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Review of Spectrum Management Practices

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Introduction

This report supplements the information provided in the FCC's Connecting the Globe: A Regulator's Guide to Building a Global Community,[1] which has been widely disseminated as a reference in organizing a regulatory framework for telecommunications. This new report updates and expands upon Connecting the Globe, giving telecommunications regulators additional material and references to use in establishing a regulatory authority for spectrum management. While a long list of actions is necessary in establishing spectrum policies for the myriad of wireless services, it is hoped that this Guide will help regulators to think through the critical issues they will encounter, and provide references for further study of specific issues.

Background

The radiofrequency spectrum, a limited and valuable resource, is used for all forms of wireless communications, including radio and television broadcast, cellular telephony, telephone radio relay, aeronautical and marine navigation, and satellite command, control, and communications. The radiofrequency spectrum (or simply, the "spectrum") is used to support a wide variety of applications in commerce, government, and interpersonal communications. The growth of telecommunications and information services has led to an ever-increasing demand for spectrum among competing businesses, government agencies, and other groups. Because two or more telecommunications signals occurring simultaneously and in the same location can interfere with each other, the spectrum must be managed to prevent interference. The process of spectrum management includes establishing a regulatory structure, usually within the government,

[1] The first version of that document, published in 1999, can be found at http://www.fcc.gov/connectglobe/. A more detailed version, published in 2000, is on CD-ROM, and is available only from FCC staff.

which develops general policies, allocates spectrum, establishes service rules, assigns spectrum to specific users, and enforces the rules that users must follow.

For further background on radio frequency spectrum and its uses, see http://www.ntia.doc.gov/osmhome/osmhome.html, and *Spectrum Allocation and Management*, presentation by Dale Hatfield, Chief Office of Engineering and Technology, FCC, June 6, 2000.

Regulatory Structures for Spectrum Management

International Spectrum Management

As a public resource, radio spectrum must be managed by governments to ensure that it is shared equitably to promote the public interest, convenience, or necessity. At an international level, spectrum is managed by the International Telecommunication Union (ITU). The ITU's Radiocommunication Sector (ITU-R) maintains a Table of Frequency Allocations which identifies spectrum bands for about 40 categories of wireless services with the goal of avoiding interference among those services. Once the broad categories are established, each country may allocate spectrum for various services within its own borders in compliance with ITU's Table of Frequency Allocations. The Table divides the world into three Regions. Region 1 includes Europe and Africa, Region 2 includes North and South America, and Region 3 includes Asia and Australia. ITU-R also coordinates efforts to eliminate harmful interference between radio stations of different countries and to improve the use of spectrum and of geostationary-satellite orbits for radio communication services. ITU-R also sponsors World Radio Communication Conferences every two to three years to update the Table in response to changes in needs and demand for spectrum. The ITU's Development Sector (ITU-D) focuses on telecommunications needs and issues of developing countries, and may in become involved in spectrum-related issues for those countries.

Bilateral/Multilateral Spectrum Management Regulatory Structures and Policies

Spectrum management has become such an important economic and political issue, that even regional organizations have begun to try to influence spectrum management policies. The European Union, for example, adopted in December 2001 a "Decision on a Regulatory Framework for Radio Spectrum Policy in the European Community," along with five other topic-specific telecommunications Directives.[2] This regulatory "package" reflects the growing importance of the European Commission relative to the National Regulatory Authorities (NRAs) in Europe.

In keeping with this trend, the Spectrum Policy Decision calls for greater cooperation among EU regulators to ensure the coordination of policies and harmonized and efficient use of spectrum in areas such as electronic communications, transport, and research and development. The Decision establishes procedures to facilitate policy-making with regard to economic, safety, health, public interest, freedom of expression,

[2] The five Directives include a general Framework Directive, and more specific Directives on Access, Authorization, Universal Service, and Data Protection.

cultural, scientific, social and technical aspects of policies, with the aim of optimizing the use of spectrum while avoiding harmful interference. A Radio Spectrum Committee will be established to support the European Commission in these activities. Some claim that one of the main goals of the Decision is to avoid the major differences that have occurred in the past over how EU countries grant licenses for mobile services. However, while the Decision gives authority to the European Commission over general spectrum allocations, it does not give this authority over assignment or licensing procedures by member states.

For further information on ITU's spectrum-related activities, see http://www.itu.int/ITU-R/. For ITU's spectrum activities related to developing countries, see http://www.itu.int/ITU-D.

U.S. System and Procedures

In the United States, the Communications Act of 1934 established the FCC as an agency, independent of the executive branch, to manage all non-federal government spectrum (which includes commercial, state, and local government uses), while preserving the President's authority to manage all spectrum used by the federal government. The President also manages frequency assignments to foreign embassies and regulates the characteristics and permissible uses of the government's radio equipment. The President delegates this authority to the Assistant Secretary of Commerce for Communications and Information, who is also the Administrator of the National Telecommunications and Information Administration (NTIA). NTIA's Office of International Affairs represents U.S. government interests in international fora, such as ITU conferences (e.g., World Radio Communication Conferences) along with the FCC and other federal agencies. NTIA's Office of Spectrum Management develops policies and procedures for domestic spectrum use by the federal government. This entails developing long range plans and war and readiness plans for spectrum use and chairing the Interdepartmental Radio Advisory Committee (IRAC).[3]

NTIA assigns frequencies and approves the spectrum needs for all federal government systems to support their mandated missions.[4] NTIA strives to improve federal spectrum efficiency by requiring federal users to use commercial services where possible, promoting the use of new spectrum efficient technologies, developing spectrum management plans, and collecting spectrum management fees from federal agencies. Since much spectrum is shared between government and private sector uses, NTIA and the FCC are working toward increasing private sector access to the shared spectrum.

The FCC classifies the commercial radio spectrum bands into various services, and authorizes specific frequency bands for those services. This spectrum authorization process is updated whenever new radio services are developed. The FCC then assigns licenses to parties or individuals to operate on a specific frequency band (*a channel*) within an authorized band in a specific location and under specified conditions. Licenses can be defined in terms of location and technical parameters (frequency, power, antenna

[3] The IRAC is composed of representatives of 20 major U.S. federal agencies who develop policies for federal spectrum use.

[4] Major federal spectrum users include the Departments of Defense, Justice, Transportation, Interior, Agriculture, Commerce, Treasury, Energy, the National Aeronautics and Space Administration, and the Federal Emergency Management Agency.

height, etc., as for broadcast licenses) or in terms of multiple channels covering geographic areas (as for cellular licenses). In making these decisions, the FCC considers the public need and benefit of the service, propagation characteristics in a given band, compatibility within and outside the selected band, amount of spectrum and signal strength required, and apparatus limitations. The FCC, as an independent regulator, is designed to be impartial from the companies and industries that it regulates, and to be protected from political pressures.[5]

For further information on NTIA's activities in spectrum management, see NTIA's Office of Spectrum Management web site http://www.ntia.doc.gov/osmhome/osmhome.html. For further discussion on spectrum allocations, including the FCC's Table of Frequency Allocations See the FCC's Office of Engineering and Technology web page on radio spectrum at http://www.fcc.gov/oet/spectrum/.

Regulatory Structures in Other Countries

Other countries take a variety of different approaches toward spectrum management. Nevertheless, many of these alternatives have proven to be effective and efficient methods of spectrum management, and are worthy of study. A significant difference between U.S. practices and those of most foreign governments involves how federal vs. non-federal spectrum is managed. While in the United States, the FCC manages all non-federal spectrum, in most countries, both all spectrum is managed by a single executive branch agency. While the FCC is independent from the executive branch, the spectrum management functions in other countries have varying degrees of independence from the executive branch.

In the Canadian government, for example, an executive branch agency called Industry Canada manages all spectrum (federal and non-federal) in an office called the Spectrum, Information Technology, and Telecommunications (SITT) Sector. SITT manages spectrum use by broadcasters, operators, and radio license holders, and protects Canada's rights and interests regarding spectrum use through international agreements and regulations.[6] However, broadcast licenses are managed by an independent regulatory agency called the Canadian Radio-television and Telecommunications Commission (CRTC). CRTC regulates and supervises all aspects of the Canadian broadcasting system, as well as telecommunications common carriers and service providers. This includes granting and maintaining licenses for spectrum use by broadcasting entities.[7]

While some claim that the Canadian system of having one agency for spectrum management is more efficient than the U.S. system, others point out that many spectrum related issues necessarily involve broadcast licenses, a function of the CRTC. For example, the transition to digital television for over-the-air broadcast services could require a reallocation of television spectrum, and a reclaiming and redistribution of broadcast licenses by the government. Similar to coordination between the FCC and

[5] Connecting the Globe, Regulatory Challenges and Opportunities, page I-1.
[6] See Description of Industry Canada service programs at http://infosource.gc.ca/info_1/IC-OR-e.html.
[7] However, broadcasters must also obtain licenses for their facilities, which are issued by Industry Canada.

NTIA in the United States, coordination between SITT and CRTC on these activities may be difficult.

The United Kingdom is currently making organizational changes in the way its spectrum is managed. Up to now, all non-military spectrum management in the U.K. was performed by the Radiocommunications Agency of the Department of Trade and Industry. This includes "international representation, commissioning research, allocating spectrum and licensing its use, and keeping the radio spectrum clean" of interference and illegal transmissions. Because the U.K. legislative and executive functions are not separate, this agency is equivalent to an executive branch agency in the United States. Under the legislation, currently moving through Parliament, a new Office of Communications (OFCOM) will be created to encompass a wide range of economic and content regulation, including spectrum management. The UK Office of Telecommunications (OFTEL) is the regulatory and enforcement agency for the UK telecommunications industry, which includes broadcast transmissions. The head of OFTEL is appointed by the Secretary of State for Trade and Industry, but otherwise is independent of ministerial control.[8]

The new OFCOM will be more independent of the administration than OFTEL, and will combine the functions of the Broadcasting Standards Commission, Independent Television Commission, OFTEL, the Radio Authority, and the Radiocommunications Agency. The U.K.'s new spectrum strategy will include the use of market mechanisms, such as spectrum pricing (the charging of fees for access to spectrum that reflect the value of that spectrum, introduced in 1998) and spectrum trading (allowing secondary markets, such as spectrum leasing by band managers), which the UK government will introduce in late 2002.[9]

A wide range of spectrum management practices exist in other countries. One of the most liberalized regimes is Australia, where spectrum management regulations are performed by the Australian Communications Authority (ACA), although the Australia Broadcast Authority (ABA) handles the granting and management of broadcast licenses.[10] There is also no separation in Australia between federal and non-federal spectrum management. One of the most traditional systems is in Japan, where spectrum management is administered by the Radio Department of the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT).[11] MPHPT also controls spectrum use by all government agencies, public safety communications systems, and the military. There are a variety of spectrum management systems with characteristics between these two extremes.

For more details on Canada's system for spectrum management, see Industry Canada's spectrum Management and Telecommunications website at http://strategis.ic.gc.ca/sc_mrksv/spectrum/engdoc/spect1.html. For more information on the U.K. system for spectrum management, see the Radiocommunications Agency website, http://www.radio.gov.uk/. For more details on Australia's spectrum

[8] For further description of OFTEL, see http://www.oftel.gov.uk/.
[9] UK Spectrum Strategy 2002, Radiocommunications Agency, PDF linked to http://www.radio.gov.uk/.
[10] This arrangement is currently under review by the Australian government.

management, see the Australian Communications Agency website at http://www.aca.gov.au/authority/aca.htm. For more information on Japan's spectrum management, see the website for MPHPT at http://www.soumu.go.jp/.

Spectrum Allocation and Service Rules

After a set of spectrum bands have been allocated for a service by the ITU, each nation can adopt some or all of those bands for the service within its own borders. In the FCC, the Office of Engineering and Technology has lead responsibility for spectrum allocations, but also consults with the other Bureaus and Offices to determine optimal course of action. The FCC maintains a Table of Frequency Allocations that includes the International Table of Frequency Allocations and the United States Table of Frequency Allocations (which includes federal and non-federal allocations). Once spectrum is allocated, **service rules** are developed to establish the band's uses, licensing rules, operating rules, technical rules, and the assignment process to be used.

Band Plans

Traditionally, in the spectrum allocations and service rules process, a "band plan" is developed to show how the spectrum in a given band is to be allocated for new and existing services. Technical standards are also usually adopted that dictate what types of technology may be used. As technologies evolve, however, incumbent spectrum licensees are often able to reduce the amount of spectrum they need to perform the same services, while emerging services have to struggle to obtain new spectrum allocations. For several examples of band plans adopted by the FCC, see http://wireless.fcc.gov/auctions/data/bandplans.html.

Market-Based Approaches

In recent years, spectrum regulatory agencies in several countries have been using various market-oriented approaches to spectrum allocations and service rules. These have included eliminating some of the restrictions on licensees, and streamlining eligibility requirements, service rules, technological standards, and build-out requirements, as long as they do not cause interference or anti-competitive concentration.

One market-based approach is to allow **transferability** of spectrum licenses and spectrum usage rights, which refers to allowing licensees to buy and sell licenses. This can include allowing partitioning of service areas and disaggregation of licensed spectrum so that licensees can tailor spectrum holdings. It can also include encouraging efficient spectrum use through secondary markets (including allowing capacity leasing, spectrum leasing, band managers, and short- and long-term arrangements).

Another market-based approach that has been used increasingly is to allow greater **flexibility** in the rules for spectrum use. Flexible spectrum use policy emphasizes a deregulatory environment, except to prevent interference. This includes allowing licensees to develop any technologically feasible services (e.g., fixed, mobile) which best accomplish their business plans. For example, in the FCC's proceeding in the mid-1990s

for personal communications services (PCS), licensees were given far greater flexibility in responding to consumer demand than previously issued licensees for wireless services. Flexibility also allows evolution within existing bands to more advanced services. In 1999, the FCC adopted spectrum management principles including allowing greater flexibility in allocations, providing regulatory neutrality for similar wireless services, promoting new spectrum-efficient technologies (such as ultra-wideband and spread spectrum technologies), encouraging the development of secondary markets for spectrum, and seeing ways to make spectrum available through, for example, assigning user fees or by reclaiming existing spectrum.[12]

Technology neutrality refers to allowing licensees to choose whatever standards and technologies they wish to deploy, as long as incumbent licensees are protected from interference. Examples where this approach has been used in the United States include the PCS proceeding, where multiple technologies were deployed for signal transmission (GSM, TDMA, CDMA…), and the possibility of allowing software-defined radio, in which functions that were formerly performed in hardware (e.g., controls of transmitted signal generation and detection of received signal) are controlled by software.[13] Under a policy framework of technology neutrality, as new technologies are developed by the private sector, new services and innovations could more easily be implemented without regulatory changes.

Because the demand for certain spectrum bands is particularly high, regulators have established **spectrum sharing** policies for more than one service to use the same band. In some cases, one or more services are designated as primary, and others as secondary. For example, in the United States, many spectrum bands are assigned to federal radar operations as a primary service and amateur radio as a secondary service. In some cases, services share a spectrum band on a co-primary basis, and they are given an equal degree of protection from harmful interference. When spectrum cannot be shared, a strategy must be developed for clearing a band of the existing licensees for a new service. **Band clearing** usually involves requiring the new licensees to pay for the costs incurred by the incumbent licensees to purchase new equipment and relocate to new frequencies. This process can take a phased approach so that spectrum is not wasted while the new service is building its system before services are offered to customers, and this can take many years to complete.[14]

Another market-based option, used increasingly, is to allocate spectrum for **unlicensed uses**. These include cordless phones, crib monitors, remote control devices, and radio frequency identification devices. Newer unlicensed technology applications include wireless local area networks (LANs), ultra-wideband technology (which spreads the transmitted signal over a wide range of frequencies at very low power, allowing

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[12] FCC 99-354, "In the Matter of Principles for Reallocation for Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium" (Nov. 22, 1999)

[13] FCC 01-264, *First Report and Order in the Matter of Authorization and Use of Software Defined Radios*, ET Docket 00-47, released September 14, 2001.

[14] An example of the use of a phased transition is found in the 2GHz band proceeding when a transition was established from Broadcast Auxiliary Services to Mobile Satellite Services, FCC 00-233, *Second Report and Order in the Matter of Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2GHz for use by the Mobile Satellite Services,* ET Docket 95-18, 15 FCC Rcd 12315, released July 2000.

devices to operate using spectrum occupied by existing radio services without causing interference).[15]

For further reading on market-based approaches to spectrum management, see *Using Market-Based Spectrum Policy to Promote the Public Interest* (FCC publication, 1997), at http://www.fcc.gov/Bureaus/Engineering_Technology/Informal/spectrum.txt.

Spectrum Assignment

Once the allocations and service rules are completed, then spectrum can be assigned to individual users. The most common way to assign commercial spectrum is to award licenses. This can be done using one of several methods: (1) a first-come, first served approach may be appropriate when there are fewer applicants than there are licenses to award; (2) comparative hearings, or "beauty contests," allow the regulator to make a licensing decision based on the technical capability and financial stability of the applicants, among other factors (payment may or may not be made for licenses under this approach); (3) lotteries allow licenses to be awarded to pre-qualified applicants through random selection; and (4) auctions award the licenses based on bidders' willingness to pay. In some countries, there is a debate over how to make a transition from a comparative hearing process to an auction process for spectrum assignment. One of the questions in that debate is how to treat licensees that have been granted licenses for free, compared to licensees for the same service that paid for their license at an auction.

Geographic vs. Location-Specific Licensing

Spectrum licenses can be assigned on either a geographic or location-specific basis. Geographic licenses permit the licensees to use a band of spectrum covered by the license anywhere within a geographic area. These can range from small areas that correspond to towns or metropolitan areas, larger aggregated areas or regions, or a single license covering an entire nation, and many variations in between. The main idea is that the licensee can use the assigned spectrum right up to the edge of the geographic boundary, but not beyond it. To accomplish this technically, lower power levels, antenna heights, and directional antennas are used near the geographic boundaries. Cellular telephony systems typically use geographic licensing. Location-specific licenses permit licensees to transmit at a specific frequency (rather than within a band) from a specific location, and stipulate power levels, antenna heights, and modulation schemes to limit how far the signal transmits before it drops down to a negligible signal strength. Terrestrial broadcast licenses are typically assigned on a location-specific basis.

For several examples of geographic license schemes used for wireless services in the United States, see http://wireless.fcc.gov/auctions/data/maps.html#areas, and also *International Survey of Spectrum Assignments for Cellular and PCS*, (FCC publication, 1996) at http://wireless.fcc.gov/auctions/data/papersAndStudies/spicer.html. For a

[15] FCC 01-290, *Notice of Proposed Rule Making and Order in the Matter of Review of Part 15 and other Parts of the Commission's Rules*, ET Docket 01-278, released October 15, 2001. FCC 02-151, *Second Report and Order in the Matter of amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices*, released May 30, 2002.

description and database of broadcast licenses in the United States, see http://www.fcc.gov/mb/databases/cdbs/.

Focus on Auctions as a Spectrum Assignment Tool

Since the mid-1990s, a number of countries have been using auctions to assign commercial spectrum licenses where there are competing applications. Although some auctions have been criticized, most assessments consider auctions to be more effective than previous methods of distributing licenses for certain types of licenses. Auctions distribute the licenses more quickly to those who value them the most, increase the likelihood that spectrum will be used productively, foster a competitive market, and can raise revenue for the federal treasury depending on how proceeds are distributed. In most countries that employ auctions, certain spectrum uses are exempt from auction. In the United States, auction exempt services include public safety, noncommercial educational broadcasters and international satellite services.

The United States was not the first country to authorize and implement spectrum auctions. New Zealand first authorized auctions of both "apparatus licenses" and spectrum "management rights" as part of its Radiocommunications Act of 1989.[16] Initially, the Act was implemented by offering "tenders" for spectrum licenses (whereby sealed bids were evaluated prior to a licensing decision) starting in 1989. To date, New Zealand has conducted four auctions for spectrum rights of various types and the fifth (for wireless local loop, local multipoint distribution services, and cellular use) is underway.

Some governments, however, have not endorsed spectrum auctions. France, for example, conducted a "beauty contest" in which potential spectrum license bidders presented their business plans and their financial portfolios. The French government selected the five applicants it considered to have the best chance of success and charged a pre-determined fee for the spectrum licenses. The Japanese government also has not authorized spectrum auctions, and continues to use comparative hearings.

For further reading on spectrum auctions, see the FCC's Auctions web page at http://wireless.fcc.gov/auctions/ (includes discussion of auction designs, how auctions are initiated and conducted, and bidding issues), and studies on auction procedures and issues. Also see New Zealand's Ministry of Economic Development website at http://www.med.govt.nz/rsm/ and auction in formation at http://auction.med.govt.nz/, Canada's spectrum auction website at http://strategis.ic.gc.ca/ssg/sz00266e.html, and the U.K. Radiocommunications Agency Spectrum Auctions website at http://www.spectrumauctions.gov.uk/.

Duration of Spectrum Licenses

Although all spectrum licenses granted by most governments are limited in duration (usually for ten-year terms in the United States), there is often a high expectation of renewal. In the United States, the FCC generally only revokes a spectrum license in

[16] *The Wireless Craze, The Unlimited Bandwidth Myth, ... by Tom Hazlett,* AEI-Brookings Joint Center for Regulatory Studies, January 2001.

cases of repeated negligence or willful misuse. This has set a legal precedent and a signal to financial markets that a spectrum licensee can be treated as a *de facto* perpetual licensee. It is recognized that the duration of a spectrum license must be long enough to encourage investors to pay for the up-front costs of building a network, a broadcasting station, or other telecommunications system associated with the license. However, it is impossible to precisely estimate the value of a spectrum license too far into the future, just as it is impossible to predict the best use of spectrum into the future. For example, the need for spectrum for wireless Internet applications could not have possibly been predicted in the 1960s, before the Internet existed.

As new technologies and services emerge, it is necessary to reevaluate spectrum allocations and license assignments, and if necessary, to reallocate spectrum and reassign licenses. Some countries are granting spectrum licenses with an explicit stipulation of the license's duration at the outset, such as the 3G licenses auctioned in Germany and the U.K., in which the license terms state that the licenses revert back to the government after 15 years.[17]

For further discussion of spectrum license duration issues, see *Principles of Spectrum Policy Reform*, by Michael Calabrese, New America Foundation, October 2001 (page 10), and *Review of Radio Spectrum Management: An Independent Review for Department of Trade and Industry and HM Treasury* (U.K. government publication), by Martin Cave, March 2002.

The Regulation of Broadcasting

Unlike the U.S. system, in most countries, broadcasting services are regulated by a separate agency from the agency that performs other telecommunications regulation, including spectrum management. In Australia, the Australian Broadcasting Authority (ABA) regulates and licenses the spectrum allocated to broadcasting by the Australian Communications Authority (ACA).[18] In Hong Kong, the Broadcasting Authority, an agency independent from the Office of Telecom Authority, regulates all broadcasters. In some countries there are slight variations on this theme. In Canada, the Canadian Radio-Television, and Telecommunications Commission (CRTC) regulates both broadcasting and other telecommunications, but only issues spectrum licenses for broadcasters. Spectrum licenses for other uses are issued by Industry Canada, which also performs the original allocations for all spectrum (including broadcasting spectrum). The U.K. system for broadcast regulation is similar to Canada's but will become more similar to the U.S. model if the U.K. pending telecom legislation is passed. In Finland, regulatory responsibilities for broadcasting are divided between the Ministry of Transport and Communications (MTC) and the Telecommunications Administration Centre, an agency under the MTC. In some countries, like Japan for example, the regulation of broadcasting is performed by an executive branch agency, the Broadcasting Bureau of Radio Department of the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT).

[17] *Principles of Spectrum Policy Reform*, New America Foundation, October 2001, page 10.
[18] This arrangement is also under review by the Australian government.

In many countries (such as the United States, Canada, and Britain), the broadcast regulatory authorities make a distinction between the regulation of signal being transmitted and the content of the programming that is broadcast. The regulators are able to enforce the rules to prevent interference between broadcasting and other wireless services. However, the laws in these countries prohibit the government from regulating the content of programming under the principle of freedom of speech. Exceptions to this prohibition are made for content that is deemed to be obscene or indecent.

Various broadcasting issues and information on U.S. broadcasting policies are addressed in the FCC Media Bureau's website at http://www.fcc.gov/mb/facts/. These include public broadcasting, emergency broadcasting services, the AM expanded band, antenna structure registration, antenna construction, tower sitings, radio frequency emission safety guidelines, government telecommunications sites in other countries, how to apply for a broadcast station, how to participate in the rulemaking process, inspections of radio installations, low power FM radio, low power television, TV translators, and digital TV. Information on U.S. policies regarding obscene and indecent broadcasts is at http://www.fcc.gov/eb/broadcast/obscind.html.

Compliance and Enforcement

Once spectrum licenses are assigned and systems are in operation, the regulatory authority must make sure that licensees obey the rules. This requires a team of trained inspectors to evaluate potential problems such as the lighting and marking of radio transmitting towers, unauthorized construction and operation of communications facilities, and an ability to monitor the airwaves to determine if harmful interference is occurring. It also requires a system for assessing penalties on licensees not complying with regulations. The regulator must take into consideration its country's financial, legal, and political constraints, and assess what can be done given limited resources.

In the United States, complaints that involve public safety systems or safety of life situations take priority over all other complaints. After an investigation is conducted and a rule violation is identified, the FCC's enforcement options include issuing a letter of admonishment/warning, a Notice of Violation, a citation, a monetary forfeiture, a consent decree, a cease and desist order. The FCC can also engage in license revocation proceedings, seizure of equipment, and referral to the Justice Department for criminal prosecution.

A key issue in spectrum-related enforcement is how "harmful interference" is defined. Although harmful interference is defined globally by the ITU, in many cases, governments understand that the definition is somewhat vague in order to retain an ability to take disciplinary action against a party that is disruptive to a spectrum user or to the overall communications environment. Because the enforcement agents cannot monitor all frequencies in all locations at all times, many cases of interference might not be detected by authorities, preventing enforcement actions to be carried out.

For a description of the FCC Enforcement Bureau's activities, including antenna structure, lighting, and marking requirements, unlicensed operations, and interference issues, see http://www.fcc.gov/eb.html. This website also contains descriptions of FCC enforcement actions regarding radio operations.

Cross-Cutting Spectrum Management Issues:

Spectrum Allocations for Government vs. Commercial Use

In most industrialized nations, tension exists between the spectrum needs of government vs. commercial interests. Important national missions, such as national security and defense, law enforcement, public safety, and air traffic control all rely on spectrum for much of their communications operations. In the United States and in other countries, the trend over the past decade has been to transfer spectrum from federal to non-federal allocations to make room for commercial operations. The rationale for such transfers is that improvements in technology have enabled federal systems to utilize more spectrum-efficient communications systems, and perform their missions with reduced spectrum. Commercial interests argue that the commercial demand for spectrum has grown at a greater rate than government spectrum demands. However, federal agencies, especially the Department of Defense, the largest U.S. federal user of spectrum, have resisted this trend, arguing that their operations have become more complex and sophisticated, and require greater amounts of spectrum for enhanced communications services.

To help ease the transition to reduced spectrum for federal agencies, in the United States, commercial licensees that purchase licenses for spectrum previously assigned to federal use must reimburse the federal agency for the costs in relocating its communications to new frequencies.[19] This provision, however, has the effect of lowering the value of the spectrum at auction, and could cause delays in the licensing process if there are disputes between federal users and license winners over the costs of relocation.

In Canada, Industry Canada allocates spectrum to all users, including priority services such as the military, government, public safety, and transportation. When there is a conflict between a government use and commercial use, Industry Canada assesses the public interest and may rule in favor of the military (the Department of National Defense, or DND) or the commercial entity.[20] Industry Canada considers DND to be a priority user of the spectrum in the decision making process, and DND (and most other Canadian government) spectrum requirements are decided after full public consultation. Also, in Canada the military, as well as all public safety and government entities, are required to pay license fees for the use of the spectrum. Under this scheme, Industry Canada

[19] FY1999 Defense Authorization Act (47 U.S.C. 923, Title X, Sec. 1064).

[20] For example, the band 902-926 MHz was allocated to DND for radiolocation for marine shipborne radar use and commercial microwave installations along the seaboards must accept the interference; the band 1427-1525 MHz was given primary fixed service allocation for subscriber radio access and DND had to move their mobile aeronautical telemetry operation to 2300-2400 MHz. Due to the U.S. implementation of DARS satellites and the location of WCS in the lower part of the same band, DND had to move its mobile telemetry operation in the 2360-2400 MHz band. DND also shares access to many land mobile and microwave bands with commercial and private systems. At 14GHz, special provisions were given for microwave channels to be available to DND in certain areas as portable tactical radio links. DND commissioned its new fast hopping land mobile network operating in the range from 30-200 MHz (which is heavily used by mobile, fixed, FM and TV stations). DND may operate on those frequencies as long as it does not cause interference to existing services. Also, Industry Canada has made certain provisions for a pool of land mobile frequencies and fixed frequencies to meet critical DND needs.

officials believe that Canadian government agencies are treated on an equal footing with private sector entities for spectrum resources.[21]

In some countries, a temporary organization or committee can convene to address spectrum reallocation issues. In the United Kingdom for example, a formal standing committee, co-chaired by officials from the Radiocommunications Agency and the Ministry of Defense, has the authority to resolve contentious spectrum allocation issues.[22]

For further reading on this issue, see *Creating the Future of Spectrum Allocation*, Toffler Associates, Manchester, MA, August 2001, and *Review of Radio Spectrum Management: An Independent Review for Department of Trade and Industry and HM Treasury* (U.K. government publication), by Martin Cave, March 2002.

Public Safety Needs

Because of the critical importance of reliable and efficient public safety communications, special consideration must be given to the spectrum needs of public safety organizations. Public safety officers (including police, fire fighters, and emergency medical service personnel) at federal, state, and local government levels need spectrum to operate their communications radios to be dispatched to incidents and to request assistance. Public safety agencies increasingly work together to respond to emergencies such as natural disasters, terrorism incidents, and other inter-jurisdictional operations. Also, because these agencies typically depend on public funding, they do not have the financial means to compete for spectrum resources with commercial concerns.

In the United States, one of the major issues with public safety communications has been the lack of interoperability among the disparate wireless communications systems of different public safety groups, both across jurisdictions and across levels of government. Although technological advances in wireless systems have been made by many private sector organizations, public safety entities often rely on outdated wireless radio systems that no longer meet mission requirements. Federal, state, and local governments, industry, and the public safety community have been working together for many years to coordinate efforts to allocate new spectrum and to achieve interoperability among communication systems. The main challenges to their efforts are the high costs of new equipment, the scarcity of unused spectrum, and the need to coordinate among many organizations to enable public safety personnel to communicate with their counterparts in other jurisdictions. Regulatory authorities that are able to plan in advance for the interoperability needs of public safety communications may avoid such spectrum shortages for critical public safety needs.

For further discussion of these and other public safety spectrum issues as they pertain to the U.S. context, see the FCC Wireless Telecommunications Bureau's public safety website at http://wireless.fcc.gov/publicsafety/.

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[21] Personal communication with David Bosquet, Manager, Wireless Networks, Spectrum Management Operations, Industry Canada, June 3, 2002.

[22] Statement of Peter Guerrero, Director of Physical Infrastructure Issues, General Accounting Office, Testimony before the U.S. Senate Committee on Commerce, Science, and Transportation, June 11, 2002. page 10.

Global and Regional Harmonization

Interference protection for different services is a major consideration for spectrum regulators, especially at national borders, where spectrum may be allocated differently in adjacent countries. All countries must coordinate with their neighbors to optimize their spectrum allocations and ensure that services do not interfere. When two or more countries agree to allocate spectrum in a similar fashion (called spectrum harmonization), all countries taking part in the agreement benefit by minimizing their interference. Countries can further agree to use similar technologies for a given service (called technology harmonization) which also minimizes interference and can enable services to be used across borders. Achieving harmonization requires not only engineering expertise, but diplomatic and political skills as well.

In the process of working toward spectrum harmonization, the first step is for the negotiating countries to come to an agreement on using the same bands for the same services. The ITU generally allocates a set of bands for a particular service, from which individual countries can choose. If a set of countries chooses the same band for a given service, then their respective industries can purchase similar equipment, and the other bands can be allocated later for other services. The next step is to decide on technical regulations for the given service. To the extent that countries impose the same restrictions (e.g., power levels, antenna heights, modulation schemes), interference is minimized across borders and among adjacent bands.

The need to harmonize spectrum and technical regulations has been especially apparent in the case of Third-generation wireless (3G) services, also known as IMT-2000/UMTS. The ITU had selected a set of bands for 3G use, and in 2000, some European nations allocated spectrum from those bands and auctioned licenses for 3G. In the United States, the FCC had already allocated and auctioned some of those bands for mobile services, but had adopted flexible technical rules that permitted 3G systems to be deployed by existing mobile operations. Some in Europe were concerned that the existing mobile bands would not provide enough spectrum for 3G to be deployed in the United States, creating uncertainty for European investors in U.S. telecom markets. However, at WRC-2000, U.S. negotiators convinced their counterparts that initial 3G services could be placed in existing mobile services bands, and additional bands would be allocated as the demand for 3G services evolves. The search for 3G spectrum from the bands allocated by ITU is ongoing in the United States. The NTIA recently concluded that an additional 90 MHz of spectrum can be allocated for 3G services from the 1710-1755 MHz and 2110-2170 MHz bands.[23] This action, as well as similar decisions in other countries, will help to promote global roaming and facilitate a minimal number of technologies (called operational modes) embedded in handsets. Multi-mode and multi-band handsets are a potential solution for the harmonization issue.

For further information on harmonization practices, see the ITU's site on 3G harmonization at http://www.itu.int/itu-T/studygroups/ssg/ssg-q6.html.

Transparency

[23] See http://www.fcc.gov/3G/ for further details on the 3G proceeding, including a link to the NTIA report on the assessment of accommodating 3G systems, published July 22, 2002.

A key element in spectrum policy involves having clear and transparent decision making and procedures. Beginning with the general spectrum allocation decisions, and continuing through the development of service rules, spectrum assignment, and enforcement activities, the government regulator usually benefits from a clear exchange of views and information with the interested parties. A transparent regulatory system allows affected parties to predict how decisions will be made, and encourages economic development by fostering investment and competition. The better a regulatory authority articulates to the public the rationale for its decisions, the greater the likelihood of compliance with its policies. In managing spectrum, transparency can be maximized by making the state of allocated frequency bands and assignments publicly available. Spectrum users should also make available to other users, on a timely basis, technical information about essential facilities and commercially relevant information necessary to use the spectrum.[24]

Transparency also promotes international trade by making clear the legal requirements for imports and foreign investment.[25] Regulatory authorities generally achieve greater transparency by establishing clearly defined laws and regulations that develop through an open, public process.

An example of how transparency can improve a market is the case of Guatemala.[26] Based on a telecom law enacted in 1996, Guatemala established an independent regulator, the Superintendent of Telecommunications (SIT), whose essential mission is to respond to private claims and adjudicate disputes over airwave rights. SIT's first action was to publish a registry of all uses of spectrum, and then it issued licenses to existing users, providing flexibility in the licenses for the use of the spectrum. With a well publicized list of licenses, any spectrum not currently assigned could then be requested by any entrepreneur, firm, or organization wishing access to the spectrum. Parties objecting to the proposed new use could file complaints, with grounds for opposition limited to interference. Other potential spectrum users are also allowed to request the spectrum under question. If no competing claims are filed, then the original petitioner receives a license without auction. If competing claims are filed, then SIT conducts an auction and awards the license to the highest bidder. The license lasts for 15 years and is freely tradable.

Despite political pressures in Guatemala to protect incumbent interests, the requested licenses have generally been issued. As of March 2000, over 3,400 new licenses were awarded (mostly through auctions) under this regime. Both the FM radio and the cellular telephone markets have seen substantial entry since liberalization occurred.

Any comments or questions regarding the content of this report can be sent to Richard Nunno at (202) 418-7378, or *Rnunno@fcc.gov*.

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[24] It may, however, be appropriate to withhold from public access detailed identification of frequencies allocated for specific government uses and certain proprietary commercial information.

[25] See *Regulatory Transparency in Japan: Half Full or Half Empty?* By Michael Marcus, Asia Perspectives, Vol. 3, No. 2, p. 20-22, March 2001.

[26] See The Wireless Craze, *The Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, ...*by Thomas Hazlett, AEI-Brookings Joint Center for Regulatory Studies, January 2001.