and information can be transmitted for a given amount of spectrum capacity.

<u>What is Spectrum Management?</u>

Spectrum management is an extremely important part of telecommunications policy and regulation. The spectrum is allocated for particular uses, and specific technical and service rules, developed by spectrum managers, govern those allocations. As a result, technical and service rules are a crucial

[1] ITU (2002), Geneva. World Telecommunication Development Report: Re-inventing Telecoms, Executive Summary. 2002 marked the year there were more mobile subscribers than fixed-line worldwide in over 97 (mostly developing) countries.

determinant of the structure and performance of industry and of institutions devoted to ensuring public safety, security and national defense.

There are four main areas of work in spectrum management: planning, engineering, authorization and monitoring; these are briefly described below:

- Spectrum planning involves the allocation of portions of the frequency spectrum to specified uses in accordance with international agreements, technical characteristics and potential use of different parts of the spectrum, and national priorities and policies.
- Spectrum authorization involves granting access under certain specified conditions to the spectrum resource by various types of radio communication equipment and the certification of radio operators.
- Spectrum engineering involves the development of electromagnetic compatibility standards for equipment that emits or is susceptible to radio frequencies.
- Spectrum monitoring and compliance involves the monitoring of the use of the radio spectrum and the implementation of measures to control unauthorized use.

What are the Economic and Technical Objectives of Managing Spectrum?

Broadly speaking, the goal of economic activity is to provide goods and services to end-users – whether bought in the market place or provided to the public by governments. Spectrum is an input into the services that end-users (households, firms and public agencies) value. In defining high-level objectives for spectrum policy, it is thus sensible to take as a starting point the maximization of value of outputs produced by the spectrum available, including the valuation of public outputs provided by the government or other public authorities[2].

Allocation of scarce spectrum to different uses should be done in a way that the marginal economic benefit of additional spectrum is the same for every use. Some important conclusions follow from this objective. Suppose a given quantity of spectrum is available for use in only two sectors, mobile communications and commercial broadcasting. How should it be divided between the two uses? Some kind of compromise is required among the value users place on both services, the cost of

[2] United Kingdom, Ofcom. Spectrum Framework Review: A Consultation on Ofcom's Views as to how Radio Spectrum should be Managed, November 23, 2004.

providing these services and the amount of spectrum used by them. In turn, relating the use of spectrum to its value pressures all users, private and public, to make more efficient use of their allocated spectrum, thereby freeing up more spectrum for use generally. From an economic efficiency viewpoint, the spectrum should be divided in such a way that the benefits to the economy at large from an additional amount of assigned spectrum are the same in each use. Market-based approaches such as auctions and spectrum trading are viewed as superior ways of achieving economic efficiency in assignment than administered methods. The Radio Spectrum Management Module provides a more detailed discussion of economic objectives and their implications.

At first glance, technically efficient spectrum use commends itself as a self-explanatory benefit. Indeed, technical efficiency may rationally count as the leading factor in spectrum allocation decisions. Applying the matter in practice, however, can bring competing policy goals into play.

Occupancy and data rate are two measures used in determining how efficiently certain assigned frequencies are being used by services and users. In practice, however, both of these measures have problems. Some uses are crucial, yet only occasional. In the absence of procedures for sharing spectrum with other users, which may be very costly to implement, capacity which is often left unused may be essential for such public safety services. Equally, the data rate measures fail to take account of the value of the information being carried. A meaningless jumble might be sent very efficiently, but it would still be a meaningless jumble. This suggests that such measures make little sense, as they abstract from the key element of economic calculation concerning the value of the service which the spectrum is being used to produce. The Radio Spectrum Management Module provides a more detailed discussion of technical efficiency objectives and their implications.

Even though spectrum management is ultimately in the interests of private and public end-users, there are many more stakeholders involved in the sector. Examples of those using spectrum include equipment manufacturers, technology companies, public sector users and others, all of whom can be affected by spectrum management decisions. It is essential that the processes employed to regulate spectrum use are efficient for all users. Knowledge and expertise of affected users are required. The regulator will have to face the challenge of balancing the needs of all stakeholders with differing sectoral interests.

How is the Spectrum Managed?

At the national level, spectrum management can be undertaken directly by government, as part of a ministry, or by an independent regulator operating under a legislative mandate or policy guidelines. It can also be managed by industry on a self-regulating basis or be assigned to a band manager. Band managers can be in the business of leasing on a for-profit basis valuable spectrum to third parties. Under proposed Federal Communications Commission rules, a band manager is granted a license under which the manager will allow others to construct and operate stations at any available site within the licensed area and on any channel for which the band managers is licensed. The preferred option depends upon a nation's historical and institutional circumstances. The key question being what delivers best on objectives.

The governance arrangements for spectrum regulators differ throughout the world, but broadly fall into two categories:

- The regulator is an independent agency, normally established by statute, with specified powers and responsibilities; or
- The regulator is part of a government ministry.

Good governance involves transparent arrangements for accountability and fairness. While decisions on spectrum allocation (among uses) and assignment (to individual users) inevitably reflect public policy objectives, government or political interference in detailed decisions, such as which firm should receive a particular license, should be avoided. The reward for such forbearance is enhanced investor confidence and, ultimately, more and better services for end-users. Whether an independent agency or a government body is better for spectrum regulation will depend on particular circumstances. In some countries, agencies may be more susceptible to capture by special interests; in others, governments. It is therefore difficult to propose a single rule.

The governance of spectrum use on a global basis is a core responsibility of the International Telecommunication Union (ITU) and in particular, its Radiocommunication Sector (ITU-R). The mission of the ITU-R sector is, *inter alia*, to ensure rational, equitable, efficient and economic use of the radio frequency spectrum by all radio communication services, including those using satellite orbits, and to carry out studies and adopt recommendations on radio communication matters. The

ITU is a specialized agency of the United Nations. It is not a global authority in the manner of a national regulator, since the international rules are written by those governed by them, i.e., the member states of the ITU. These rules are administered by the ITU's Radiocommunication Bureau (BR) and conformity with the rules is based on goodwill and supported by regulations at the national level.

In addition to activities carried out within the ITU framework, there are often bilateral and multi-lateral agreements by which the use of spectrum is harmonized across national borders. There are two types of international activities; project activities and transactional activities. International project activities are those which have a defined beginning and ending date such as the World Radiocommunication Conference – 2003 (WRC). Like all types of project activities, tasks and sub-tasks can be defined and milestones established. Transactional international activities such as frequency coordination requests, elaborated on further below, are of an ongoing nature. These activities are described in more detail in Section 6 of the Module: International Affairs.

Some spectrum management functions (for example, enforcement of licenses or engineering work) can be outsourced or "contracted out" to private bodies or even to organizations in other countries. This should be determined on the basis of how the functions are most efficiently performed. The Spectrum Management Module provides a fuller discussion of the potential and options for outsourcing.

Traditional Approaches and Recent Innovations to Spectrum Management

Historically, regulators have assigned frequencies by issuing licenses to specific users for specific purposes, limiting access to and use of radio spectrum. This is referred to as the administrative approach to spectrum management which can be prescriptive as to the details of how spectrum is used and, with good planning, how interference amongst uses can be controlled. This reflects the joint concerns of governments to coordinate frequency use internationally and to avoid interference at a time when radio technology was in its infancy. But the last decade has seen significant innovation in the theory and practice of that regulation. This gradual change follows a growing consensus that regulatory practices originally intended to promote the public interest may, in some cases, have in fact delayed the introduction and growth of new beneficial technologies and services, or artificially increased the cost of service. Significant growth in demands made on spectrum and the resulting need for technically efficient use have given rise to policy makers and regulators worldwide focusing anew on spectrum regulation and reform. There is renewed emphasis on striking the best possible balance between the certainty of interference-free spectrum to encourage a stable roll-out of services and flexibility to allow improvements in cost, services and technologies to spread more readily to consumers and public services[3].

At this stage in the discussion it is important to emphasize a key feature of the administrative method, which is that restrictions on allowable uses are made by the spectrum manager. Potential users of spectrum can make proposals for allocations, for example, for new communication technologies, but without the allocation being made, matters cannot progress further.

As can be expected, such methods are often slow and unresponsive to new technological opportunities. It requires a level of knowledge and foresight on the part of the spectrum regulator which is often more assumed than real. Attention has recently focused on creating genuine markets for spectrum and spectrum licenses under which both the ownership and use of spectrum can change in the course of a license's operation. This is a major step beyond the typical auctioning of licenses which are not subject to trading and change of use. It does, however, require the full specification of what 'property rights' to spectrum can be traded and utilized.

Market methods are employed both at the initial issue of spectrum licenses, such as when auctions are used and, more significantly, when users have been authorized to buy or sell spectrum rights in the lifetime of a license (trading) and permitted to change the use of the relevant spectrum to different services (sometimes called liberalization).

It is generally believed that with a greater number of spectrum users, a more competitive market exists and there is less need for regulating end-users. The design of the assignment mechanism and of associated conditions of use is crucial to the establishment of infrastructure-based competition. The assignment mechanism can shape the market structure by dividing up the spectrum and limiting the amount that any one user can acquire.

[3] Falch, Morten (2004), Technical University of Denmark. Economical versus Technical Approaches to Frequency Management, Telecommunications Policy Vol. 28, pp. 197-211.

Some spectrum, especially for short-range use (wireless LAN, radio frequency identification devices, microwave ovens, various remote control devices, wireless security systems) need not be licensed at all, either because users seldom interfere with one another or because new technologies can be employed which are capable of dealing with interference as it happens. Unlicensed spectrum was previously of little interest. However, in the last five years it has been debated more widely. This has been made possible by several technological developments:

- Deployments of new technologies in the 2.4 GHz band, particularly W-LANs, have been commercially successful, leading many to ask whether further unlicensed allocations would result in more innovation and deployment.
- The development of ultra wideband (UWB) and the promise of software-defined radio (SDR) have led some to question whether these technologies can overcome historical problems with unlicensed spectrum.

If such coexistence can be achieved, a spectrum commons may be desirable. The Spectrum Management Module provides a comprehensive discussion of the technology and market factors affecting the use of a spectrum commons.

Regulators should look for the right balance among the three methods of administrative assignment, market factors and spectrum commons. The choice will be based on such things as the general scarcity of spectrum in various parts of the country and portions of the spectrum, the human and financial resources available to the regulator, the types of use — commercial or public service, and opportunities for innovation and commerce. The growing recognition that spectrum regulators may not be able to collect and process the information needed to make plans for efficient administrative assignments is one of the factors promoting spectrum reform throughout the world.

While the international framework for the utilization of the radio frequency spectrum is set out in the ITU’s Radio Regulations, there is considerable flexibility within this framework for the establishment of spectrum policies at the national level. At the national level, determining who may use the spectrum within a given country requires a certain degree of planning, the extent of which depends on how much the regulator wishes to rely on the market. The greater the reliance on the market, the less planning is required.

Transparent Regulation and Processes

One of the most important features of the work performed by a spectrum regulator is transparency. Transparency must form the basis of all work done by a regulator and should be a feature of every process the spectrum manager puts into force. The public and all stakeholders should understand the functions of the regulator and the organization. They should be able to see the work of the regulatory authority as open, accessible, and accountable. In terms of the processes followed, they should find the processes both predictable and fair. These are all easy principles to accept, but sometimes difficult to follow in practice. The benefits of transparent regulation are summarized as follows.

BENEFITS OF TRANSPARENT REGULATION
1. ***Efficiency and Effectiveness*** **–** Open processes enhance consensus and create confidence in the regulator. Increased public participation promotes diverse ideas in decision-making and increases support for rules and policies, making implementation easier. In addition, transparency can lead to greater efficiency by ensuring that duplication of functions is avoided. 2. ***Certainty and Reliability*** **–** Regulatory credibility and legitimacy builds stability and is essential for attracting investment. This is particularly important in newly liberalized markets, where potential entrants need to have trust that their investments will be protected from arbitrary action and that further commercial development will not be thwarted by sudden changes in “rules of the game.” 3. ***Accountability and Independence*** **–** Openness promotes accountability and legitimacy, reinforces regulatory independence, and reduces political and industry interference. Stakeholders can thus have confidence that their views will be heard, without bias, by the regulator. When regulatory actions are open to public, regulators are more likely to engage in careful and reflective decision-making. 4. ***Continuity*** **–** A stable set of rules governing transparency will transcend political changes and outlast political appointments, ensuring a continuous regulatory record regardless of who is in charge of the regulatory agency or which political party is in office. Source: ITU – Trends in Telecommunication Reform, 2002, Chapter 6.

3. PLANNING FOR SPECTRUM USE

Planning for Spectrum Use, or simply Spectrum Planning, is done to ensure that the spectrum resource is used to the fullest extent possible. Spectrum managers need to take into account the changing needs of society and secure opportunities that match existing demands with new ones through innovative uses of technology. At the national level, plans and technical standards for spectrum use are created to ensure that applications of technology are done in a consistent manner and that interference is reduced to acceptable levels. At the regional and international level, agreements are formed amongst nations for spectrum use and technical specifications to aid coordination of services globally.

In this section, spectrum planning is discussed with the objective of forecasting future requirements of spectrum and methods for adjusting spectrum use over time. These planning activities result in spectrum use standards establish the target map for future spectrum use and the paths taken to get there. Technical standards are then discussed. Technical standards provide the rules of the road and govern which types of equipment can operate under specific operating conditions.

As previously mentioned, radio spectrum supports a wide range of business, personal, industrial, scientific, medical research and cultural activities, both public and private. Communications are foremost among those activities and, together with other radio services, are increasingly important to economic and social development.

It is helpful to grasp many of the various uses and the characteristics of radio spectrum used to enable these services. The following table helps to relate different radio services with various frequency ranges and band propagation characteristics.

Examples of Radio Frequency Propagation and Related Services

Band	Frequency	Range	Use	Bandwidth	Interference
VLF	3-30 kHz	1000’s km	Long range radio-navigation	Very narrow	Wide Spread
LF	30-300 kHz	1000’s km	Same as VLF strategic communications	Very Narrow	Wide Spread
MF	.3-3 MHz	2-3000 km	Same as VLF strategic communications	Moderate	Wide Spread
HF	3-30 MHz	up to 1000 km	Global broadcast and Point to Point	Wide	Wide Spread
VHF	30-300 MHz	2-300 km	Broadcast, PCS, Mobile, Wan	Very Wide	Confined
UHF	.3-3 GHz	< 100 km	Broadcast, PCS, Mobile, Wan	Very wide	Confined
SHF	3-30 GHz	Varies 30 km to 2000 km	Broadcast, PCS, Mobile, Wan, Satellite Communication	Very Wide up to 1 GHz.	Confined
EHF	30-300 GHz	Varies 20 km to 2000 km	Microcell, Point to Point, ,PCS and Satellite	Very Wide up to 10 GHz.	Confined

What is Spectrum Planning?

Spectrum resource planning ensures the efficient and effective use of the spectrum resource. Spectrum regulators need to make decisions about the uses of spectrum and on who should be allowed to use it (i.e., uses and users). Planning is usually undertaken for long-term, medium-term and short-term timeframes. Long range (strategic) planning (10 to 20 years) is required to foresee spectrum requirements far into the future. Medium-term planning (5 to 10 years) is needed to determine what changes should be made to regional, sub-regional, national and local spectrum policies to meet the changing needs of users and evolving technology that have already been identified. Finally, short-term planning (anything under 5 years) is important where, depending on the nature of spectrum governance in place, changes to spectrum policies can be made to adjust earlier decisions.

Forecasting future spectrum use is critically important if future spectrum needs are to be met. The challenge of forecasting spectrum can be overcome by employing various techniques including projections based on historical growth; and through monitoring of new technologies and noting their spectrum requirements. It is critically important to consult with spectrum users for they are usually in the best position to forecast growth in their sector.

It is also very important to know the current uses of spectrum as a baseline for future planning. This can be ascertained from existing records of frequency use across the entire radio spectrum. International and often national frequency registers are used to aid planning and facilitated through the use of computer-automated tools.

Planning at International and National Levels

The international framework for the utilization of the radio frequency spectrum is set out in the ITU's Radio Regulations. Spectrum related information such as details concerning individual nationally based frequency assignments are regularly submitted to the ITU's Radiocommunication Bureau for purposes of coordination with other countries and then registered in the Master International Frequency Register. This information is in an ITU-R publication known as the Radiocommunication Bureau's International Frequency Information Circular which contains details on the current and intended frequency usage by ITU Member States.

There is, however, considerable flexibility for the establishment of national policies following recommendations contained within the ITU-R framework. Determining who may use spectrum within a given country involves planning mechanisms. In general where there is greater the reliance on the market to assign spectrum, less planning is required.

There are a number of important policy questions to be reviewed and resolved affecting the regulation of spectrum at the national level. These policy questions include the government's own use of spectrum. One underlying concern for spectrum assigned to government departments is underutilization. Other policy matters include the extent to which market mechanisms should be used to assign spectrum and used set the price for spectrum; and, what are the permanent or temporary property rights of licensed and unlicensed users.

Frequency Allocations Tables

A frequency allocation table developed within the framework of the ITU's Radio Regulations: Article 5 is an important first step in long and medium-term planning at the national level. The national frequency allocation table should be consistent with that country's regional allocations. Once a national frequency allocation table is developed, further sub-allocations or designations of use are often made in order to group like technologies or like users in a given frequency band.

Planning Challenges – Reallocation of Spectrum to Different Uses

One of the biggest planning challenges facing spectrum regulators is the reallocation of spectrum. When frequencies have been used for one purpose, perhaps for decades, it is often difficult to reallocate these frequencies for a different use. The need for reallocation – often known as re-farming - can arise in several ways:

- The international table of frequency allocations may have changed and the national table of frequency allocations must be realigned to remain consistent with it;
- A radio service may not have developed as expected;
- New technologies are made available that are more spectrum-efficient, allowing spectrum to be freed up either for the same use in that band or other uses.

The questions arises as to who pays for the costs of transitioning existing users to new frequencies. Various approaches have been used. Some simply require the user to absorb the cost. In other cases, the beneficiaries of the change are either invited or required to reimburse all or part of the transition costs of the incumbent user. Another approach is for the regulator to establish a re-farming fund by setting aside a portion of spectrum revenues where funds come from either general taxation revenues, specific telecommunications charges such as license fees or other spectrum-related fees or from a combination of these two.

Users and Stakeholders

There are many users and stakeholders ranging in power and size who are affected by allocation and assignment decisions including a large number of differing businesses and public bodies directly involved as users of spectrum. The overall universe of stakeholders includes:

- The interests of end-users, as purchasers of services and beneficiaries of public services, are pervasive.
- Traditional spectrum management has involved the assignment of spectrum to Equipment manufacturers to provide services based on a specified technology and using specified apparatus.
- Providers of commercial services will quite properly pursue their own profits. This will involve seeking access to spectrum for their own use and preventing commercial rivals from gaining access to it.
- Providers of public services have much spectrum – about a third or more in many countries – is assigned to them for services such as emergency services or national defence. Regulators typically grant requests for spectrum from such bodies free of charge, or subject to an administrative charge only.

Solving problems through Consultation

Consultation with stakeholders is essential in virtually every aspect of spectrum management including the development of national legislation and regulations, spectrum policies, technical standards, etc. While it is seldom practical to consult with each individual spectrum user, effective consultations can take place by also allowing associations or bodies representing groups of users to contribute. Some helpful guidelines for conducting public consultations include the following:

- It is important that the spectrum regulator's proposals be made public.
- Options may be presented for public comment.
- Allowing for exchanges between interested parties.
- Consultations with stakeholders should be transparent and fair.

Technical Standards – Planning for Compatible Use of Spectrum

As mentioned at the beginning of this section on Spectrum Planning, there are technical standards which describe how spectrum is used – Spectrum Use Standards; and standards which state conditions of technical compliance – Radio Equipment Standards. The distinction between these two main types of standards is described in the paragraphs that follow:

- Spectrum use standards state the minimal technical requirements for the efficient use of a specified frequency band or bands. Furthermore, spectrum-use standards can be designed to match ITU-R Recommendations developed by the Radiocommunication Sector of the ITU
- Radio equipment standards are used by the regulator in the license approval process, as well as in testing and certification of radio equipment such as transmitters, receivers and antennas to determine compliance with radio or manufacturer specifications. Radio equipment standards to state the limits (if at all) on how certain radio equipment can interfere with other equipment in either shared or adjacent frequency assignments and form the basis for certification and testing of radio equipment. Equipment is said to be certified when it complies with applicable standards of the country. The ITU also has equipment standard regulations for reference by its members. Radio equipment standards also:

    - specify the minimal acceptable technical specifications and performance characteristics of radio equipment in general use;
    - exist for both licensed radiocommunication equipment or stations and license-exempt radiocommunication equipment which include low-power devices such as garage-door openers, radio frequency identification devices (RFIDs) or equipment utilizing ISM or unlicensed bands such as WiFi and WiMax.

  As a result, radio equipment standards and certification processes for specific types of equipment are the same for all manufacturers and importers, ensuring consistent quality for consumers. Finally, the regulator can use radio equipment standards to require that manufacturers produce equipment which provides for greater efficiency in spectrum use.

Technical standards are an important to users of radiocommunication services and radio equipment since operators and suppliers rely on technical standards as a basis for preventing interference and in many cases ensure that radio systems perform, as designed. Standards documentation provides; general information describing the equipment and the application, an indication of licensing and certification requirements, channelling arrangements, modulation techniques used by the equipment, and transmitter power and transmission limits for unwanted emissions.

Other Standards

There are other standards associated with the use of radio such as radiation standards and land use standards. The authority for regulating these standards most likely rests with other departments and agencies. Once a decision by government on policy or regulation has been reached however, the spectrum management authority may need to take certain measures such as making modifications to radiocommunication equipment standards to ensure public safety.

- Radiation standards refer to electromagnetic emissions at certain frequencies that may be harmful to life or some other concern to public safety. The spectrum manager is not typically responsible for conducting the research and determining the scientific basis for these concerns. Agencies of government such as the Ministry of Health and public and private research institutes conduct research to substantiate concerns.
- In connection with the deployment of radiocommunication system, other standards relating to the environment, construction and land use may apply. This is particularly true where location with respect to essential facilities such as power transmission lines and airports is a factor.

Developing Technical Standards

Developing radiocommunication equipment standards and spectrum-use standards occurs at the national, regional and international levels. In some cases, due to the importance and size of the national economy, national standards acquire international importance. Smaller nations routinely adopt, either formally or informally, radiocommunication equipment standards developed by other standards organizations, which is a cost-effective manner of designing a set of standards. Indeed, countries within almost all regions, including Europe, the Caribbean, Africa and Asia have opted to recognize both European (ETSI) and North American standards (FCC and ANSI). There are standards bodies in most regions of the world and particularly in regions where high technology and telecommunication and radiocommunication equipment are manufactured.

Coordinating the Use of Technical Standards across Regions

Testing compliance of radiocommunication equipment with national standards is done by either government-operated testing facilities or by private sector laboratories. National governments are increasingly favoring private sector facilities since technological change and innovation lead to ongoing acquisitions of high cost test equipment. Policies and regulations have evolved around the coordination of standards testing across regions and markets through the certification of Conformity Assessment Bodies (CAB's). CAB's are organizations recognized by the spectrum management authority to conduct testing and certification of radiocommunication equipment. A Mutual Recognition Agreement amongst importing and exporting participants to establish mutual acceptance of the results of testing and equipment certification procedures undertaken by those bodies in assessing conformity of equipment to the importing parties' own technical regulations.

Conformity to radiocommunication equipment standards and certification are necessary conditions for interoperability of radiocommunications services and terminals such as handsets. It is not a guarantee, however. Across a region or within a country, a common technology or standard such as GSM or CDMA may be used by service providers with similar networks but operating at different frequencies, making it difficult for users to migrate between networks. The absence of roaming agreements may also prevent interoperability even when frequencies and the technologies are the same.

4. AUTHORIZING SPECTRUM USE

Introduction

Authorization is the process by which users gain access to the spectrum resource. This may involve assigning specific frequencies to users, allotting certain frequency bands or sub-bands to specific users who may or may not be able to transfer such spectrum rights to others or it may mean simply authorizing the use of specific equipment or categories of equipment.

Spectrum authorization activities include analyzing requirements for proposed frequencies in accordance with national plans and policies for frequency allocation. They include actions to protect radiocommunication systems from harmful and obstructing interference. Spectrum authorization strategies are used to ensure proper use, facilitate reuse, and achieve spectrum efficiency.

It is perhaps helpful to define three important terms which are used throughout this section: allocation, allotment and assignment.

- Allocations are entries in a table of frequency allocations which sets out the use of a given frequency band for use by one or more radiocommunication services. An allocation then is a distribution of frequencies to radio services.
- Allotments are entries for designated channels in a plan for use by one or more countries in those countries or within designated areas for a radiocommunication service under specified conditions. An allotment then is a distribution of frequencies to geographical areas or countries.
- Assignments are authorizations given to radio stations to use radio frequencies or radio frequency channels under specified conditions. An assignment then is a distribution of a frequency or frequencies to a given radio station.

Some basic principles and rules have been established.

- Allocations are made on a primary or on a secondary basis.

- Stations of a secondary service cannot cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date.
- Stations of a secondary service cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or to which frequencies may be assigned at a later date.
- Stations of a secondary service can, however, claim protection from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date.

Regulatory Strategies for Allocation and Assignment

At the national level, spectrum is most often allocated in accordance with existing international ITU Frequency Allocations and prospective changes resulting from national planning processes. Traditional allocation processes have evolved around service definitions and associated technical rules. Allocations need to support increased usage of cost effective communications achieved through service expansion and interoperability and reduced equipment cost. Rapid changes in the marketplace caused by demand growth and rapid technology development make traditional service oriented allocations somewhat inflexible. For example, use of spread spectrum techniques and more efficient equipment permits increased sharing of spectrum, even if some minimum levels of interference are experienced.

Spectrum Allocation Strategies include:

- Flexibility in the use of spectrum achieved by way of less emphasis on services and use of spectrum sharing techniques.
- Consistency with International Allocation Agreements to ensure comparable costs and service integration.
- Emphasis on technology neutrality combined with continued diligence in eliminating harmful interference.
- Protection of frequency use and freedom from harmful interference in sub-bands allocated for public safety and security.

Assignment involves assigning and licensing of frequencies to systems and individual services. An operator is assigned a set of frequencies in order to provide communications services. The assignment of frequencies is done, in a way, to avoid harmful interference with other users in adjacent bands. Spectrum should be used efficiently and so assigned frequencies should follow channelling plans which follow appropriate technical standards and result in the reuse assigned spectrum. Underutilized spectrum and unoccupied assigned spectrum are wasteful uses of the resource. Assignment and pricing techniques should support efficient and optimal use of assigned spectrum.

Spectrum Assignment Strategies include:

- Users of assigned spectrum must comply with license conditions and applicable technical standards otherwise licenses can be revoked.
- Government should enforce license conditions and ensure interference free use.
- Public Safety and Security must be safeguarded through active surveillance and enforcement.
- Capacity planning and band planning should be done involving multi-lateral industry consultative processes and assignment and planning databases should be publicly available.
- The regulator can establish the right to recall and refarm spectrum.
- Certain assignments can be unlicensed due to public interest and administrative efficiency.

Additional spectrum authorization activities include licensing, examination, certification of radio operators, equipment, type approval, type acceptance and international notification and registration. In terms of licenses, there are various types, including individual licenses, system licenses, class licenses, general licenses, etc. Some uses of spectrum are not licensed. It is important, however, to recognize that unlicensed does not necessarily mean unregulated since equipment may still need to meet certain technical standards.

<u>Technical Aspects of Assignment</u>

A major challenge for assignment procedures arises when technological innovation alters the optimal use to which a particular frequency should be put. In certain circumstances, this does not create a problem. Thus if, under an administrative procedure, a license expires at the moment when a change of use is desirable, a new license can be issued to provide the new service. If a market regime involving secondary trading and involving change of use is in place, then the purchase and sale of the relevant spectrum license should allow the transition to take place without regulatory intervention. Indeed one of the arguments for the use of markets is that it takes the regulator out of the process of responding to technological change which is occurring at an increasing rate.

In reality, however, things are usually a great deal messier. There may be uncertainty over what entitlement to spectrum a licensee has. In a market regime where licenses are of limited duration (e.g. twenty years), there may be a period of uncertainty, when a switch to a new use is desirable but no one is prepared to make the necessary investments to achieve it, because of uncertainty about future access to spectrum.

Methods for Assignment

A number of methods are used to manage processes by which access to spectrum may be granted. If there is no excess demand for spectrum licenses, the method chosen might be 'first-come, first-served': a reserved basis for certain uses or users in a form of a-priori planning and so-called beauty contests which may be held to decide who will be assigned certain frequencies or bands of frequencies. Applicants might have to be qualified in specified ways but the qualified applicants would be granted licenses until the license term was exhausted.

If excess demand is anticipated, use of a competitive assignment process is normally preferred. For this to be done fairly and transparently, the regulator must set out the various criteria to be employed, relating for example to the technical and financial qualifications of applicants, their access to capital, the scope and geographical range of their services, and so on. Each criterion should have a pre-announced weight, and an objective method of measurement should be specified.

If an auction method is used to make an assignment, the procedures to be employed must be set out in fine detail to ensure that all competitors are on an equal footing. For example, if a sealed bid is employed, the date and place at which it must be lodged have to be clear. If an open auction process is utilised, in which bidders make offers for licenses in successive rounds of bidding, a whole range of procedures relating to the frequency of rounds, increments in amounts bid, obligations to make new bids and so on must be specified. These points are discussed further in the Practice Note on auctions.

Precisely what the spectrum manager has to do in order to achieve an effective assignment depends on the method chosen, and also upon linkages with other authorisations such as the issuing of broadcasting licenses. New technological developments may change the methods used to issue authorisations and may require ‘refarming’ of spectrum. The process of refarming will require engineering and administrative support and, in some cases, financial support. For example, costs to refarm spectrum can be passed onto new licensees or a Refarming Fund administered by the regulator can be used to assist new licensees who cannot bear the cost of technology change arising from the relocation of their radiocommunication service to new assigned frequencies (unlicensed or special use).

In all cases, it is vital that the regulatory body abide strictly by the conditions it has specified for the assignment. Any departure or evidence of partiality, prejudice or of conflict of interest will be damaging in several ways. First, legal challenges can delay the start of services of benefit to end users, possibly for many years. Secondly, doubts about the integrity of the process will deter companies from participating in competitive assignment processes. As a result, inferior candidates may be successful, leading to long term harm for consumers

License Conditions

Spectrum authorization typically involves the licensing of frequency assignments and radiocommunication equipment by the spectrum manager. Licensing places restrictions on the operation of radio stations and the use of assigned frequencies to prevent harmful interference. Under either administrative or market-based methods such as auctions utmost clarity is required about what license conditions are entailed by the license. These must be specified in respect of technology, geography and time.

The most complex is technology. Under administrative assignment of licenses to a particular user providing a particular service (a specified form of radar, GSM, etc.), the technological restrictions in the license are normally defined in terms of the location, power and geographic coverage of the specified apparatus. The specifications are chosen to avoid interference with other users. Any departure by the licensee from these conditions is a breach of the license. If, however, spectrum licenses are flexible and can be employed for any purpose – following a trade of the license, for example – apparatus licensing of the kind described above does not work, as each possible use will be associated with different equipment. In these circumstances, licensees will have to face restrictions in what emissions their activities are allowed to make at the boundaries of the license area – i.e. what spill over they can make into adjoining geographic areas and frequencies. This is considerably more complex.

The geographical scope of a license is more easily specified once the interference issue noted above has been resolved. The duration of the license must also be specified and can include features such as renewal options and conditions for trading which have been already discussed.

Unlicensed Spectrum

Some spectrum may be reserved for unlicensed use (spectrum commons). Until recently unlicensed spectrum was of little interest. The main unlicensed bands are those designated as industrial, scientific and medical (ISM). These are bands where there are primarily non-communications uses of the spectrum, for example, for microwave drying and heating purposes, etc. Because these uses generate interference, the ISM bands were generally not licensed for radiocommunications. Hence, they were often made available for unlicensed usage. In determining the most appropriate regulatory policy regarding unlicensed spectrum, it is necessary to determine:

- Whether there is spectrum that is currently not congested or can be expected to remain uncongested and so could become unlicensed.
- Whether there is spectrum that is congested, but only because of inefficient usage; and where a change in management policy to unlicensed usage will remove the congestion.

There are many factors that influence congestion. Some of these are caused by suboptimal allocation policies and can be expected to be gradually alleviated by the introduction of trading. Some are caused by allowing the use of equipment that is inefficient in its use of spectrum. The other factors influencing congestion are the bandwidth and time of transmissions. These mostly depend on the usage.

Having decided on the most likely use, spectrum should be subject to licensing where any of the following hold true:

1. The band is likely to be congested. Examples of such services are cellular and broadcasting.
2. A guaranteed quality of service (QoS) is needed. This is the case, for example, with most public safety communications.
3. International treaty obligations provide restrictions that would be breached by operation on a license-exempt basis either now or at some known point in the future.

Without regulatory intervention, the problem of dealing with congestion can not be practically resolved. Equipment will only be made efficient to the extent that it is necessary for that piece of equipment to operate reliably and not for the greater good of all the users of the band.

In summary, many observers conclude that spectrum should be unlicensed if it were unlikely to be congested. Still, there is no definitive way to predict congestion. A judgment needs to be made on the basis of the frequency band, likely use and range. The range in turn depends on the use. Hence, a key stage in predicting the congestion likely in the band is determining the most likely use.

Improving Utilization and Efficiency

Improved technology used in analyzing spectrum use and information systems are playing increasingly important roles in assigning and keeping track of spectrum use as well as administrative functions such as collection of license fees and preparing submissions of various information to other countries or to the ITU where required. It is very important tailor systems and the application of such technologies to the real requirements and to the resources available.

Precisely what the spectrum manager has to do in order to achieve an effective assignment depends on the method chosen, and also upon linkages with other authorisations such as the issuing of broadcasting licenses. No matter what method for assigning frequencies is adopted, some level of spectrum engineering support is required to ensure, inter alia, that the use of frequencies authorized will not result in interference or to resolve any cases of intra-national or international interference that might arise. Such capability is also required to assess, for example, some of the newer technologies such as software defined radio equipment.

5. SPECTRUM PRICING

Spectrum prices or charges are set to recover the cost of running a spectrum regulatory agency since it takes money to run a spectrum regulatory agency. The resources the spectrum management agency requires include: skilled labour, IT resources, investment in technical monitoring equipment, and expenditures to pay for participation in ITU and other international meetings. As well, the normal inputs such as office space and utility services needed to be funded. Governments can remunerate such costs directly from general revenue and in certain circumstances they should do so (for example if full cost recovering would deter spectrum use).

Administrative methods of setting spectrum prices are increasingly being supplemented by the use of market based methods for determining spectrum prices. Spectrum pricing methods have taken various forms: from setting license fees at a level sufficient to recovering the cost of spectrum management; through to applying administrative incentive prices (AIP); and, to auctions and using them to make initial assignments and as a consequence establish a price for spectrum.

Spectrum Pricing Objectives

The pre-eminent policy objective for spectrum pricing is that it should be done in a way which promotes spectrum efficiency. Spectrum efficiency does come with a cost and the spectrum manager should attempt to find an optimal cost/benefit trade-off. Secondly, use of the spectrum provides considerable benefit to the national and regional economies and this benefit should be maximized. Next, managing radio frequency spectrum costs money and someone has to pay these costs. As a principle, those who benefit from the use of the spectrum should be the ones to pay these costs. A user-pay principle should apply. Finally, important social and cultural objectives can be advanced by use of the spectrum and spectrum pricing should facilitate the achievement of government social and cultural objectives.

Allowing a spectrum regulator to establish its own charging regime, collecting all spectrum related revenues and retaining them to fund spectrum management activities can be a source of concern to policy-makers. In economic terms, the regulator is effectively a monopoly and has little incentive to contain its costs if it can increase its revenues by raising license fees and other charges. Safeguards can be put in place to avoid such practices, such as putting limits on the growth of the regulator's expenditures.

In countries where spectrum revenues exceed the cost of spectrum management and sometimes by a very large margin, governments view this as a spectrum dividend whereby the government and hence all members of the public reap the financial benefits of such royalties. However, attention must be paid to the broader legislation within a country, as spectrum revenues in excess of costs may be viewed as taxation. The power of taxation may be reserved to another government entity and the legislation dealing with spectrum management may or may not be constructed so as to allow revenues to exceed costs.

Methods for Cost Recovery

The activities of each licensee impose direct costs on the regulator. These include the costs of issuing, maintaining data, spectrum monitoring and enforcing its individual licenses. Some costs will be common to a band or to a radio service (such as band planning); whereas others will be common to a group of bands and some, such as management overheads, will straddle all licensees.

Regulators have tackled the issue of setting prices to recover costs in several ways. Some have used detailed costing models to establish which licenses have imposed which costs; others rules of thumb. Rules of thumb, such as setting charges on the basis of a percentage licensee's turnover, are likely to be subject to increasing criticism by those who think they are overcharged. In these circumstances, a simple model of direct costs can be developed. As well, a method of allocating indirect or common costs will be needed – for example, based on licensees in proportion to the direct costs which they impose. Or they can be allocated in accordance with the amount of spectrum (e.g. in MHz) with which a license is associated.

Spectrum or license charges can be assessed as a percentage of (royalty on) revenues or profits, which has to be handed to the spectrum regulator under the terms of the license received or profits earned by an operator. This can be a way to cover regulatory costs, or it can be designed to raise revenue for the government.

Another method of for recovering costs involves trying to set proxy prices which might otherwise emerge in a market context, and then set charges which license holders have to pay in relation to costs of spectrum management. This is sometimes called ‘administered incentive pricing’: ‘administered’ because they are set by the regulator with potential ‘incentive’ properties. These types license fees are designed to not simply recover the cost to manage spectrum but also promote efficient spectrum use. The idea is that if a user has unused spectrum, they will choose to return it rather than pay the charge. Also, if a user can pay a lower fee by using spectrum more efficiently, that user may adopt more spectrum-efficient operations.

At first sight, cost recovery fees might seem to fall in this category since cost recovery prices may motivate a user to return excess spectrum or to use spectrum more efficiently, but the primary motivation for this method is to fund the spectrum regulator (and perhaps gain some additional revenue) and prices are more likely to be set too low to impose an appropriate level of discipline on licensees. This arises because the value to a nation of its spectrum greatly often exceeds the cost of operating the spectrum regulation organization.

The choice between these approaches has to be made by the regulator in the light of considerations of fairness, and the likely effect of the charges on spectrum use. If a high allocation of indirect costs makes a license uneconomic, the matter may require reconsideration.

<u>Administered Incentive Prices</u>

In the absence of a primary or secondary market for spectrum (or even in their presence), it may be desirable to give licensees an incentive to economise on spectrum use, in order to discourage extravagant use or hoarding. This applies both to private sector (or commercial) users and to public sector users.

Administrative Incentive Pricing (AIP) is used by some regulators to promote efficiency in spectrum use within a framework of administrative spectrum management since AIP’s are intended to be set at a level which reflects the scarcity of spectrum and encourages economy in its use.

Spectrum should be priced in any use at its opportunity cost by applying the right level of price pressure without forcing excessive economies which result in valuable spectrum being unused. The right level of price can be found by estimating the value other resources saved if the same spectrum were redeployed to produce some other service, or the extra costs incurred if it were not available to provide the currently employed service causing the current service to be produced with less spectrum. Doing this in practice will require the regulator to identify the relevant alternative or alternatives, and perform the necessary cost calculations, as exemplified in the practice note below. This will inevitably produce results which are only approximately accurate, but the regulator may conclude that it is better to apply incentives for cost efficiency via a price which is only approximately right, then not to charge any price at all.

If AIP's are based on opportunity cost, then it follows that they should be zero (and replaced, probably, by cost recovery prices based on direct cost only) if the spectrum has no alternative use. This might arise because:

- There is no shortage of spectrum in the relevant frequency, so that all users can be accommodated;
- There is a legal impediment to using the spectrum in question for other purposes; this might apply for instance, to spectrum used for the purposes of aeronautical communication under the auspices of the International Civil aviation Organisation (ICAO).

In conclusion, AIP is another tool available to regulators to encourage spectrum efficiency. It is applicable in an administrative regime for spectrum assignments and can be applied to private and public sector users. But the regulator must be sure that the AIP are taking effect. For example, if a ministry paying AIP on spectrum simply has its budgetary allocation increased to allow it to pay, there is no incentive to economize and the regime is ineffectual.

<u>Auctions</u>

Auctions are essentially a method of assigning spectrum at the time of its first issue by the spectrum regulator to those who value the spectrum most highly. It is normal for the bids to be made in money terms, where the competitor offering the largest monetary sum wins the license. Spectrum prices emerge as a consequence of winning bids in auctions or from secondary trades of existing licenses. Auction and spectrum trading transaction prices not only embody 'opportunity costs' – the cost-saving potential of the spectrum license, but also any excess profits which the license holder can derive through exclusivity or market power. As a result, they should be used with caution.

Competition for licenses can take forms different than money. For example, competitors can bid against one another over which of them will offer service over the largest geographical area. Or the competition can be in terms of which operator will charge the lowest amount for service or requires the least amount of subsidy. Once the rules are established, however, the winner is determined by the operation of the competitive process, not by an administrative decision. It is important that the winner of an auction is not effectively tied down as a firm granted a license by any other means.

The key differences between auctions and comparative hearings or administrative decisions are that:

1. An auction assigns the license to the firm which bids the most, and that may in certain conditions be the most efficient firm;
2. A competitive auction will, if it operates properly, direct any expected excess profits from providing the service to go to the Government, rather than the operator as would be the case if the operator were chosen via a competitive hearing.

Literally hundreds of spectrum auctions have been conducted in the past ten years. Some have attracted great attention by generating billions of euros or dollars from bidders. Most have been on a much smaller scale. Even so it still remains the case that most of the spectrum in use in all countries has been allocated by administrative methods. In practice, auctions tend to be confined to cases where:

- The spectrum available is in scarce supply;
- Many firms want to acquire license;
- The service to be provided with the spectrum can be precisely defined;
- The monetary value of the license is relatively high, justifying what can be a complex assignment procedure.

Some examples are given below:

- A spectrum regulator proposes to assign a single license for the provision of a national second generation mobile telephone service. The successful applicant must commit itself to providing coverage to 50% of the land area and 80% the population. Sealed bids must be submitted by a specified date, by firms which have pre-qualified (i.e. have shown their competence to be the licensee). The winner in the firm which bids the most.
- Two or more licenses to provide national 3G mobile services are auctioned. Pre-qualified applicants bid against east other in an open bidding auction. This is to say, they have the opportunity to submit new bids for the licenses at pre-specified intervals. The auction ends when the winning bids for each license are the same, in term of bidder and sum bid, as they were in the previous round. To ensure completion of such an auction, firms must be made to bid at a specified frequency.

A successful auction requires a clear understanding by participants of what rights and obligations are available to the winner or will be imposed upon them. If there is uncertainty about this, it will discourage competitive bidding. Auctions differ two main ways: in the number of lots (or licenses) made available; and the way the auction is conducted. There has been a significant number of mobile licenses grant by auction around the world and they form a good basis for analysis and understanding. In relation to these wireless communication licenses, some the key variables in designing the auction are:

1. The number of licenses to be offered to the service: this decision is of fundamental importance, since it determines the structure of the services market. The objective of maximizing consumer welfare suggests the harnessing of competitive forces to the maximum – i.e. issuing, subject to spectrum availability, as many licenses as the market will be able to support (plus one or two extras to permit freedom of entry into the market);
2. Any commitments made at the time of the auction relating to restrictions on the award of subsequent licenses;
3. Whether national or local regional licenses are issued; here the regulator may find it helpful to anticipate the kind of business plans (national or regional) firms are likely to have and

make licenses available, accordingly there is nothing to preclude a mixture of national and regional licenses;

4. How long the licenses will last: too short a period may discourage investment in the services, while too long a period may allow the spectrum in question to stagnate if it cannot be sold on for another purpose;
5. Any obligations a licensee may have to make periodic payments in the course of the license;
6. Any network roll-out obligations or ‘use it or lose it’ clause;
7. Any foreign ownership restrictions.

A range of methods have been employed and some have been judged successful, others found to have failed. Regulators can learn from this experience to choose a procedure which meets their circumstances. The greatest experience has been accumulated in the USA, where the Federal Communication Commission (FCC) has run a series of auctions starting in July 1994, and continuing in 2006.

One commentator has drawn the following lessons from these auctions, which typically have involved the auctioning of multiple local licenses which can be aggregated to provide regional or national services:

- Open bidding is better than a single sealed bid;
- Simultaneous open bidding is better than a sequential auction, in which licenses are auctioned one after another;
- Allowing bidders to bid for packages (e.g. a group of local licenses capable of providing wider area services) is desirable in principle but found (in 2001) to be too difficult in practice;
- Collusion in a major problem, which can be countered by concealing bidders’ identities (i.e. publishing the bid, but not who made them), and setting high resume prices, amongst other ways.

The most conspicuous recent auctions have probably been those for 3G (UMTS) licenses in Europe. In 2000-1 a sequence of auctions took place, beginning with the UK, where operators bid very large amounts ($35 billion for five 3G licenses). Although revenues from the German auction several months later were also high, thereafter they declined on a per capita basis.

Where a small number of national licenses are being auctioned, for example in a developing country, a simpler approach is possible. A good example of this is provided by the auction of three identical GSM licenses in Nigeria in 2002. This was done with a carefully thought-out process which involved invitation and pre-qualification stages, as well as the auction itself. Recognising the problem of collusion, the designers made alternative plans which depended on the number of qualified bidders for the three licenses. If they were five or more - i.e. if bidders exceeded the number of licenses by more than one, an ascending clock auction would be held. If these were only four, a sealed bid process would be implemented.

Spectrum Trading

In the traditional administrative approach to assignment and authorization system, spectrum is first allocated specified uses and then assigned to particular firms or public organisations to carry out the authorized use with specific obligations laid down in a license or permit.

Auctions alone merely introduce an initial market-based selection by organizations that will exercise highly specified spectrum usage rights, whereas secondary trading seeks to develop a primarily market-based solution both for spectrum assignment and for spectrum allocation, on the condition that flexibility in use is permitted.

Secondary trading of spectrum which permits the purchaser to change the use to which the spectrum was initially put while maintaining the right to use is viewed by many as the key step to be taken in the reform of spectrum management regulatory practice, capable of unlocking the potential of new technologies and of eliminating artificial scarcities of spectrum which find expression in inflated prices for spectrum-using services.

Once secondary trading is allowed, industry structure can be affected by mergers of companies or the direct transfer of spectrum ownership. There is a risk of a structure emerging which contains a monopoly or, more generally, a dominant firm or firms, which can set excessive prices. This problem can be combated by ordinary competition law where the law exists; for example a dominant position might be broken up or a merger disallowed. But it may also be necessary for the regulator to have the power to scrutinize and, if appropriate, prohibit certain spectrum trades.

A useful aid in dealing with problems of market power is to encourage co-operation between the spectrum regulator, with its technical knowledge, and the competition authority, which is skilled in market analysis. South Africa has been successful in achieving this goal.

The issue here, as so often in spectrum regulation, is a trade-off between the costs of *ex ante* scrutiny, which are incurred by firms and the regulator (and hence, ultimately by consumers of spectrum-using services), and potential cost to consumers of abuses of market power, if a trade takes place which triggers that risk. The argument for *ex ante* scrutiny will be stronger if a) spectrum ownership is already concentrated, and b) ordinary competition law is non-existent, underdeveloped, or difficult to enforce.

If spectrum markets are to work properly, participants must have basic information about spectrum holdings adjacent to where they are considering buying licenses. Otherwise buyers will not appreciate the constraints relating to interference to which they will be subject. This raises problems of confidentiality – both commercial confidentiality and the need for secrecy where spectrum is used for security or defence purposes. For a variety of reasons concerned with the policing of interferences as well as the policing of competition, the regulator will have to keep a register of spectrum use and license holdings. Much of this can be published, and its existence will be of great help to potential licensees seeking to find out who their spectrum neighbours would be if they offered a particular service in a particular frequency in a particular area.

Several countries have now had experience of secondary trading in spectrum licenses for a decade or more. These include countries in regions as diverse as North America, Australasia and Central America. In the European Union, the European Commission has proposed a target of having about one third of a major spectrum holding tradable and flexible by 2010. It is thus possible to evaluate the experience of secondary trading.

The evidence suggests that spectrum turns over about as fast as commercial property, somewhere between 3 and 10% of licenses changing hands every year. The data suggest that licenses are held as a strategic asset (for use by the licensee) rather than for speculative purposes. A number of transactions are the consequence of mergers and acquisitions, and some are intra-group asset transfers. Changes of use are comparatively rare, but several big transactions have been of this kind, especially on the boundary between broadcasting and mobile communications.

Has trading with flexibility caused interference problems? Given the rather limited experience so far, it is too soon to say anything definitive on this matter. Clearly, interference problems still persist in many countries, but most of these are due to illegal transmissions, rather than the complicated effects of change of use following secondary trading. Nor is there evidence of firms trying to 'corner the market' in particular frequency bands by license acquisition. Indeed, given that many countries where trading is allowed also plan to authorise flexibility, cornering the resulting fairly wide market for interchangeable spectrum will be very difficult.

Where there is excess demand for licenses, they can be assigned by lot (i.e. by randomly choosing winners from all qualified license applicants). If the licenses are potentially valuable, thousands or even millions might apply.

Defining Property Rights

Where trading occurs, it is (to say the least) desirable or even necessary that buyer and seller – as well as the regulator and the courts where appropriate – share the same understanding of the bundle of rights and obligations which are changing hands. This is true of land, for example, and also of a spectrum license. Clearly defined property rights are thus a precondition for efficient spectrum markets. The dimensions of rights and obligations in a spectrum license include:

1. The band which is available for use;
2. The geographical area in which it can be used;
3. The period for which the license is entitled;
4. The uses to which it can be put;
5. The licensee's degree of protection from other users;
6. The licensee's obligation not to interfere with other spectrum user's rights.

Freedom from interference and restrictions of rights to interfere with others are two major related dimensions of property rights in spectrum licenses. Under administrative assignment procedures, the license typically specifies what transmitting apparatus a firm could locate where, and the power at which it could be operated. By setting conditions for all licenses in this way, using an interference model which simulated the impact of apparatus on neighbouring reception equipment, interference can be controlled.

However, when change of use is allowed under a license, this form of control is no longer feasible as the nature and location of the apparatus to be employed are no longer given: they are now up to the licensee. This requires a redesign of the interference model, from one where calculating the impact of specific apparatus is done, to one which sets limits to the emissions the licensee can deliver at the geographical and frequency boundaries of the spectrum it is licensed to use. Various approaches to specifying these limits have been applied in Australia, the United Kingdom, and the United States.

Under a secondary trading regime, licensees can bargain with one another to make adjustments to specified boundary emission levels. If such deals benefit both sides, it is likely, but not inevitable, that they will be made.

Lotteries

Finally, spectrum can be assigned by means of a lottery: a winning ticket chosen at random will carry with it a spectrum award. This is a ‘non-pricing’ method of assignment. Although this procedure may seem attractive and equitable, it has many drawbacks. First, if many apply, the cost of administration may be large, especially if all applicants have to be vetted for suitability. Second, the lucky winners may not have the qualifications to operate the licenses efficiently. If they are not allowed to sell the license, this may be a recipe for disaster. And if, thirdly, they are allowed to sell them on to efficient operators, the winners will be appropriating auction proceeds which would otherwise go to the government.

6. SPECTRUM MONITORING

Introduction

Effective spectrum monitoring processes support activities centered on making interference-free assignments and includes the use of data and electro magnetic compatibility (EMC) verification activities. As well, monitoring and compliance activities are needed to ensure user compliance with both license conditions and technical standards helping users avoid incompatible frequency usage through the identification of sources of harmful interference. Furthermore, spectrum use planning and resolution of spectrum scarcity issues can be accomplished through study and analysis of spectrum occupancy data. Understanding the level of spectrum use or occupancy in comparison to assignments is important for efficient use of the spectrum resource. Spectrum monitoring provides statistical information on the technical and operational nature of spectrum occupancy.

In summary, the following central underlying objectives are supported by spectrum monitoring:

- Improving spectrum efficiency by determining actual frequency usage and occupancy, assessing availability of spectrum for future uses;
- Ensuring compliance with national spectrum management regulations to shape and sustain radio environments and user behaviour, maximizing the benefit of the spectrum resource to society;
- Resolution of interference problems for existing and potential users.

Spectrum Efficiency

One radiocommunication system is more "spectrum efficient" than another if it conveys the desired information using less of the spectrum resource. Spectrum efficiency also involves the arrangement of communication systems within the spectrum resource. In this broader sense, spectrum is used inefficiently when systems are not packed together as tightly as possible in frequency bands (as when excessive guard bands are used), or when portions of frequency bands are unused while other bands with similar physical characteristics are congested. The allocation of frequency bands, the development of channeling plans, and the assignment of frequencies to specific systems all affect spectrum efficiency.

In order to promote spectrum efficiency, spectrum managers must possess some means of quantifying spectrum use and evaluating various radio technologies and frequency selection techniques. Management decisions can then be based on the relative spectrum efficiency of the various technologies and techniques. Data is collected through spectrum monitoring measures of spectrum occupancy and utilization for purposes of making assignments including the effects of spectrum reuse and band clearing efforts. As well, as spectrum becomes scarcer in highly congested areas, monitoring data is used to support spectrum engineering activities including validation of tolerance levels, determining the probability of interference and development of band-sharing strategies.

License Compliance

In addition to supporting assignment and authorization activities, spectrum monitoring supports the second goal: compliance with license conditions and regulations through determination of deviations from authorized parameters, identification of sources of interference and location of legal and illegal transmitters.

A radio system can deny the use of part of the spectrum resource to another system that would either cause interference to, or experience interference from, the first system. A radio system is said to "use" spectrum resources when it denies other systems the use of those resources. Spectrum use can be quantified, subject to certain assumptions, both for a single radiocommunication system and for a related group of systems. The spectrum manager needs to choose the measuring system carefully and to ensure capabilities exist with the spectrum management agency to effectively monitor and analyze frequency bands. Circumstances will vary by country and monitoring solutions should be tailored to meet needs, budget and institutional capacity.

The International Telecommunication Union has created a system which classifies radio emissions according to the bandwidth, method of modulation, nature of the modulating signal, and type of information transmitted on the carrier signal. These form the technical basis for establishing equipment specifications for radio systems designed to operate within certain frequencies.

Emissions of a radio transmitter are authorized to an assigned frequency band within the necessary bandwidth and tolerance for the frequency band. Emissions which do not meet technical parameters are unwanted emissions consisting of spurious emissions and out-of band emissions. These types of emissions can be generated accidentally or through distortions caused by various components of the radio system.

Transmission of radio signals emitted by a radio transmitter can therefore be in-band in accordance with technical parameters or unwanted and due to several causes including out-of-band emissions and spurious emissions.

Monitoring is therefore done to obtain detailed information on the technical or operational characteristics of radio systems. The spectrum manager will monitor radio equipment to determine conformity with applicable standards. This can be done as part of an equipment certification process where measurements can be taken and recorded and then used in analyzing the compatibility of radio systems - Electromagnetic Compatibility (EMC).

Resolving Interference Problems

Spectrum monitoring activities determine measurements of radio waves and radiation causing interference to authorized transmitters and receivers. Interference may be the result of authorized emissions causing unintended results such as spurious emissions. Interference may also be caused by unauthorized transmitters or devices operating beyond technical specifications. In either case, the spectrum manager will use a combination of engineering analysis and data obtained from spectrum measurements to resolve problems associated with interference problems.

The identification of unauthorized transmitters can be very difficult to achieve, especially in congested areas and where various services share the same frequencies. In some bands, where spectrum sharing is encouraged through the use of Class Licenses or Radio Frequency

Management Approaches

At the international level on multi-lateral and bi-lateral bases and at the national level, there are several management and process models typically used in spectrum monitoring. ITU member countries often work together to operate monitoring facilities and to coordinate efforts to prevent, detect, and control of (harmful) interference to radio transmitters since it is recognized that development and duplication of monitoring facilities is both uneconomical and operationally inefficient. Article 16 of the Radio Regulations lays down the provisions governing the establishment and operation of the international monitoring system.

Stations comprising the international system check for transmissions that have effects beyond national boundaries, particularly for frequencies below 30 MHz, are in accordance with the internationally agreed conditions of operation. This includes checking frequency, bandwidth, emission type and usage. Where non-compliance with any prescribed condition is determined, the ITU provides for an infringement report to be sent via the Radiocommunication Bureau to the country responsible.

Cooperation involving non-governmental organizations and industry associations who advise regulators on policy and technical matters also occurs between countries. For example, broadcast and microwave propagation issues and solutions are identified and analyzed by associations and confirmed through spectrum monitoring tasks performed by the regulator.

Monitoring and enforcement of license and technical standards at the national level has traditionally been a responsibility of spectrum regulators, whether within independent agencies, or attached to the Ministry of Telecommunications. Departments such as Defence and Transport also often have responsibility over frequencies allocated to governmental use. In addition to public sector agencies, private sector participants are sometimes involved in the monitoring and problem resolution processes. These include industry associations, advisory councils, etc.

There are several examples where band management organizations govern specified frequency ranges under government authorization. An agency of government or non-governmental organizations (NGOs) assumes responsibility for essential monitoring activities and shares information on problems affecting civilian applications. Another example involves industry associations taking responsibility for monitoring and taking steps to resolve interference problems in fixed-link microwave services. Finally, the spectrum regulator concentrates its monitoring resources on public priority frequency bands affecting essential services, including air navigational aids, fire, safety, ambulance, police and areas of concentrated commercial activity such as is typically found in VHF/UHF.

Spectrum Monitoring Technology

Fixed, remote, unmanned and mobile monitoring equipment can be combined to provide tools for verification of licensing compliance, channel occupancy, spectrum planning, and regulatory enforcement. Those can also provide greater flexibility in the design of national and regional monitoring systems. Monitoring equipment and integrated software tools are very complex and expensive and integrated monitoring systems can be very expensive as well. Fortunately, advances in computerization, monitoring technology, and security techniques have permitted greater use of remote unmanned monitoring techniques involving integrated spectrum observations.

The following paragraphs provide a brief summary of the main types of equipment. The basic types of monitoring equipment include; antenna, spectrum analyzers, and direction-finding equipment. These basic types can be further categorized by frequency range (HF, VHF, UHF, etc.) and signal type – analogue or digital. With the advent of spread spectrum and computer-based radio technologies like Cognitive Radio, the sophistication, complexity and prices for monitoring equipment have risen. Simple systems for VHF/UHF monitoring can be comprised of several fixed antennas, receivers and limited function spectrum analyzers. More complex systems can consist of multiple sites and mobile and fixed stations. The approaches to monitoring and the architecture of the spectrum manager's monitoring system have a bearing on the types of systems needed and the configuration of operations and resources.

An antenna is simply an electronic component designed to radiate energy and transmit or receive radio waves. Different antenna types are used for different radio frequencies and for different coverage areas. All antennas radiate some energy in all directions but careful construction results in large directivity in certain directions and negligible power radiated in other directions. Antennas are linked to either radio receivers or signal generators of direction-finding equipment and can be applied in Mobile and Stationary Systems, providing complete coverage of the frequency range from 100 Hz to 30 GHz and beyond in the case of some manufacturers.

Spectrum Analyzers help determine whether each radio service operates at the assigned frequency and within the allocated channel bandwidth. The common measurements taken by a spectrum analyzer include frequency, power, modulation, distortion, and noise. Understanding the spectral content of a signal is important, especially in systems with limited bandwidth. Since transmitters and other intentional radiators operate at closely spaced adjacent frequencies, power amplifiers and other components are measured to determine the amount of signal energy that spills over into adjacent channels and causes interference. The concern is that these unwanted emissions, either radiated or conducted (through the power lines or other interconnecting wires), might impair the operation of other systems.

Radio Direction-Finding, or RDF, is the technique used for determining the direction and/or location of a radio transmission/transmitter. Radio direction-finding using triangulation techniques can also be used to determine the location of a radio transmission. Radio direction-finding is used by spectrum managers to locate the source of radio frequency interference.

Designing Spectrum Monitoring Systems

Key considerations in the design of spectrum monitoring systems include types of equipment, speed and sophistication of data capture and processing, degree of integration with software tools for analysis and comparison with other license and type approval data. Other considerations include proximity to active airspace, staff skills, and mobile versus fixed locations.

- State-of-the-art spectrum monitoring equipment is highly integrated. Integration typically involves the use of graphical user interface (GUI) based spectrum management tools and systems which are specifically designed to operate multiple electronic components simultaneously and remotely over data protocols such as TCP/IP. This allows for an integrated network system for management of the radio spectrum using remote devices. These devices can be located at existing government sites and facilities on the outskirts of population centres. Remote devices permit access to monitoring equipment from anywhere through compatible computer, a modem and a telephone line or network connection (LAN or WAN).

There are organizational and functional aspects to architecting spectrum monitoring systems. Organizational components include centralized, regional and remote locations for siting of monitoring equipment in stations and operational staffing or use of unmanned remote capabilities, where applicable. Functional components of spectrum monitoring systems include: central monitoring control; operational consoles for operation of equipment and analysis of data; and data networking and management systems for data communications and repository.

<u>Enforcing License Requirements</u>

Spectrum users need to comply with license requirements and technical rules and regulations since without effective regulations and enforcement procedures, the integrity of the spectrum management process can be compromised. Spectrum managers are particularly concerned with interference problems affecting public safety and security services such as ambulance, fire fighting, police, and navigational services at airports.

Monitoring is used to obtain detailed information on the technical and operational characteristics of radio systems which are in use or are being tested for future use. Measurements will typically include frequency, power and emission spectrum of a transmitter. License conditions can be verified against actual use of equipment aiding in the determination of electromagnetic compatibility (EMC).

In the case of harmful interference, the spectrum manager may do, at the owner's expense, any one or more of the following:

1. Take suitable measures to eliminate or reduce the interference or disturbance;
2. Remedy a fault in or the improper operation of the equipment;
3. Modify or alter the equipment or;
4. Disconnect the equipment.

In the course of conducting exercises to resolve interference problems, the spectrum manager may be required to enter user premises and inspect radio equipment to determine compliance with license conditions and technical standards and in some cases seize equipment. An important aspect of completing these tasks noted above is the requirement under law and regulation to establish the appropriate limits on regulatory powers and authorities and clearly establish the duties and obligations of the spectrum manager/inspector and protection of rights for the public under circumstances where inspection of property is necessary. There are (hopefully rare) occasions when the user of a transmitter causing harmful interference is endangering the public in a persistent and willful manner and the reasonable course of action requires the spectrum manager to seize equipment preventing future endangerment.

As well, it is helpful to have an appropriate framework and process for responding to and managing complaints, for settling disputes, and resolving interference problems. Consideration needs to be given to penalties, remedies, enforcement and alternative dispute resolution (ADR) mechanisms for industry disputes with the aim of ensuring rapid resolution.

7. INTERNATIONAL AFFAIRES

The international framework for spectrum management is set out in a treaty ratified by the Member States of the International Telecommunication Union (ITU) and, in particular, the Radiocommunication Sector (ITU-R). The mission of the ITU-R sector is, inter alia, to ensure rational, equitable, efficient and economical use of the radio frequency spectrum by all radiocommunication services, including those using satellite orbits and to carry out studies and adopt recommendations on radiocommunication matters.

The ITU's Telecommunication Development Sector (ITU-D) has well-established programmes to facilitate telecommunication connectivity and access, foster policy development, assist in regulatory and network readiness, to expand human capacity through training programmes, to formulate financing strategies, and to enable enterprises in developing countries. These programmes are designed to address topics of interest to spectrum regulators.

In addition to activities carried out within the ITU framework there are international project activities leading to bilateral and multi-lateral agreements harmonizing spectrum use across national borders. Some of these international project activities include the ITU World Radio Conference (WRC) and related Regional Conferences and Study Groups.

There are many international activities related to spectrum management and to follow all of them is very resource intensive. Priorities should be established so that the most critical activities are closely monitored. A cost effective way of involvement in ITU work is to participate in the ITU related activities of regional and sub-regional telecom organizations. These organizations can be an efficient and effective way by which countries can influence global decisions.

It is also important for countries to be aware of and where appropriate participate in activities that touch on spectrum matters in other international bodies in addition to activities within the framework of the International Telecommunication Union. These organizations include, as mentioned previously, the World Trade Organization (WTO) and the International Civil Aviation Organization (ICAO). Other bodies include the International Maritime Organization (IMO) and the World Meteorological Organization (WMO).

In addition to activities in the ITU and other global, intergovernmental organizations, bilateral and multilateral agreements for the use of the spectrum are often developed. Such agreements might, for example, set out how two or more countries will coordinate their use of certain frequency bands. Establishing agreements requires negotiations between the spectrum authorities in the respective countries and possibly the involvement of foreign affairs ministries depending on the legal status of the resulting agreement which can take the form of a simple exchange of letters, a memorandum of understanding, a treaty, etc.

8. ORGANIZATION EFFECTIVENESS AND CAPACITY BUILDING

Organizational effectiveness relates to the capacity of a spectrum management organization to sustain its staff resources, plans and strategies, learning, infrastructure and financial resources it needs to continue to achieve its mission. Organizational effectiveness is a long-term outcome that capacity building strategies should affect.

It is crucial to the understanding of spectrum management organizational effectiveness to thoroughly grasp its mandate and mission. The country's legal and regulatory frameworks along with policies concerning governance provide the essential definitions of policy goals and outcomes. The governing framework includes the following, amongst others:

- International agreements and regulation such as ITU Radio Regulations, WTO agreements, multi-lateral and bi-lateral regional agreements on telecommunications and trade;
- National Telecommunications Law, Competition Law, and Investment Law and related regulations;
- Spectrum Regulations;
- Employment Law and related regulations.

Developing Spectrum Management Capacity

Strategies for organization, function, process development, staffing, staff retention and training are important considerations for spectrum regulators. The central concerns of spectrum management — namely promoting spectrum access and efficient use, resolving conflicting demands, managing change, enhancing coordination and avoiding interference, fostering communication and consultation, and ensuring that data and information are shared — require a broader view of capacity development. This definition covers both institutional and individual capacity building.

Spectrum regulators need to consider strategies for developing the spectrum management organization, including human resource development, spectrum management functions, process development, staffing and staff retention, and training. These capacity-building strategies flow from legislation, policies and the regulatory framework and includes other agencies are involved in certain aspects of spectrum management.

The traditional spectrum management regulatory functions include:

- Charting the major trends and developments in technology and considering the needs of current and future users of the radio spectrum.
- Evaluating information, capabilities and technology choices to support decisions affecting the allocation, allotment and assignment of radio spectrum.
- Identifying solutions to interference problems and technical compatibility among radio systems are key areas of focus.
- Licensing radio communication equipment and making frequency assignments.
- Monitoring and compliance activities help by avoiding incompatible frequency usage and through identification of sources of harmful interference.

How spectrum managers fulfill these requirements and meet strategic operational and organizational goals represent formidable challenges made more difficult in an environment characterized by change and innovation. These types of capacity-building problems are not new, nor are they unique to spectrum management. Solutions do exist for developing, planning and implementing processes that will improve organizational structure, function and the development of required skills.

Organization

The country’s legal and regulatory frameworks, along with policies concerning governance, provide the defining building blocks for the spectrum management organization. The implication for capacity building is the need to develop and maintain human resource skills independently of other organizations, or to find ways of sharing in the development and utilization of human resources through strategies such as matrix management or centres of excellence within the combined regulator.

No two spectrum management organizations will be organized in the same manner, yet some similarities do exist in structures organized around the key functions of planning, engineering and authorization and monitoring. Cost and resource availability put pressure on spectrum managers to create organization and design functions which ensure productivity. This can be achieved through sharing and cross-fertilization of skills.

Human Resources

Spectrum management is a knowledge-based function requiring skilled and committed personnel who are able to keep pace with continuous advancements in radio technologies, and increasingly complex demands from users seeking access to the spectrum resource. Providing a challenging and rewarding experience for staff, trainees and new recruits means giving them the tools and support they need for learning and development throughout their careers.

Designing functions and roles, staffing, and developing necessary skills and capacity do present difficult and important challenges for spectrum regulators, especially those in developing and emerging countries. There are a number of complex tasks which need to be planned, as set out below.

Routine tasks and methods are associated with licensing of radio communications, type approval of radio equipment, and routine monitoring. These tasks are supported by well-defined administrative processes which can be dramatically improved and made more cost-effective through the use of efficient information management systems. Quality of service can be improved by placing service points of presence close to clients and users.

Technical tasks require staff with extensive formal and methods-based training and experience. Frequency assignment, technical standards, spectrum engineering, information systems and radio monitoring are tasks that require these levels of training. Core professionals/specialists work closely with clients.

Conceptual and coordination tasks are associated with planning, coordination, consultation, and strategic initiatives associated with international consultation on spectrum planning matters.

Automated Systems

Planning and engineering functions provide areas for developing expertise needed to ensure the regulator has the appropriate technology, standardized processes and procedures to perform necessary tasks and comply with legislation and regulations. In support of these functions, automated systems can be acquired or developed to support data management and administrative requirements. Important business processes involving analysis, data checks and processing can be support through automated processes. The time required and costs involved in determining, acquiring or developing automated systems can be great. Spectrum regulators need to carefully analyze needs and develop IT systems and support plans.

Capacity Building through Consultation

The impetus for consultative mechanisms involving stakeholders arises from the need for improved short-term planning and assignment processes which reflect the economic value of spectrum to the public, and for improved transparency in decision-making. The design of consultative processes should take place within a broader assessment of the role, contribution and extent to which industry and stakeholder groups should participate in the implementation and monitoring of the broader agenda of planning and efficient usage of spectrum. Action based on partnerships and involvement of major groups opens up a wider political sphere for the participation of social and economic actors and constitutes a "bottom-up" source of strength[4].

Consultative processes occur on at least three distinct levels — international, national/domestic, and industry/subject-specific. Processes can be formalized, informal or ad hoc. Planning subjects range from policy and regulatory framework development and formulation through forecasting of demand and technology application to procedures such as channel planning for broadcast frequencies.

[4] ITU (2005): Geneva. The National Spectrum Management Handbook - Chapter 2, Liaison and Consultation.

End Note

This executive summary provides readers of the online toolkit with an overview of the many topics and issues addressed in the content, reference documents and practice notes associated with Module 5 - Radio Spectrum Management. One of the important recurring topics in the module is the contrast between administrative and market-based methods for assigning spectrum to various uses and users. Spectrum managers are responding to innovation and change which are taking place in all aspects of spectrum use and spectrum management. As technology continues to make advances and new services and uses are being developed, methods for planning involving consultation and assigning spectrum are becoming better understood and continue to evolve. A goal of the authors has been to examine the various methods being used by spectrum managers by drawing upon the theoretical basis and pointing to practical applications and by describing important implementation considerations giving spectrum managers a basis for further analysis and discussion and a choice as to what approach is most appropriate in their circumstances.