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Report to Congressional Requesters

January 2003

TELECOMMUNICATIONS

Comprehensive Review of U.S. Spectrum Management with Broad Stakeholder Involvement Is Needed

GAO-03-277

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GAO Highlights

Highlights of GAO-03-277, a report to Congressional requesters

Why GAO Did This Study

The radiofrequency spectrum—a natural resource used for wireless communications—is a critical input to various commercial and government functions. Because of expanding commercial and government demand for spectrum, there is increasing debate on how best to manage this resource to meet current and future needs. GAO was asked to examine whether future spectrum needs can be met, given the current regulatory framework; what benefits and difficulties have arisen with the application of market mechanisms to spectrum management; and what barriers exist to reforming spectrum management.

What GAO Recommends

GAO recommends that the Chairman of FCC and the Assistant Secretary of Commerce for Communications and Information, in consultation with other agencies and congressional committees, develop a plan for the establishment of an independent commission with wide representation to determine whether overarching spectrum management reform is needed. GAO received comments from FCC and NTIA stating that they would take this recommendation into consideration. Because the agencies did not specifically agree to implement our recommendation, we have added a matter for congressional consideration regarding the establishment of such an independent commission.

www.gao.gov/cgi-bin/getrpt?GAO-03-277

To view the full report, including the scope and methodology, click on the link above. For more information, contact Peter Guerrero at (202) 512-2834 or guerrerop@gao.gov.

What GAO Found

In the past, the United States relied primarily on a command and control approach to spectrum management, wherein the federal government largely dictated the use of spectrum. This approach generally met commercial and government users' needs for spectrum. However, increased use of commercial wireless services, such as mobile telephones, and expanding government agency missions have created growing demand for spectrum resources. GAO found that concerns exist as to whether the current spectrum-management approach can adequately meet future needs for spectrum.

Spectrum Serves Many Commercial and Government Needs

3kHz				300GHz
Submarine communication	Amateur radio	Broadcast TV	Mobile phone	Weather radar
AM radio	Military tactical radio	FM radio	Satellites	Military and commercial satellites
	Marine communication	Federal and public safety	Military applications	

Source: GAO.

The United States and most other countries that GAO spoke with are incrementally adopting market-based mechanisms for spectrum management. By invoking the forces of supply and demand, market-based mechanisms can help promote the efficient use of spectrum, especially in an environment with increasing and unpredictable demand. A prominent example of a market-based mechanism is the requirement for commercial spectrum users to bid at auction for the right to use spectrum. However, because of mission and system requirements, there is some question as to whether these mechanisms can or should be applied to certain government functions. Also, legal and technical limitations can, in some instances, hinder the application of these mechanisms to commercial users.

GAO found several barriers to reforming spectrum management in the United States. While active dialogue among key stakeholders is ongoing, differing priorities have led to little consensus on appropriate reforms. In addition, the current spectrum-management structure—with multiple agency jurisdictions and a slow decisionmaking process—has hindered consideration of whether fundamental reform is needed. In the past, commissions—such as the Defense Base Closure and Realignment Commission—have been used to look at major policy change when complex problems arise.

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Abbreviations

3G	third-generation wireless services
CSIS	Center for Strategic and International Studies
DOD	Department of Defense
DOJ	Department of Justice
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FCC	Federal Communications Commission
IRAC	Interdepartment Radio Advisory Committee
ITU	International Telecommunication Union
MHz	Megahertz
NTIA	National Telecommunications and Information Administration

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, DC 20548

January 31, 2003

The Honorable Conrad Burns
The Honorable Ernest F. Hollings
The Honorable Daniel K. Inouye
The Honorable John F. Kerry
United States Senate

The radiofrequency spectrum is a natural resource that is used to provide an array of wireless communications services critical to the U.S. economy and to a variety of government functions, such as scientific research, national defense, homeland security, and other public safety activities. As new technologies and services are brought to market in the private sector and new mission needs unfold among government users of spectrum, nearly all parties are becoming increasingly concerned about the availability of spectrum for future needs, because most of the usable spectrum in the United States has already been allocated. Along with this concern, there is a growing view that current spectrum management in the United States may not be able to respond adequately to the rapidly changing needs and competing demands of spectrum users.

To promote a more efficient use of spectrum, many countries, including the United States, are incrementally adopting market-oriented approaches to spectrum management. Examples of these approaches include requiring commercial spectrum users to bid at auction for the right to use spectrum, charging spectrum users market-based fees to use spectrum, and allowing greater flexibility in how spectrum is used. However, market-oriented mechanisms are not universally supported among interested parties. As a result, increasing debate is emerging on how best to manage this scarce spectrum resource to meet critical commercial and government needs, both now and in the future.

As agreed with your offices, this is our final report in response to your request that we study a variety of spectrum-management issues. Our first report, released in September 2002, provided an overview of the development of the legal and regulatory framework for spectrum management at the federal level and assessed key issues associated with

spectrum management at federal agencies.[1] That report contained four recommendations: (1) that the Chairman of the Federal Communications Commission (FCC) and the Secretary of Commerce, who oversees the National Telecommunications and Information Administration (NTIA), jointly develop a clearly defined national spectrum strategy; (2) that the Secretary of State, the Secretary of Commerce, and the Chairman of FCC jointly review the adequacy of the preparation process for the 2003 World Radiocommunication Conference; (3) that the Secretary of Commerce direct NTIA to analyze the human capital needs of federal agencies for spectrum management, as well as develop a strategy for addressing any identified shortcomings; and (4) that the Secretary of Commerce develop a strategy for enhancing its oversight of federal agencies' use of spectrum. FCC, NTIA, and the Department of State generally agreed that these recommendations should be implemented.

This report builds on that effort by examining market-oriented approaches to spectrum management and other issues. Specifically, this report discusses (1) concerns about whether future spectrum needs can be met, given the current regulatory framework; (2) the advantages of market-based mechanisms and how they have been applied to help meet future spectrum needs; (3) whether there are difficulties with using market-based mechanisms; and (4) if it is found that fundamental spectrum reform is needed, whether the current regulatory environment is conducive to facilitating such reform. In addition, in appendix II we provide information on certain stakeholders' views on auctions and spectrum royalties.

To respond to these objectives, we reviewed a broad array of technical, economic, and legal research related to spectrum management. For example, we reviewed spectrum-management reports completed by several foreign governments. In addition, we interviewed experts on spectrum issues and officials from companies and from government agencies, including FCC and NTIA. We also conducted semistructured interviews and analyzed the results of these interviews with spectrum-management officials in 12 other countries: Australia, Canada, Finland,

[1]See U.S. General Accounting Office, *Telecommunications: Better Coordination and Enhanced Accountability Needed to Improve Spectrum Management*, GAO-02-906 (Washington, D.C.: Sept. 30, 2002).

France, Hong Kong,[2] Italy, Japan, Mexico, New Zealand, Spain, Sweden, and the United Kingdom. We selected these countries based on their geographic size, gross national product per capita, population density, level of mobile telephone penetration, primary methods for assigning spectrum, and whether the country uses market incentives to encourage government conservation of spectrum. For Canada and the United Kingdom, which have both recently adopted certain market-based mechanisms, we conducted more in-depth case studies of spectrum-management practices, interviewing not only spectrum managers but also government users and commercial firms. We also surveyed representatives to the Interdepartment Radio Advisory Committee (IRAC), which represents 20 federal agencies that use spectrum, regarding their spectrum use and their views on certain policy issues. Finally, we invited 10 experts to participate in an expert panel (see app. VI for a list of panel members). These experts participated in a day-long conference at GAO and discussed a series of issues on spectrum-management concerns. For more detailed information on how we chose the countries we reviewed, the panelists we invited to serve on the expert panel, and other aspects of our research methodology, see appendix I. We conducted our review from January 2002 through December 2002 in accordance with generally accepted government auditing standards.

Results in Brief

Today, there are considerable concerns about whether the current regulatory framework will be able to provide future access to spectrum to meet the needs of commercial and government users. In the past, commercial wireless providers' access to spectrum has accommodated rapid growth and competition in wireless markets. Additionally, most of the government spectrum users we spoke with and surveyed said they have had access to sufficient spectrum to meet the critical mission needs of their agencies. Looking to the future, however, commercial wireless markets are expected to continue to grow, and new services and technologies may require additional spectrum as well. Likewise, the events of September 11, 2001, highlighted the importance of wireless

[2]We recognize that Hong Kong is a special administrative region of China. However, the structure and policies used to manage spectrum in that region are independent of the spectrum policies of mainland China, and thus resemble the policies of an individual country. For ease of exposition, we will be including Hong Kong when we discuss countries in several places in this report.

communications for homeland security and national defense; federal government and public safety users have stated that these events exacerbated their already growing needs for spectrum. The rapid growth and evolution of the wireless sector has led many experts and industry participants to question whether a spectrum-management structure that relies largely on "command and control" methods—that is, policies wherein government largely dictates the use of spectrum—can adequately address today's complex issues. Recently, there have been numerous forums, initiatives, and hearings to address spectrum issues. It appears that many parties believe there are significant challenges to meeting the growing demands for spectrum within the current regulatory framework and are seeing spectrum-management reform as essential.

Spectrum managers as well as many experts we interviewed identified a variety of advantages to implementing market mechanisms as part of spectrum-management policies. In the past 10–15 years, the United States and several other countries have adopted certain market-based mechanisms as part of the spectrum-management structure. These mechanisms are generally designed to allow the normal workings of the marketplace—that is, the forces of supply and demand that promote economic and technical efficiency—to have a greater impact on spectrum decisions than was typically the case in the past. In part, the intent of employing these policies is to improve the efficiency of spectrum use. Some countries have implemented market-based mechanisms for both government and commercial users, while others have adopted these tools solely for commercial users.

While many of the experts we spoke with believe that the adoption of market-based mechanisms may help to address future demands for spectrum, the application of these methods may not be desirable or effective in certain contexts. Charging government users for the spectrum they use could, in theory, encourage more efficient use, but because of the primacy of certain government functions—such as homeland security and national defense—it may not be desirable. Further, some observers believe that, in practice, fees charged to government users will not, in all cases, be effective in promoting efficiency in spectrum use. One difficulty can arise when government use, such as air traffic control, is dictated by international spectrum allocations that limit the ability of certain government spectrum users to change their spectrum use in response to assessed fees. Also, applying a market-based mechanism in the case of government services that have no commercial corollary—and therefore no observable price—can be difficult. Additionally, some users and experts believe that increasing flexibility in commercial spectrum use—a

commonly discussed market-based mechanism that allows spectrum licensees more freedom to change how they use their assigned spectrum without administrative approval—will result in more radio interference among users. Finally, some experts note that market-based mechanisms work only if each user's "rights" in the use of spectrum are clearly defined; such definitions may be difficult to establish.

Under the current framework for managing spectrum, it has been difficult to resolve conflicts among existing spectrum users. While various stakeholders have been actively searching for ways to improve spectrum management to meet future spectrum needs, certain key conflicts among these stakeholders have limited their ability to find solutions that are satisfactory to all. For example, considerable conflicts exist between incumbent spectrum users and potential new commercial providers, and no consensus exists on how best to balance the needs of the private sector with those of the public sector. While FCC and NTIA have worked to resolve issues, at times their resolution of key policy issues has been protracted and contentious. Moreover, in the current regulatory environment, no one agency has been given ultimate decisionmaking authority over all spectrum in the United States or the authority to impose fundamental reform. Therefore, FCC and NTIA may not be in the best position to conduct an overarching review of spectrum-management structure that would consider a full range of possible structural changes. In the past, presidential or congressional commissions have been established to find solutions to complex problems such as those faced in reforming the spectrum-management system in the United States.

In order to develop solutions to key spectrum-management issues, this report recommends that the Chairman of FCC and the Assistant Secretary of Commerce for Communications and Information, in consultation with officials from the Department of State, Office of Management and Budget, Office of Science and Technology Policy, and pertinent congressional committees, work together to develop and implement a plan for the establishment of a commission that would conduct a comprehensive examination of current U.S. spectrum management. This commission would examine, among other things, whether structural reform of our current system is needed. The commission should be independent and involve all relevant stakeholders—including commercial interests, government agencies, regulators, and others—to ensure that the diversity of views on key spectrum-management issues are represented. The review should be time-limited and, if change is needed, should have as its primary objective the establishment of a framework to implement that change. Although the commission could be established by statute, executive order,

or other means, a statutory basis for the commission may provide the most appropriate framework for achieving a wide-ranging review of issues that may ultimately need legislative solutions. In appendix IV, we have presented possible issues and stakeholder concerns that a commission could consider as part of its comprehensive examination.

We provided a draft of this report to FCC, the Department of Commerce, and the Department of State for their review and comment. Regarding our recommendation for an independent commission to evaluate the need for overarching spectrum reform, FCC and the Department of Commerce stated that they would take our recommendation into consideration. The Department of State did not provide comments on this report.

Because FCC and the Department of Commerce did not specifically agree to implement our recommendation, the Congress may wish to consider taking appropriate action to ensure that the question of whether overarching spectrum-management reform is needed is fully examined. This could take the form of holding hearings or enacting legislation to establish an independent commission that would conduct a comprehensive examination of current U.S. spectrum management.

Background

The radiofrequency spectrum is the medium that enables wireless communications of all kinds. Although the radio spectrum spans the range from 3 kilohertz to 300 gigahertz, 90 percent of its use is concentrated in the 1 percent of frequencies that lie below 3.1 gigahertz,[3] because these frequencies have properties that make this portion of the spectrum well suited for many important wireless technologies.

Spectrum is used to provide a variety of services in the United States. Companies are licensed to provide mobile telephone, paging, broadcast television and radio, and various satellite services. Additionally, some companies maintain spectrum licenses for a variety of private tasks, including communication in a particular location (such as a large industrial complex) or among remote vehicles of a company. A variety of government users also employ spectrum to provide public safety services and other functions of federal, state, and local government agencies. For

[3]Radio waves are a form of electromagnetic radiation that propagate in space as the result of particle oscillations. The number of oscillations per second is called "frequency," which is measured in units of hertz. The term "kilohertz" refers to thousands of hertz and "gigahertz" to billions of hertz.

example, local and state police departments, fire departments, and other emergency services use spectrum to transmit and receive critical voice and data communications. Federal agencies use spectrum for varied mission needs, such as law enforcement, weather services, aviation communication, and national defense.

Since the beginning of radio communications, concern about interference among users has been a driving force in the management of spectrum at the national and international levels. Interference among spectrum users can occur when two or more radio signals interact in a manner that disrupts or degrades the transmission and reception of messages. Spectrum managers have worked to minimize interference through their two primary spectrum-management functions, the "allocation" and the "assignment" of radio spectrum.[4]

The *allocation* process begins with the International Telecommunication Union (ITU), a specialized agency of the United Nations, where member nations identify spectrum bands for about 40 broad categories of wireless services. The Department of State coordinates and mediates the views of FCC and NTIA to reach a U.S. position on spectrum issues for international discussions. Once spectrum-allocation decisions are made at the ITU, regulators within each country will, to varying degrees, follow the ITU decisions when allocating spectrum for particular types of radio services or classes of users to meet domestic needs. In the United States, spectrum allocation is handled primarily by two agencies: FCC—an independent agency that regulates spectrum use for nonfederal users, including commercial, private, and state and local government users—and NTIA, an agency within the Department of Commerce that regulates spectrum for federal government users. NTIA works in consultation with IRAC, which is composed of representatives from federal agencies, to manage the federal spectrum use.

Once spectrum is allocated for specific uses, the spectrum-management agencies *assign* portions of spectrum to specific users. Spectrum assignment has generally been very proscriptive regarding how a specified portion of spectrum can be used. That is, generally a license or assignment specifies the frequencies the license holder may use, the length of time the license covers, the geographic areas the license covers, and the services

[4]Our September 2002 report, GAO-02-906, provided an extensive discussion of the organization of spectrum management in the United States.

that may be provided. FCC assigns licenses for commercial enterprises, state and local governments, and others. NTIA makes frequency assignments to federal agencies. In addition to licensed uses for spectrum, FCC authorizes unlicensed use of spectrum in some frequencies. Unlicensed spectrum has traditionally been used for low-powered devices that operate in a limited geographic range, such as cordless phones, baby monitors, and garage door openers, and it is increasingly being used to provide services such as wireless access to the Internet.

Over the years, FCC has used a variety of methods to assign spectrum for commercial users. Sometimes spectrum has been assigned on a first-come, first-served basis. When more than one party applies for the same license, FCC has used several alternative approaches to assign the license. FCC historically used comparative hearings, which give competing applicants a quasi-judicial forum in which to argue why they should be awarded a license instead of other applicants. In 1981, partially in response to the administrative burden of the comparative hearing process, the Congress authorized the use of lotteries, which allowed FCC to randomly select licensees from the qualified applicant pool.[5] In the Omnibus Budget Reconciliation Act of 1993, the Congress authorized FCC to use auctions to award spectrum licenses for certain wireless communications services. Auctions, a market-based mechanism, grant a license to the company that has bid the highest price for specific bands of spectrum. Since auctions were put into place, FCC has conducted 42 auctions.

Since nearly all of the usable radio spectrum in the United States has been allocated already, accommodating more services and users often involves having more than one user sharing spectrum, or reallocations of spectrum from one use to another. "Spectrum sharing"—one method of accommodating more services and users—enables more than one user to transmit or receive radio signals on or near the same frequency band. Within the United States, about 56 percent of the spectrum is shared by federal and nonfederal users, while about 31 percent is designated exclusively for nonfederal use and about 14 percent exclusively for use by federal agencies.[6] Another method of accommodating new users and technologies is "band clearing," or reclassifying a band of spectrum from

[5]In 1981, Congress added Section 309(i) to the Communications Act to give FCC the authority to assign a broad range of licenses by lottery. In 1997, Congress eliminated FCC's authority to issue licenses by lotteries, with certain exceptions.

[6]NTIA officials told us that, even within the exclusive bands, some sharing may take place.

one set of radio services and users to another, which requires moving previously authorized users off of the band. Band-clearing decisions that affect federal and nonfederal users may require coordination between FCC and NTIA to ensure that moving existing users off of a band is technically feasible and meets the users' needs. Such moves often involve costs because existing users of the band may need to modify or replace existing equipment.

In addition to spectrum-management policies directed at the allocation and assignment of spectrum, advances in technology could also help to accommodate more services and users. For example, by compressing pieces of information, digital technologies are able to use less spectrum than would analog technologies to transmit a given amount of spectrum. Also, with appropriate technical standards, ultrawideband devices—which use very low power over very large bandwidths—can operate using spectrum occupied by existing radio services, in some cases, without causing interference. This permits scarce spectrum resources to be used more efficiently, as more than one service can use the same spectrum. See appendix III for more discussion of technological advancements that could help relieve spectrum scarcity.

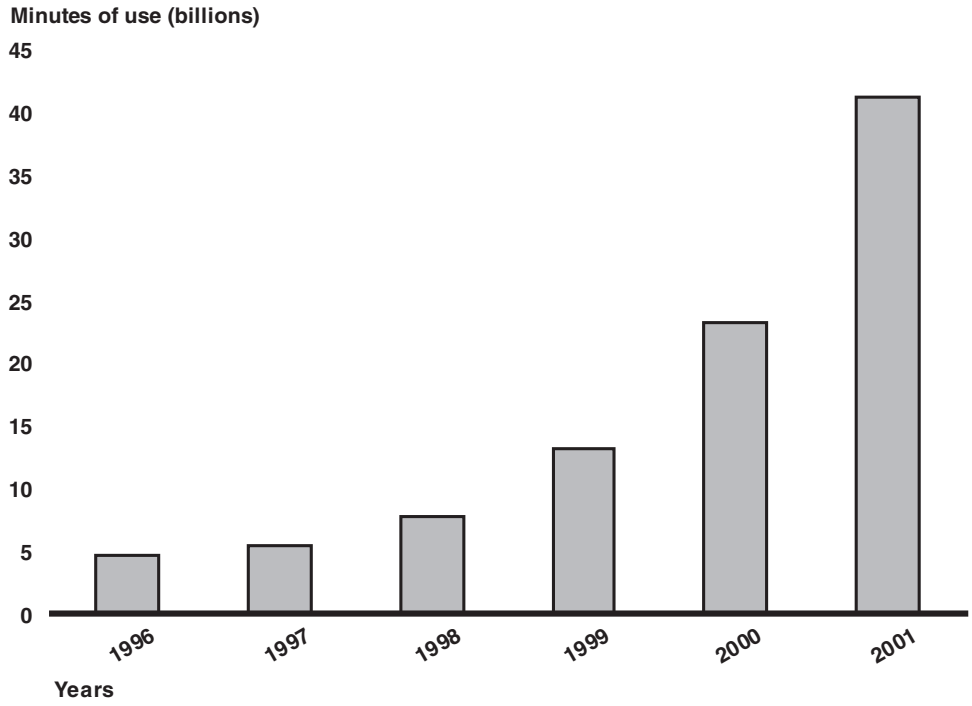
Concerns Exist That Future Needs for Spectrum Will Be Difficult to Meet

In the past, the spectrum available to commercial users has accommodated rapid growth in wireless telephone markets and supported a competitive structure in that market. In addition, many government agencies' spectrum managers say that, in the past, government users' needs for spectrum have generally been met. However, concerns exist about the ability to meet the growing needs of both commercial and government users. In addition, some observers are particularly concerned that some spectrum is not currently used as efficiently as possible. Many are also concerned that current spectrum-management practices, which generally take a command and control approach—that is, policies wherein government largely dictates how spectrum is used—may not work effectively as spectrum needs rapidly change. Key stakeholders are voicing these concerns as they search for ways to meet these needs.

Spectrum Allocated to the Commercial Sector Has Accommodated Rapid Growth and Competitive Structure in Some Wireless Markets

Many industries that rely on spectrum to provide services have grown dramatically over the past 20 years, including mobile telephone service and varied satellite-provided services. In particular, the availability of spectrum has accommodated the dramatic growth of mobile telephone service since it was first launched in the 1980s. Between 1985 and 2001, subscribership increased from approximately 340,000 to over 128 million, and wireless use (measured in minutes) grew by almost 800 percent between 1996 and 2001 (fig.1). This growth resulted from an increase in subscribership as well as a marked increase in the average number of minutes used by each subscriber. In terms of revenues, the industry has also mushroomed: in 1985 annual revenues were $482 million, and by 2001 annual revenues stood at over $65 billion. Finally, the number of people employed in the mobile telephone sector grew from about 3,000 in 1985 to over 200,000 by 2001.

Figure 1: Number of Mobile Telephone Minutes Used per Month, on Average, 1996–2001, in Billions



Source: GAO's analysis of Cellular Telecommunications and Internet Association's data.

In addition to the rapid growth in wireless services, most observers believe that wireless phone markets are highly competitive. According to a recent FCC report,[7] 94 percent of the U.S. population lives in counties with access to 3 or more mobile telephone service providers, and 80 percent lives in counties with at least 5 providers.[8] Officials from the wireless companies we spoke with and participants on our expert panel overwhelmingly perceived wireless markets as competitive. Twelve of the 13 wireless service providers that we interviewed said that mobile markets are competitive. Even in rural areas wireless markets appear competitive. For example, officials at the 3 rural companies we spoke with reported that they were among 3 to 6 competitors in the small and rural markets they serve. Similarly, all 10 of the participants on our expert panel reported that wireless markets are "extremely" or "moderately" competitive.

A number of policy decisions implemented by the Congress and FCC have helped to accommodate the rapid growth and competitiveness of wireless markets. In the 1990s, the Congress mandated the transfer of over 200 megahertz (MHz) of spectrum from government use to nonfederal use. This provided additional spectrum for commercial wireless services. Since 1994, FCC has conducted 42 auctions for spectrum dedicated to various kinds of wireless services. Additionally, FCC's licensing scheme for mobile telephone service helped ensure that many providers were available in each market region. In every region, FCC authorized up to eight different mobile telephone licenses.

Government Spectrum Managers Say Government Users' Needs Have Generally Been Met

Our survey of the 20 IRAC agencies asked whether agencies were able to meet their critical mission needs, given their current spectrum resources. Of the 16 agencies that responded to this question on our survey, 13 said that all or most of their critical mission needs were being met; 3 agencies responded that some critical needs were not being met. Moreover, officials at FCC and NTIA stated that spectrum needs of government users have generally been met.

[7]See Federal Communications Commission, *Seventh Annual CMRS Competition Report*, FCC 02-179 (Washington, D.C.: July 3, 2002).

[8]FCC notes in its *Seventh Annual CMRS Competition Report* that, as a result of treating providers that serve any part of a county as if they served the entire county, the report likely overstates the number of providers serving consumers in various locations.

Officials at three of the four government agencies we interviewed in greater depth told us that their agencies have generally received the spectrum necessary to meet their mission needs. Officials at the Federal Aviation Administration (FAA) told us that their agency has been able to meet aviation requirements with the currently available spectrum. Officials at the Department of Defense (DOD) said that their missions had not yet been compromised because of a lack of spectrum.[9] The Federal Emergency Management Agency (FEMA), which most often uses spectrum allocated to the U.S. Army, also told us that it has been able to obtain spectrum when needed.[10] The Department of Justice (DOJ), however, stated that in just the past few years, as the use of wireless surveillance activities has increased, congestion has increased, resulting in increased occurrences of interference.

Agency officials we interviewed noted that they have taken measures to achieve mission requirements in the absence of new spectrum assignments. For example:

- Officials stated that their agencies share considerable spectrum with other federal agencies, as well as with nongovernmental users. FAA officials noted that spectrum allocated for certain systems, such as radar, is shared among a number of users, including FAA, DOD, the U.S. Customs Service, and the National Weather Service; DOJ officials also noted that they share spectrum in the government bands and are in the design phase of a plan to implement greater sharing with a variety of users having similar missions.
- FAA and DOD officials noted that they perform internal audits of spectrum use within their agency. FAA told us that the results of these internal audits are used to make more efficient use of the available spectrum; DOD said that it has relinquished use of underutilized spectrum that has been identified during these audits.
- All four government agencies told us that, when possible, they use commercial vendors—who use spectrum assigned for commercial uses—to provide nonsafety–related spectrum services, such as mobile telephone service.

[9]DOD pointed out that reallocation of spectrum under the Omnibus Budget Reconciliation Act of 1993 did not affect bands in which DOD had extensive operations. Reallocation of spectrum under Title III of the Balanced Budget Act of 1997, which did identify bands in which DOD has operations, has not yet taken place.

[10]Since FEMA did not exist when current wideband channels were allotted, FEMA's operational units were transferred to FEMA from the U.S. Army, along with the attendant frequencies.

- Officials at both DOJ and DOD told us that they attempt to economize on spectrum use by implementing new technologies. DOJ is planning on making greater use of trunking technology;[11] DOD is investigating new technologies that use spectrum more efficiently, or do not depend on spectrum.

Commercial and Government Users See Future Spectrum Needs Growing

Commercial users have expressed a need for more spectrum in certain highly congested areas, as well as to accommodate new services. This spectrum is needed to accommodate the expected growth in the demand for wireless voice services as well as for additional services that will be provided over telephone handsets, including the transfer of data at higher speeds than current wireless devices are able to do—so-called third-generation wireless services (3G). Also, certain commercial users have argued that additional spectrum should be made available for unlicensed use by low-powered devices. These users, as well as staff at FCC, have stated that more spectrum for unlicensed services is particularly helpful in trying to bring new technologies, such as local area Internet access, to the market. In a recent speech, an FCC Commissioner noted that a research study had predicted that 21 million Americans will be using wireless local area networks—a service that can be provided without a license—by 2007.

Officials of the United Telecom Council, an organization that helps utilities and railroads to manage their spectrum needs, told us that these entities also need more spectrum for the wireless communications used by their maintenance personnel. These officials told us that since 1997, utilities have increasingly had to share spectrum assignments with certain other users.[12] Moreover, within these arrangements, no limit exists as to the number of licenses that can be assigned for use on any particular frequency. As a result, they told us, these frequencies are either too congested to be used safely or are in imminent threat of such congestion. In a recently released report, NTIA stated that the events of September 11,

[11]Trunking is like a time-share system that allows several users to share spectrum. Under a trunking system, several users share a given set of frequencies under the assumption that it would be a rare occurrence for all users to need the spectrum at the same time. Thus, less spectrum can be provided to meet the users' needs than if each were assigned discrete sets of frequencies reserved exclusively for its own use.

[12]Prior to 1997, utilities and railroads had spectrum allocated exclusively for their industries. But in 1997, in an effort to increase the efficient use of spectrum, FCC consolidated 20 previously exclusive Private Land Mobile Radio services into two pools—the Public Safety Pool and the Industrial/Business Pool. The frequencies within the Industrial/Business Pool are specified in 47 CFR § 90.35 (b)(3).

2001 have underlined the importance of these industries and the roles they play in times of disaster response and recovery.

Officials at most of the federal government agencies we spoke with also told us that they face increasing needs for spectrum and are concerned that adequate spectrum will not be available in the future. Furthermore, of the 17 IRAC members who responded to our survey, 12 believed that their spectrum needs would at least moderately increase over the next 2 to 3 years. Fifteen of the 17 respondents felt that they would have at least some difficulty meeting their future critical mission needs because of insufficient spectrum, whether or not they were meeting those needs at this time.

Two of the four agencies that we interviewed in depth also revealed an expectation of increased spectrum needs. In particular:

- Officials at DOJ believe that they will need access to additional spectrum to support homeland security, accommodate increased border patrol, and provide for additional surveillance.
- Defense spectrum use has grown exponentially since Desert Storm in 1991, according to DOD spectrum managers we interviewed. A DOD official testified before the Senate Committee on Commerce, Science, and Transportation in June 2002 that DOD's spectrum usage is projected to grow by more than 90 percent by 2005—and this estimate was made prior to September 11, 2001. According to DOD officials we interviewed, since September 11th, DOD's spectrum needs have further increased.

Finally, public safety officials with whom we spoke said they needed additional spectrum. In particular, these officials said that small bits of spectrum located in various bands have been allocated for public safety use, and that some of these slices of spectrum have been allocated very close to certain commercial providers. Public safety officials told us that this situation has resulted in there being some interference between public safety users and commercial vendors, and they noted their continued need for more contiguous blocks of spectrum to provide critical safety-of-life services.[13]

[13]While a 24 MHz block of spectrum has been allocated to public safety users, it is currently occupied by broadcasters, who may not vacate that spectrum for some time. For a further discussion of the digital television transition see U.S. General Accounting Office, *Telecommunications: Additional Federal Efforts Could Help Advance Digital Television Transition*, GAO-03-7 (Washington, D.C.: November 2002).

Concerns Exist about Inefficient Spectrum Use in the Public and Private Sectors

Given the concern about the growing need for spectrum, stakeholders are particularly concerned that some users may not be applying the most spectrally efficient technologies.[14] If that is the case, then spectrum scarcity may be exacerbated by this inefficient use. As such, policies to promote more spectrally efficient technologies can help to meet future spectrum needs by freeing up unneeded spectrum.

Some observers, including several of our expert panel members, commercial users, and regulators we spoke with in certain other countries, expressed concern that government users do not have adequate incentives to conserve their use of spectrum and therefore may not deploy this valuable resource efficiently. NTIA, which manages federal spectrum, is responsible for promoting the efficient use of that spectrum to the maximum extent feasible. Our September 2002 report noted that it is not clear that NTIA is able to ensure that spectrum is being used efficiently.

NTIA currently charges federal government users a small spectrum-management fee for each frequency assignment the government user holds. However, it is not clear how much these fees, which are designed to recover 80 percent of the administrative costs in NTIA's spectrum-management budget, encourage government users to economize on their use of the spectrum. Officials from two federal agencies that use spectrum noted that the current charges—approximately $55 per assignment—were not high enough to cause them to economize on their use of spectrum. Recently, NTIA has expressed an interest in examining a fee structure that provides a greater incentive to promote efficient use of spectrum than is currently being used by NTIA.

Federal agency officials told us that they have some nonfinancial incentives to conserve spectrum. Officials from two of the agencies we interviewed reported that because they are unlikely to get substantial new spectrum from NTIA, they face internal pressures to conserve and reshuffle current spectrum resources to meet new needs. Also, DOD

[14]This discussion focuses primarily on the concept of "technical efficiency"—that is, getting the most use, or "output," out of a portion of spectrum, given the mission or market context of its use. Other important aspects of efficiency are also relevant in spectrum management. In particular, economic efficiency relates to whether spectrum is allocated across various uses in a way that maximizes society's welfare. In free markets, economic incentives give signals to firms and consumers that help to ensure that resources flow to their most valued use. With spectrum, this free flow of resources is not fully functional, so the question of whether spectrum is allocated in an economically efficient manner is also an important focus of analysis.

officials stated that the department's internal goal of being a responsible steward of America's resources drives it to use spectrum efficiently. Agencies we spoke with noted that NTIA requires that federal agencies review their assignments every 5 years. However, in our first report, released in September 2002, we noted that one agency official said that these reviews are often perfunctory, there is no independent verification of the reviews, and there is no other evidence that these reviews are effective. Those we spoke with for this report did cite other audits of spectrum use in the federal government—including spectrum reviews by the White House—as incentives to use spectrum efficiently. Finally, NTIA has required the adoption of certain technologies—such as narrowbanding[15] and trunking—that conserve spectrum. However, NTIA officials told us that, in practice, it is difficult for NTIA to invoke its enforcement authority because its primary enforcement tool is the ability to remove frequency assignments from agencies not complying with certain requirements. Because license removal is a radical measure that could interfere with government agencies' ability to carry out important missions, it is difficult for NTIA to use this approach.

Some of those we spoke with also expressed concern that public safety users do not employ the most efficient technologies and are therefore wasteful with their spectrum. The head of a commercial wireless organization noted that public safety communications equipment is often antiquated. One public safety official we interviewed stated that public safety officials often do not have adequate funding to update their equipment to be more spectrally efficient.

Concerns also exist that some nongovernmental users do not have incentives to be efficient. In August 2001, FCC commenced an audit of private land mobile radio stations licensed on frequencies below 512 MHz. These license holders included industrial/business users and public safety users.[16] As part of the audit, FCC sent letters to over 260,000 licensees seeking information to determine whether they (1) were meeting required construction deadlines and (2) were operational. As of October 2002, FCC

[15]Narrowbanding is a technique for reducing the amount of spectrum (bandwidth) needed to transmit a radio signal, thereby freeing up spectrum to meet future growth.

[16]Specifically, these licenses apply to the Industrial/Business Radio Pool (for example, entities engaged in commercial activities; operating educational institutions; operating hospitals, clinics, or medical associations) and the Public Safety Radio Pool (for example, state and local governments, entities providing rescue and disaster relief services).

had received responses from over 228,000 licensees, and these licensees reported that over 33,000 licenses (7.9 percent of licenses) were not being used and could be canceled. FCC officials told us that they would like to undertake more spectrum audits such as this.

Additionally, some concerns exist that certain commercial users may not employ spectrally efficient technologies. Members of the expert panel and government users have stated that they believe the television broadcasting industry does not employ spectrally efficient technologies. Several stakeholders noted that in part this is attributable to a lack of receiver standards. Some expert panel members and some government users also noted that mobile satellite services, radio broadcasters, and the mobile telephone industry are also not necessarily using the most spectrally efficient technologies.[17]

Concerns Exist That Primary Reliance on Administrative Management May Not Be Effective in Today's Rapidly Changing Environment

For most of the history of wireless transmissions, the national governments of the countries we reviewed have used centralized administrative techniques—often called command and control—to allocate and assign spectrum. An important focus of this regulatory approach has generally been to minimize interference among users. Using the ITU allocation tables as a starting point, individual countries have traditionally allocated spectrum for particular uses and assigned spectrum to particular users by licensing them to use the spectrum in specific ways. Until the past 10 to 15 years, when some countries started using auctions to assign spectrum, countries throughout the world assigned spectrum on a first-come, first-served basis, or used some other administrative device (such as comparative hearings) to decide among applicants who wanted the same spectrum. In the United States, FCC used comparative hearings and, later, used lotteries to assign spectrum to competing commercial carriers.

One of the benefits of using market forces to allocate and assign spectrum resources is that these methods help to ensure that spectrum moves into the services that are most highly valued by consumers, as measured by their willingness to pay higher prices for those services. When resources move to more valued uses, a form of efficiency known as "allocative

[17]FCC officials noted that analog television is being replaced by digital television, which is far more efficient, that analog mobile telephone service has largely transitioned to digital service, and that, regarding mobile satellite services, FCC is in the process of considering rule changes to enable these providers to become more efficient.

efficiency" is advanced. For example, if, because of the development of cable and satellite television, broadcast television were to lose viewers and its spectrum were to become more valuable for other uses in higher demand, such as mobile telephone service, then market forces—that is, market mechanisms in spectrum management—would naturally lead to a reallocation of some of that spectrum to these other uses. However, without market forces helping to direct resources, spectrum managers would have to predict the most valued use of the resource in order to make decisions designed to allocate spectrum to the services that would best serve society's interests.

Because of the growing demand for spectrum and the inability to predict where technology will lead, spectrum managers in some countries, as well as many other interested parties, are questioning the continued appropriateness of relying largely on traditional command and control methods for allocating and assigning spectrum. In October 2001, FCC's Chairman underlined the need to move away from reliance on command and control methods when he stated that it is becoming an "impossible task" for government officials to determine the best use for spectrum and to repeatedly adjust allocations and assignments of spectrum to accommodate new spectrum needs and new services. Similarly, in June 2002, the Assistant Secretary of Commerce for Communications and Information at NTIA indicated her support of market-oriented approaches for commercial users when she stated that NTIA is hoping that FCC will move forward fairly rapidly with its efforts to promote secondary markets for spectrum.

Key Stakeholders Are Discussing Ways to Meet Future Spectrum Needs

Because stakeholders are concerned that the current system may not be able to meet the country's future needs for spectrum, they have been having discussions and looking to find solutions for these concerns. These forums and initiatives are indicative of a general sense among many interested parties that managing spectrum is difficult, complex, and challenging, and that significant reforms to the current processes may be needed. These initiatives include a variety of task forces and working groups, including:

- *FCC*: In June 2002, the Spectrum Policy Task Force, composed of senior FCC staff, was announced. The task force's mission was to identify and evaluate changes in spectrum policy to increase public benefit. The task force released its report in November 2002, with four key recommendations: (1) To provide an incentive for spectrum holders to be technically innovative and economically efficient, FCC should move

toward more flexible, market-oriented policies, which would require FCC to clearly define spectrum users' rights and responsibilities. (2) FCC should adopt a new standard for judging acceptable interference, to be called the "interference temperature." (3) FCC should increasingly consider the dimension of time to make allocation and assignment decisions, so that spectrum users could better share unused and underused spectrum. (4) FCC should begin basing its spectrum policy on the "commons" and exclusive use models rather than on the command and control model, except in cases where there is a compelling public interest, such as public safety.[18]

- *NTIA*: In April 2002, NTIA held a Spectrum Management and Policy Summit. The purpose of this conference was to discuss how spectrum management could be more effective and to find ways of meeting future spectrum needs. Additionally, NTIA included in the Department of Commerce's fiscal year 2003 budget a proposal for an NTIA Spectrum Management Reform initiative. The fiscal year 2003 appropriation request for the program, which is expected to take about nine years to be implemented, was $1.425 million. The purpose of this initiative would be to review the management processes that are currently being used to allocate and distribute spectrum, including those used by NTIA, FCC, and the individual federal agencies that manage spectrum.
- *Public Safety Wireless Advisory Committee*: This committee, established by FCC and NTIA in response to concerns voiced by the Congress that the agencies' individual reporting of public safety's spectrum needs may be insufficient, outlined public safety's spectrum needs through the year 2010. The committee suggested focusing on obtaining new spectrum allocations for public safety, implementing technologies to allow more efficient spectrum use and sharing, and encouraging public safety users to utilize commercial services when possible.
- *The Center for Strategic and International Studies (CSIS*): Recognizing increasing demands on the spectrum allocation process, CSIS conducted a series of roundtable discussions in the past 2 years on spectrum allocation and long-term spectrum-management needs and goals for the U.S. government and economy. In addition, CSIS has convened a Commission on Spectrum Management to further examine the issue and expects to release a report on spectrum management in mid-2003.

In addition, both the Senate and the House of Representatives are looking at ways to better meet future spectrum needs. Issues being examined

[18]See FCC's "Spectrum Policy Task Force Report: ET Docket No. 02-135," November 2002, for a more in-depth discussion of each recommendation. FCC has issued a public notice asking for comments on this report. The comment period ended on January 27, 2003.

include creating funds for reallocating spectrum from one use or user to another and setting aside unlicensed spectrum for broadband use. Hearings have been held to examine the current process and the impact of this system on the implementation of 3G technologies—which include transferring data at higher speeds than current technologies generally permit. Also, a variety of bills introduced in the 107th Congress addressed diverse spectrum-related issues.[19]

Many Countries Are Adopting Market-Based Mechanisms to Help Meet Future Spectrum Needs

There appears to be general agreement among many regulators and experts that a more dynamic system for allocating and assigning spectrum is needed. To promote the movement of spectrum to those uses where it is most highly valued, the United States and some other countries have adopted some market-based mechanisms in their management of the spectrum. According to spectrum managers we spoke with in various countries, some have adopted these mechanisms for both government and commercial users, while others have adopted mechanisms only for commercial users. Spectrum managers in the remaining countries we studied said that they were not using these market-based mechanisms, but some reported that they were exploring using these mechanisms.

Many Countries Identified Advantages to Using Market-Based Mechanisms for Spectrum Management

While spectrum users have been shielded historically from the normal workings of the marketplace, market-based approaches to spectrum management invoke mechanisms or policies that leverage the information normally available in markets—such as prices of goods or services—to promote the efficient use of spectrum. Regulators can implement market-based mechanisms in a variety of ways. They can:

- Create a market where none previously existed. For example, markets for spectrum have been created over the past 10 to 15 years by adopting auctions as a method for assigning spectrum licenses to mobile telephone and other wireless service providers.
- Remove or relax rules and regulations that created barriers to the full functioning of spectrum markets. For example, some countries reported that they are considering rules and regulations to permit users to more readily purchase or lease spectrum from other license holders, allowing a

[19]Legislation addressing spectrum policy introduced in the 107th Congress included S. 2869, H.R. 5638, H.R. 4738, and H.R. 4641.

more robust secondary market.[20] Similarly, with more flexibility, spectrum licensees can more readily make business decisions to change how they use their assigned spectrum without having to get regulatory approval.

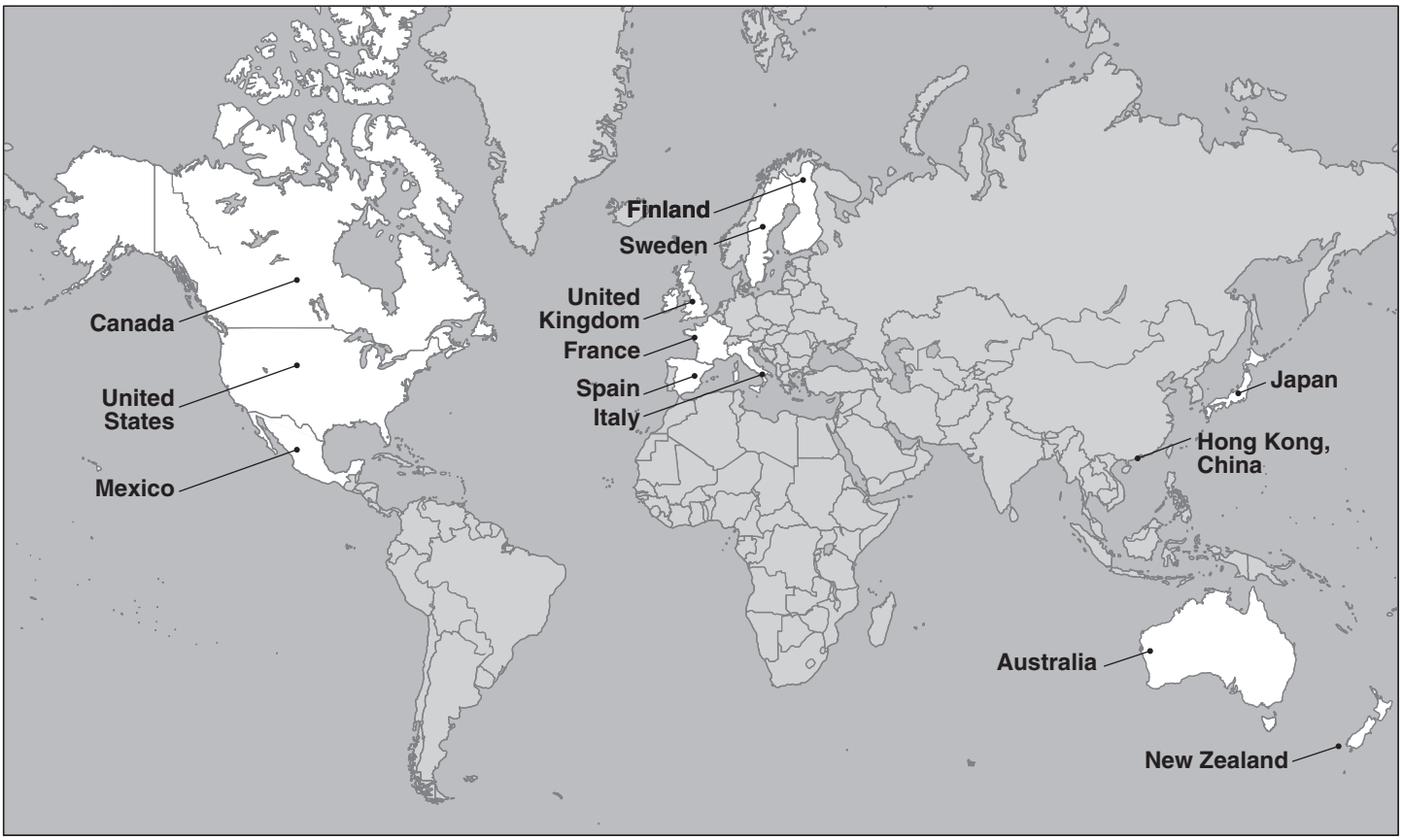
- Implement a policy that artificially mimics the functions of a market. For example, in some countries, regulators have developed fees that are based on information about prices for spectrum that would likely exist under a free market. These "incentive-based fees" differ from other regulatory fees that are assessed only to recover the cost of the government's management of spectrum. Incentive-based fees are designed to promote the efficient use of spectrum by compelling spectrum users to recognize the value to society of the spectrum that they use. Mechanisms such as these might have the most applicability for users that do not function within a commercial context.

According to the spectrum managers in the 13 countries we reviewed (see fig. 2), many have adopted a variety of market-based mechanisms including auctions and incentive-based fees, more flexible licenses, and secondary markets. Managers in many countries told us that they are moving away from administrative processes and adopting market-based mechanisms for a variety of reasons. Spectrum managers in the countries we studied shared their views on the advantages of market-based policies, which included their usefulness in

- facilitating the reallocation and reassignment of spectrum to its most efficient use;
- allowing the market to handle the assignment and allocation of spectrum, which some believe the market can do better than managers can;
- requiring government agencies to pay market prices for spectrum just as they do for other resources, such as land and electricity; and
- addressing the challenges of spectrum management under conditions of increasing demand and rising unpredictability of new opportunities for using spectrum.

[20]In its current Notice of Proposed Rulemaking and its Policy Statement on Secondary Markets, issued concurrently, FCC established guiding principles for the development of secondary markets. Their goals include the establishment of clear definitions of spectrum usage rights for assignees and the ability of assignees to be able to easily transfer, aggregate, and divide their licenses and spectrum usage rights. The countries we studied have followed these principles to varying degrees.

Figure 2: Countries Studied as Part of GAO's Review



Source: © 1998 Cartesia MapArt.

Some Countries Have Adopted Market-Based Mechanisms for Government and Commercial Users

According to spectrum managers in Australia, Canada,[21] and the United Kingdom, these countries have adopted market-based mechanisms as part of their spectrum-management approaches for both government and commercial users. As table 1 shows, in addition to holding auctions, these countries have instituted incentive-based pricing—which is designed specifically to provide an incentive to conserve on spectrum—for commercial and government spectrum. These countries have also introduced greater flexibility and secondary markets for spectrum holders. Of these three countries, Australia was the first to institute market

[21]While Canada's fees do not attempt to closely mimic a market, we define these as market-oriented because the fees are set using certain "market indicators" and are set to recoup more than the cost of administering the licenses.

mechanisms, adopting auctions in 1994 and incentive-based pricing in the early 1980s. Canada and the United Kingdom started using auctions at a later time—in 1999 and 2000, respectively. With regard to incentive-based pricing, Canada has been using this mechanism since the late 1980s and the United Kingdom since 1998. See appendix V for more information on spectrum management in all of the countries we reviewed.

Table 1: Market-Based Mechanisms Adopted by Countries for Both Government and Commercial Users

	Countries		
Details on the Use of Market-Based Mechanisms	**Australia**	**Canada**	**United Kingdom**
Auctions (for commercial users only)			
Year of first auction or tender[a]	1994	1999	2000
Number of auctions or tenders to date	18	2	2
Incentive-based pricing (for commercial and government users)			
Time when country instituted pricing	Early 1980s	Late 1980s	1998
Revenue from spectrum fees as a percentage of management costs[b]	400%	500%	130%
Flexibility and secondary markets (for commercial users only)			
Degree to which spectrum licensees have flexibility in terms of how they use licensed spectrum without regulatory approval	Some licenses have flexibility regarding which technologies can be used with the spectrum.	Licenses acquired in auctions have more flexibility in use of the spectrum.	All licenses restricted to use specified at the time spectrum was obtained.
Degree to which spectrum licenses can be traded in secondary markets without regulatory approval	All licenses have clearly defined rights and are tradable without regulatory approval.	Some licenses have clearly defined rights and are tradable without regulatory approval.	Licenses cannot be easily traded.

Source: Spectrum managers interviewed in each country.

Note: GAO's analysis of information elicited from interviews with spectrum managers.

[a]The term "tender" can have different meanings with regard to spectrum management. For our purposes, tender refers to a simple form of auction in which participants bid a price they are willing to pay for a spectrum license.

[b]If this ratio is 100, it means that spectrum fees are covering only the administrative costs of spectrum management. The percentages do not include auction revenues.

The incentive-based pricing systems in these countries were designed to encourage government spectrum users to recognize the market value of the spectrum they use.[22] Although officials told us that these fees have been successful in providing incentives for government agencies to use

[22]These countries are also imposing incentive-based pricing for some commercial uses.

spectrum efficiently, part of that success was attributed to other factors. In particular, political pressures and budgetary policies were key to helping promote efficient spectrum use.

- In Australia, the fees paid by government and nongovernmental users (including the military) are based on a formula that includes factors such as the demand for frequency, amount of spectrum assigned, geographic location, and power of transmission. Australian officials report that government users appear to be able to fulfill their missions despite having to pay for spectrum. When asked to explain the mechanism by which these fees provide an incentive for government users to conserve on spectrum, the spectrum manager we spoke with told us that the impact in Australia is largely the result of synergy between the spectrum fees and declining government agency budgets. Since the 1970s, budgets have been constrained because of the government's attempt to recover some of the benefits of the gains in efficiency arising from various government management reforms. The official we spoke with believes that this budgetary pressure, combined with more appropriate pricing of spectrum licenses, leads government users to be more efficient with their spectrum. This greater efficiency may manifest itself in government users' relinquishing spectrum that they do not currently need.
- Spectrum managers in Canada reported that they charge incentive-based fees for most uses of spectrum, including many government uses. Although the fees are currently based on the amount of equipment in use, Canada is considering changing its fee structure to be based more on other factors such as bandwidth, geography, and the degree to which spectrum is shared. Spectrum managers in Canada reported that the fees have helped some government agencies to use spectrum more efficiently and that a number of licenses have been returned as a result of the fees. They reported that some of these results might also have come about because of their close working relationship with licensees.
- The United Kingdom developed an approach for determining spectrum fees for all users, except those who had purchased their spectrum at auction and certain providers of exempted services (such as certain military functions). The approach considers alternative means to provide a service that is currently being provided with certain assigned spectrum. Then, an evaluation is made of how that service could be provided by using alternative spectrum, or without any spectrum at all, if possible. A key evaluation is made of the difference in cost between the current means of providing the service and the next best means. Adjusted for certain other factors, this difference represents the "opportunity cost" of the spectrum to the user—that is, the value of the spectrum to that user. As such, this dollar value is the basis for the incentive-based portion of the fee the user must pay. Officials in the United Kingdom believe that

spectrum fees are working to improve the efficiency of government spectrum use because agencies are generally facing budgetary restrictions and therefore cannot easily finance spectrum fees through the budgetary process.[23]

For commercial users, these countries are working to provide more flexibility in licensing and to establish or improve secondary markets for spectrum.

- In Australia, licenses may be traded, sold, or sublet.[24] Some of these can also be traded, sold, or sublet in portions based on geography, time, or bandwidth. Australian spectrum managers have not been satisfied with the speed of development of secondary markets in that country, however, and spectrum managers are considering measures to stimulate these markets. Payments among users are also allowed as part of the spectrum-clearing process. Although government funding for moving incumbent spectrum holders to alternative spectrum is not provided, new spectrum licensees are allowed to pay incumbent license holders to induce more rapid clearing of spectrum.
- In Canada, licenses acquired through auctions have greater flexibility of use than those acquired in other ways, which enables spectrum licensees to more freely decide to modify how they use their assigned spectrum. For example, licenses gained through the auction process have a broader class of services that can be provided with the spectrum than licenses gained through other assignment mechanisms. According to officials there, Canada is planning to extend this flexibility to spectrum obtained in comparative hearings as well. Although holders of auction-based licenses can also participate in the secondary market, officials report that secondary markets are not well developed.
- The United Kingdom is in the process of increasing the flexibility allowed by its spectrum licenses. Its recent major review of spectrum management recommends allowing more flexibility in the services that spectrum users can provide and the technologies they use. The United Kingdom is planning to issue future licenses with as much flexibility as possible, while recognizing that international coordination and interference management

[23]In March 2002, the United Kingdom released the results of its independent review of spectrum management.

[24]Only one type of license, a class license, cannot be traded, sold, or sublet. Although class licenses are referred to as licenses in Australia, they are actually open, standing authorities that allow anyone to operate certain low-power devices, similar to unlicensed spectrum in the United States. Device users do not have to apply for a class license and do not pay a fee.

may sometimes limit flexibility. The United Kingdom also sees the development of a robust secondary market as a valuable tool for ensuring that spectrum flows to its most valued use.[25]

United States and Certain Other Countries Have Adopted Some Market-Based Mechanisms for Commercial Users Only

According to the spectrum managers we spoke with in each country, the United States, New Zealand, Mexico, Italy, and Hong Kong have adopted market-based mechanisms for the commercial sector only (see table 2). For various reasons, these countries do not charge government users more than cost recovery for their use of the spectrum. In the United States, NTIA and FCC do not have the authority to impose fees that exceed the costs of spectrum management. Similarly, managers in Italy are currently prohibited from charging fees above a cost-recovery level.[26] Officials in New Zealand reported that they had considered charging government users an incentive-based value for spectrum, but decided against it because they were concerned that determining the value of spectrum not bought and sold in a commercial market would be too difficult.

[25]No European Union member states use secondary markets because, prior to 2003, the European Commission prohibited their use. Since this prohibition will be phased out by July 2003, some of these countries are thinking about implementing secondary trading of spectrum licenses.

[26]Managers in Italy report that the law may soon be changed to allow for spectrum holders to be charged a fee to account for the scarcity of resources, thus allowing them to recover costs greater than the cost of administering the spectrum.

Table 2: Market-Based Mechanisms Adopted by Countries for Commercial Users Only

	Countries				
Details on the Use of Market-Based Mechanisms	**New Zealand**	**United States**	**Mexico**	**Italy**	**Hong Kong, China**
Auctions					
Year of first auction or tender	1989	1994	1996	2000	2001
Number of auctions or tenders to date	12	42	17	2	1
Flexibility and secondary markets					
Degree to which spectrum licensees have flexibility in terms of how they use licensed spectrum without regulatory approval	Many licenses have flexibility in use of the spectrum.	Some licenses have more flexibility in use of the spectrum.	Some licenses have more flexibility in use of the spectrum.	Licenses are restricted to use specified at the time spectrum was obtained.	Licenses are restricted to use specified at the time spectrum was obtained.
Degree to which spectrum licenses can be traded in secondary markets without regulatory approval	Many licenses have clearly defined rights and are tradable without regulatory approval.	Licenses cannot be easily traded.	Licenses cannot be easily traded.	Licenses cannot be easily traded[a]	Licenses cannot be easily traded.

Source: Spectrum managers interviewed in each country.

Note: GAO analyzed information elicited from interviews with spectrum managers.

[a]Italy recently approved a law that allows the trading of certain broadcasting frequencies, with the requirement that they are used exclusively for experimentation with terrestrial digital video broadcasting.

The United States has used auctions since 1994, shortly after congressional legislation first authorized auctions to be used for commercial spectrum assignment. FCC has also adopted rules that afford companies more flexibility regarding various license provisions—such as the technologies that a company may use or the services that it may provide with its licensed spectrum. FCC plans to increase the flexibility of its licenses, and it is considering liberalizing the right to engage in secondary markets. In recent congressional testimony, an FCC official noted that flexible spectrum rules, which allow companies to respond to market conditions without government intervention, are essential in today's dynamic world of wireless communications. With regard to secondary market activity, spectrum trades in the United States generally require regulatory approval from FCC. Despite this requirement, a majority of companies we spoke with in the United States have either purchased spectrum licenses from another company or traded spectrum licenses with

another company. FCC has an ongoing proceeding looking at ways to encourage the growth of secondary markets. For example, FCC is seeking to institute policies that would allow commercial users to sublease slices of spectrum covered by a license for variable lengths of time.

With regard to the use of market-based mechanisms for commercial users in other countries, spectrum managers told us the following:

- New Zealand was the first country to implement a market-based mechanism to assign spectrum. Today, New Zealand assigns "management rights" to some spectrum it auctions. A winner of such a license is allowed to assign the spectrum in various configurations to itself or others. As such, auction winners essentially have a profit motive that gives them an incentive to assign spectrum to its most valued use. Although licenses are tradable in New Zealand without regulatory approval, spectrum managers reported that because there is not a scarcity of spectrum in that country, there is very little market activity.
- More recently, Italy has begun to use auctions to assign spectrum, but as with many other European countries subject to certain restrictions on the regulation of spectrum under European Commission law, Italy is moving more slowly than Canada, Australia, and New Zealand to adopt certain market mechanisms. At this time, Italy issues very restricted licenses and has a very limited secondary market for spectrum.
- Spectrum managers in Hong Kong reported that they assigned spectrum for 3G services in 2001 using a royalty-based auction, which is unique among the countries we reviewed. Unlike most auctions in other countries in which participants bid the total fixed cash price they are willing to pay for spectrum, bidders in Hong Kong bid on the percentage of future revenues—that is, a royalty rate—that they would pay to the government on an ongoing basis. Officials in Hong Kong told us that they chose the royalty method so that the government could share some of the risk inherent in paying for spectrum in future years. They explained that the risk exists because 3G services are new and their full potential cannot be estimated accurately. They also reported that they were concerned that requiring companies to spend large amounts of capital in a cash auction requiring an up-front payment for spectrum would result in too large a financial burden for potential bidders, who also require capital to roll out their networks. Spectrum managers told us that the royalty auction resulted in four incumbent providers of traditional wireless services offering the minimum bid allowable (5 percent of revenue) for the four

licenses to provide advanced wireless services.[27] We further discuss Hong Kong's use of royalty auctions in appendix II.

Several Countries Have Not Adopted Market-Based Mechanisms at This Time, but Some May in the Future

Spectrum managers from five of the countries in our study—Japan, France, Finland, Spain,[28] and Sweden—reported that they have not used mechanisms that we have defined as being market-based in managing their spectrum. Some of these countries, however, reported that they are considering changing laws and regulations in the future to encourage more efficiency. France, which imposes a large fee to participate in comparative hearings, reported that it has legislation pending to require most users—including government users but not broadcasters—to pay for spectrum. Similarly, managers from Finland reported that they are currently reviewing their policies to extend spectrum fees to more users. Finally, Sweden reported that a committee has proposed changes to Swedish law to allow greater use of market-based mechanisms.

Market Mechanisms May Not Be Effective in All Contexts and May Be Difficult to Implement

While a move to market-based mechanisms could help to meet future spectrum needs by encouraging users to better utilize spectrum, these mechanisms may not be effective in some contexts and may be difficult to implement. In particular, the context in which certain government users function may not be conducive to the influence of market-based mechanisms. For commercial users, implementing market-based mechanisms may heighten concerns about interference among users. Moreover, market-based mechanisms can work well only when license holders have clearly defined "rights" regarding their use of spectrum.

[27]For the first 5 years after the auction, licensees are required to make the minimum payment of 50 million Hong Kong dollars per year. After that, they must begin making the royalty payments.

[28]On at least one occasion, Spain has considered financial criteria in the process of awarding spectrum licenses.

Greater Reliance on Market-Based Mechanisms for Government Users May Be Undesirable, Ineffective, or Difficult to Implement in Some Circumstances

Greater reliance on market-based mechanisms may not be desirable or effective for some government users or uses. The purpose of market-based mechanisms is to provide users with an incentive to use spectrum as efficiently as possible. This may result in users' considering alternative methods of providing services by adopting technologies that either (1) use less spectrum, (2) use less congested parts of the spectrum, or (3) do not require spectrum at all. Because of the primacy of certain government functions—such as homeland security and national defense—charging government users for these functions may not be desirable. In addition, if particular users are unable to adopt any alternative method in a reasonable time frame, market-based mechanisms, such as incentive-based spectrum fees, are not likely to result in reduced spectrum use. In other words, market-based mechanisms can create an incentive for spectrum conservation only if users can actually choose to undertake an alternative means of providing a service. Government users provided several examples of circumstances in which market-based fees might not provide incentives:

- Spectrum used for certain functions, such as air traffic control, has been allocated internationally—the same bands of spectrum are allocated for this service around the world. The benefit of this in the context of air traffic control is that airplanes on international flights can use the same radio equipment and systems in every country, making air travel safer and less costly than it would be if countries provided services on different bands. If FAA wanted to use bands that are different from those allocated in these international agreements, airplanes from the United States that are making international flights would require multiple communications systems and procedures, which would impose considerable additional costs on carriers. In fact, the United Kingdom charges government users incentive-based fees but exempts spectrum used for air traffic control from these fees.
- It may also be inappropriate to apply market-based mechanisms for defense systems that involve international agreements. For example, the United Kingdom does not charge the Ministry of Defence for spectrum identified for North Atlantic Treaty Organization use. In addition, DOD has publicly stated that the ability to operate certain systems depends on international agreements with other countries that allow DOD to use certain frequencies within other countries' borders. DOD officials note that it is important for DOD to employ the same systems, and thus the same portions of spectrum, inside the United States as it does overseas. DOD officials said that it would be very difficult to renegotiate these arrangements in response to spectrum reallocations, or to the implementation of incentive-based fees for spectrum in the United States.

- Many government defense systems that use spectrum—such as large weapons systems, or satellite systems—not only involve complex international agreements, but are also large and complex from an engineering perspective. These systems usually require years of development, and spectrum may be only a small part of the total resources used by a given system. Thus, once a system is designed and operational, any benefits of conserving spectrum by redesigning these systems are likely to be outweighed by the costs of making such modifications. Consequently, imposing an incentive-based fee for spectrum employed in projects with a long time horizon may not result in spectrum conservation.

  In some cases, charging government users a market-based fee for spectrum may have the potential to make spectrum use more efficient, such as in situations where a government user is providing a service similar to that of a commercial vendor. Nevertheless, implementing market-based incentives may still be challenging, for several reasons:

- It is difficult to place prices on goods and services that are not traded in the marketplace. For commercial users, spectrum prices are reflective of the value of the services provided with that spectrum, as measured, in part, by what consumers will pay for the service. Some government services are unique and provide safety-of-life or national defense services. For example, FAA's air traffic control services and DOD's precision weapons–guidance systems rely on spectrum, yet there are no equivalent commercial services. Government spectrum users have said that services without a direct commercial corollary cannot be easily valued. One government representative noted that the value to the nation of spectrum allocated to government services is difficult to measure through market mechanisms.
- If government users can obtain any needed funding for spectrum fees through the budgetary process, market-based incentives are not likely to be effective in conserving spectrum. Two of the three countries that believed that their incentive-based pricing systems were providing some financial incentives for government users to conserve on spectrum reported that one factor contributing to this conservation was a requirement for agencies to reduce their overall budgets while paying for spectrum. Thus, agencies could not easily finance the increased cost of spectrum through the budgetary process. In the United States, most of the limits or caps on discretionary spending contained in the Budget Enforcement Act of 1990 expired in fiscal year 2002. These limits or caps would have constrained discretionary spending, including amounts available for using the spectrum, if government users were charged for that use.

- In the commercial sector, the profit motive typically provides an incentive for individuals and companies to use spectrum efficiently. Government users do not have a similar financial incentive to conserve on spectrum, because spectrum efficiency is not directly rewarded within government agencies. Thus, imposing fees may create some pressure, but does not mimic a profit motive. Linking spectrum-efficient decisions to performance contracts and individual awards could create greater individual efforts to make such decisions.

  Another impediment to implementing market-based incentives for government users may be the views of those users. Our survey of IRAC agencies found that 7 of the 17 agencies responding to this survey did not support greater flexibility of use for government spectrum users, 13 did not support the practice of allowing agencies to buy or sell spectrum, 12 were opposed to allowing agencies to lease spectrum, and 13 were opposed to paying fees for spectrum that exceeded regulatory costs. However, 9 agencies were "greatly" or "moderately" supportive of allowing commercial users to pay government license holders to relocate to alternative spectrum, and 11 greatly/moderately supported creating a trust fund to pay for spectrum reallocation.

Impediments Have Limited Implementation of Market-Based Mechanisms for Commercial Users

Despite the potential benefits of adopting market-based mechanisms for spectrum management, some impediments have limited the implementation of these methods for commercial users. Even though both FCC and NTIA support the use of market-based mechanisms for commercial users, FCC's implementation of these tools has been limited. Impediments to more widespread implementation of market-based mechanisms—such as auctions, secondary markets, and flexibility of use—include statutory restrictions, the degree to which the most highly-valued spectrum is already assigned, and the sometimes conflicting interests of commercial entities.

Auctions: FCC has auctioned off only a limited amount of the spectrum it oversees. Because most of the spectrum is already assigned, the amount of spectrum that could be auctioned without reallocating spectrum is quite limited. Also, FCC has attempted to auction additional spectrum by relocating some users to other parts of the spectrum. Relocation can impose significant costs on the incumbent spectrum holder and sometimes on the new entrant who may be required to fund the relocation. In addition, FCC officials told us that there are statutory limits to their ability to use auctions.

Secondary markets: Further implementation of secondary markets in the United States will require that the rights of licensees with regard to their assigned spectrum be more clearly specified. In other resource markets—such as those for land—commercial entities usually have the right, without regulatory approval, to buy or sell the resource, or to lease the resource from another entity that owns it. Although the Communications Act of 1934 prohibits the ownership of spectrum, companies have generally been able to buy and sell spectrum licenses with FCC's approval. However, according to an FCC official, it is unclear at this time whether, in general, license holders can legally lease all or part of their spectrum rights to other users for some limited period of time. The opposition of some stakeholders, who are concerned that conferring any specific spectrum rights will make it more difficult to release spectrum for new services and technologies that might develop in the future, further complicates providing rights to spectrum users. For over 2 years, FCC has been considering these issues under a Notice of Proposed Rulemaking on secondary markets and hopes to resolve some of these issues shortly.

Flexibility of use: Granting greater flexibility in the use of spectrum would enable license holders to behave like other resource owners in having the opportunity to make economic decisions that put their resource to its most highly valued use. Although FCC is examining ways to improve access to spectrum by providing additional flexibility, an FCC official told us that only a small portion of the spectrum it assigns is held under licenses that allow for considerable flexibility of use. FCC's ability to introduce additional flexibility has been limited because most of the desirable spectrum has already been assigned, making it more difficult to change the rules embodied in these licenses. Moreover, there are considerable disagreements among commercial users over the appropriate degree of flexibility. In particular, some interested parties are concerned that allowing greater flexibility could result in more interference among users. In its report, the FCC Spectrum Policy Task Force made a number of recommendations for handling this potential interference, including the promotion of receiver requirements and creation of a new standard for quantifying acceptable levels of interference, the "interference temperature."

Diversity of Views among Stakeholders and Current Regulatory Structure Are Barriers to Meeting Future Spectrum Needs

While a number of discussions and activities are under way to help ensure that future spectrum needs can be met, stakeholders appear to be having difficulty finding consensus that balances the needs of various interest groups. Regulatory actions aimed at providing solutions are often protracted. Moreover, because of the bifurcated regulatory structure in the United States, an examination of whether an overarching redesign of spectrum management is required may best be undertaken by an entity independent of the two regulatory agencies currently involved. In the past, Presidents and the Congress have appointed bipartisan commissions to address difficult policy issues such as this.

Stakeholders Have Major Disagreements on Spectrum Policy

Stakeholders have been actively searching for ways to improve spectrum management and, thus, to alleviate concerns about meeting future spectrum needs. However, certain conflicts among the stakeholders make it difficult to find workable solutions that balance the needs of various spectrum users. Many conflicts arise because of divergent economic interests among users. For example:

- *Concerns about the cost of reallocation.* Incumbent users are often opposed to relocations of current users to new bands, because such moves are likely to require the purchase of new equipment and may thus impose significant costs and disruption on incumbents—although some of this cost may be shared with the firms receiving licenses to use the cleared spectrum. But firms with new services view reallocations as being essential for bringing the benefits of wireless services, including Internet services, to the American public.
- *Concerns about interference.* Many conflicts with regard to spectrum decisions arise over concerns about interference. A good example of this concern arises with regard to unlicensed spectrum users. Many licensed spectrum users, both commercial and government, have expressed concern that allowing certain unlicensed uses—wherein devices operating at low power and in fairly limited range use the same frequencies as licensed providers—may create interference that compromises the quality of services provided by licensed users. Conversely, those wanting to introduce certain new technologies view access to unlicensed spectrum as beneficial to the public interest and maintain that the degree of interference created by certain unlicensed uses is not "harmful."
- *Concerns about policies that influence markets' competitiveness.* Many policy initiatives can have an effect on the competitiveness of wireless markets. For example, allowing greater flexibility for spectrum holders to use spectrum in a variety of ways could create opportunities for firms to enter markets for certain services, increasing the competitiveness of those markets. In fact, some experts have noted that, at times, incumbent firms

oppose certain spectrum policies, in part, because of concerns about the effect on competition in the market.

Another area where conflicts among spectrum stakeholders have arisen relates to difficulties in determining how to balance the needs—or a *process* to ensure a balancing of needs—between public-sector and private-sector spectrum users. Government users have said that because they offer unique and critical services that are not comparable to those provided in the commercial sector, a dollar value cannot be placed on the government's provision of spectrum-related services. FCC officials, commercial users, and others have stated that the ability of commercial users to acquire adequate spectrum is also critical to the welfare of society, because the commercial wireless sector makes important contributions to a healthy, robust economy. FCC and Department of Commerce officials acknowledge the difficulty of balancing the critical needs of government and commercial spectrum users. To illustrate this point, they refer to the difficulties experienced in negotiating two recent agreements: the reallocation of spectrum from government to commercial users for 3G services and the rules under which ultrawideband devices will share spectrum with federal users.

Regulatory Environment Results in Protracted Policy Development and Implementation

Under the divided management framework, no one entity has been given ultimate decisionmaking authority over all spectrum use. There must be coordination and cooperation in order to determine how best to accommodate users of spectrum. While any decisions involving spectrum can be difficult, those involving spectrum allocations can be particularly protracted. Because most of the desirable spectrum has already been allocated, allocating spectrum for a new technology or service usually requires that some existing users be moved to another part of the spectrum. Since existing users are likely to experience costs for relocating but little, if any, benefit, they are often reluctant to make a move. Even within the jurisdiction of a single spectrum-management agency, reallocations of spectrum may require lengthy negotiations. Moreover, decisions involving the reallocation of spectrum between federal and nonfederal users, and thus between regulatory jurisdictions, can be even more difficult. Some examples of protracted spectrum decisions both within and across regulatory jurisdictions include:

The reallocation of spectrum in the 700 MHz band. In 1997, the Congress directed FCC to reallocate to public safety services the 24 MHz of the spectrum that will be recovered from the transition to digital television, and to put up for auction the remaining recovered spectrum. In 1999, the

Congress directed that the proceeds from these auctions were to be deposited with the Treasury by September 30, 2000. Auctions for spectrum in the 700 MHz band have been rescheduled several times. Several mobile telephone companies supported a postponement of these auctions. Those in favor of postponing the auction believed that because it was unclear when the spectrum would be vacated, it would be difficult for companies to determine the value of the spectrum. On June 18, 2002, the Congress passed legislation removing the former statutory auction deadlines but requiring FCC to auction, before September 19, 2002, 18 MHz of spectrum, some of which was desired by rural carriers. This auction was completed in September 2002. The auction of the remaining spectrum in the 700 MHz range has been postponed indefinitely.

The narrowbanding initiative for federal spectrum users. In 1992, the Congress directed NTIA to adopt and implement a plan for federal agencies with existing mobile radio systems to use more spectrum-efficient technologies. In 1993, NTIA responded to the Congress with a report that included a plan for implementing narrowbanding—a technology that would use about half as much bandwidth as agencies are currently using.[29] NTIA set interim deadlines for the narrowbanding requirements, which are to be fully implemented by 2008. The plan required that some agencies move to spectrum occupied by another agency. As a result, the plan provided a time line according to which each agency would adopt narrowbanding because, as NTIA officials pointed out, the implementation of narrowbanding by any given agency depends, in part, on whether the other agencies have adhered to the schedules laid out by NTIA. We recently asked NTIA about the progress of agencies in meeting their narrowbanding requirements. NTIA was not able to tell us how many agencies have complied with the interim deadlines, because some agencies had not yet responded to NTIA's June 2002 request for information on compliance with narrowbanding requirements. NTIA officials noted that while they can legally remove frequency assignments from spectrum users that are not complying with the plan, in reality it is difficult for the agency to exercise its authority in overseeing the adoption of narrowbanding.

[29]See National Telecommunications and Information Administration, *Land Mobile Spectrum Efficiency: A Plan of Federal Government Agencies to Use More Spectrum-Efficient Technologies*, NTIA Report 93-300 (Washington, D.C.: October 1993).

Allocation of spectrum for 3G wireless services. Spectrum managers first considered the need for spectrum to accommodate these new services in 1999, when FCC released its spectrum policy statement. In October 2000, President Clinton directed that a plan be developed to select spectrum for 3G services, but this initial attempt was unsuccessful. In a letter in June 2001, FCC's Chairman wrote to the Secretary of the Department of Commerce, "It is apparent that additional time is necessary to allow the Commission and the Executive Branch to complete a careful and complete evaluation of the various possible options" for making spectrum available for 3G. FCC's Chairman stated that the public interest would best be served by providing additional time for informed consideration, even if this resulted in some delay in reaching allocation decisions. Finally, he requested relief from the 2002 statutory deadline for spectrum to be auctioned. A task force was established, which included officials at the Department of Commerce, FCC, Department of Defense, and other federal agencies. In July 2002 the task force released a study concluding that 90 MHz of spectrum could be allocated to 3G without disrupting communications services critical to national security.[30] The deadline set for the band clearing to occur is now 2008, although certain provisions need to be met before DOD would be expected to relinquish its portion of those frequencies. On November 7, 2002, FCC officials released a Notice of Proposed Rulemaking that suggests service rules for the reallocated spectrum. FCC officials stated that they would likely adopt an order establishing the service rules by mid-2003 and would likely hold an auction in 2004. Despite these developments, FCC officials have stated that additional spectrum would need to be allocated to fully support 3G services.

[30]45 MHz of the spectrum being reallocated would come from government users, and the additional 45 MHz from nongovernmental users.

FCC and NTIA Are Attempting to Work in a More Coordinated Fashion to Address Difficulties in Spectrum Management, but Jurisdictional Responsibilities Differ

Recognizing that the absence of a generally agreed upon national spectrum strategy can make it difficult for FCC and NTIA to avoid contentious, protracted negotiations when providing for future spectrum needs,[31] we recommended in our September 2002 report that the Secretary of Commerce and FCC should establish and carry out formal, joint planning activities to develop such a strategy to guide decisionmaking. Both FCC and NTIA responded positively to this recommendation, and they have recognized the need to address concerns about current spectrum-management policies and procedures by establishing task forces and working groups within their own agencies. For example, the FCC Spectrum Policy Task Force addressed some of these issues and released a report in November 2002, and NTIA held a Spectrum Summit in April 2002 to gather information from stakeholders on the current problems with the spectrum-management process. In response to our previous report, FCC stated that a cornerstone of both these efforts is to improve coordination between FCC and NTIA, to conduct joint planning, and to develop a national spectrum-management strategy. NTIA officials told us that their request for funding for spectrum reform as part of the President's fiscal year 2003 budget is also a result of their view that the United States needs to take a broad view of the organizational structure and processes for spectrum management.

Despite the increased amount of communication between FCC and NTIA, their different jurisdictional responsibilities appear likely to result in piecemeal efforts that lack the coordination to facilitate major policy changes. In particular, FCC and NTIA's recent policy evaluations and initiatives tend to focus on the issues applicable to the users under their respective jurisdictions. Thus, while these current efforts may be beneficial within the current regulatory environment, an analysis of whether there is a need for comprehensive reforms—such as changes in the structure of spectrum management—may best be undertaken by an independent body.

[31]At NTIA's Spectrum Management and Policy Summit, held in April 2002, it appeared that stakeholders did not have a clear agreement on what would be included in a national spectrum strategy.

Some Stakeholders Have Suggested That Changes to the Structure of Spectrum-Management Functions May Be Needed

As we discussed in our September 2002 report, the current structure of spectrum-management functions within the U.S. government has been in place for many years. In particular, the bifurcated system was put into place with the Radio Act of 1927, and in 1934 the Federal Communications Commission was created to, among other things, oversee nonfederal licensing of spectrum. The federal oversight of spectrum has moved within the executive branch several times and has been the responsibility of NTIA since it was created in 1978. Although the organization of spectrum management has been static for many years, the application of spectrum in providing services has evolved dramatically. In particular, a plethora of new services and applications has emerged in the past 25 years, including various types of mobile telephone service, paging services, wireless video and data services, wireless local area networks, and Internet access. On the government side, the past 25 years have seen untold new wireless applications for public safety, national defense, and other key missions. Additionally, new technologies, such as ultrawideband and software-defined radio, would use radio spectrum in new ways.

Recognizing that the United States may not have an adequate regulatory structure to address spectrum-management concerns, commercial and government spectrum license holders, as well as other stakeholders, have suggested various changes in the domestic spectrum-management structure. The ideas range from temporary solutions to overarching systemic changes, but they all aim at improving the efficiency of the way spectrum is managed. Stakeholders' proposals for improving the process include:

- *Creation of spectrum allocation assessment commission*: Several stakeholders have suggested the creation of a politically independent entity that would audit current spectrum allocations and make a comprehensive reallocation proposal. Some have suggested using the Base Realignment and Closure process as a model for creating an independent commission to look at spectrum allocations and assignments.
- *Move NTIA out of the Department of Commerce*: Some government agencies that we interviewed suggested that NTIA would be better positioned as a voice for all government spectrum users if it were moved outside of the Department of Commerce. It has been suggested that making NTIA either a commission or an executive office would provide it with a level of independence it does not currently have within another government agency. Eight out of 12 IRAC-member agencies that answered this question on our survey were greatly or moderately supportive of making NTIA an independent agency outside the Department of Commerce.

- *Create a spectrum oversight committee*: Along with several government spectrum license holders and a commercial user, a majority of those on our expert panel who responded to a poll felt that creation of a formal entity to provide FCC/NTIA oversight may be appropriate. They said that setting up an oversight committee would create an office where disputes could be settled. It would also serve as a place to create a uniform spectrum policy that both FCC and NTIA could follow.
- *Merging FCC and NTIA into one agency*: Some expert panel members suggested the merging of FCC and NTIA into one regulatory agency. Merging the responsibilities would allow a single agency to create one policy for the management of spectrum and create a single voice to address problems when they arise between parties.
- *Undertake an independent review of spectrum-management practices*: Seven of our 10 panelists said they favored an independent review of current spectrum-management practices, similar to that recently completed in the United Kingdom.

Spectrum-Management Structures in Some Other Countries Differ from Those in the United States, but These Alternative Structures May Not Be Applicable in the United States

The structure for managing spectrum in the United States is unlike those in most countries that we examined. According to information obtained from interviews with spectrum managers in other countries, most of the countries have a single government entity that manages spectrum for all users. For example, Industry Canada makes all final decisions about spectrum for all Canadian users, and its decisions are not subject to judicial review. Similarly, in New Zealand, the Ministry of Economic Development is responsible for both government and nongovernmental users of spectrum. Also, some countries have committees or advisory boards that analyze conflicting requests and help spectrum managers make decisions. For example, the United Kingdom Spectrum Strategy Committee prioritizes spectrum needs and makes final decisions when any major conflicts arise. Also, the Radio Advisory Board of Canada attempts to garner consensus on issues so that Industry Canada does not have to analyze many different filings with opposing views.

While other countries have adopted alternative spectrum-management systems, they may have limited applicability for the United States for a few key reasons. First, the role of the military in the United States is unique in the world. Second, the divided structure in the United States reflects the President's responsibility for national defense and the fulfillment of federal agencies' missions, along with the U.S. government's long-standing encouragement and recognition of private investment in developing commercial radio and other communications services. While alternative structures may not be fully pertinent to our domestic structure, it is

interesting to note how other countries have organized their spectrum-management functions. For more information on spectrum-management structures in other countries, see appendix V.

In the United States, Commissions Have Been Used to Look at Major Policy Change When Complex Policy Disputes Arise

In the past, commissions have been established to look at certain difficult policy issues. As table 3 shows, in the United States both the Congress and the Executive Branch have created commissions to examine a variety of issues.

Table 3: Examples of Commissions Examining Major Policy Issues

Commission	Established by	Date established	Term	Reporting	Mission
President's Commission on Administrative Management (Brownlow Committee)	Executive Order	March 1936	Approximately 10 months	Report to the President on January 1, 1937	Ensure that the President is chief Administrator of an executive branch with institutional support and reorganize the government along hierarchical lines, to provide clear lines of authority and accountability
Commission on Organization of the Executive Branch of the Government (First Hoover Commission)	Act of Congress	July 1947	Approximately 3 years	Report to Congress by January 13, 1951	Determine how to limit spending to the amount consistent with efficient performance of essential services, eliminate duplicative services, abolish unnecessary services/activities, and provide definition for and limitations of executive functions
Commission on Organization of the Executive Branch of the Government (Second Hoover Commission)	Act of Congress	July 1953	Approximately 2 years	Report to the Congress by May 31, 1955	Address the policy issues that underlay big government, identify desirable spending reductions, cut back and eliminate services, and define responsibilities of executive branch officials
President's Commission on Postal Organization	Executive Order	April 1967	1 year	Final report to the President within 1 year	Study the organization and structure of the postal service and report on the feasibility of transferring it from the Post Office Department to a government corporation or other such form of organization
National Commission on Social Security Reform	Executive Order	December 1981	1 year, 2 months	Report to the President by January 20, 1983.	Review the condition of the Social Security trust funds, identify long-term problems, and analyze potential solutions that will put Social Security on a sound financial footing
Defense Base Closure and Realignment Commission	Act of Congress	November 1990	Approximately 5 years	3 reports to the President and Congress, 1 for each year that it meets	Provide a fair process that will lead to timely closure and realignment of military installations within the United States
Amtrak Reform Council	Act of Congress	December 1997	Approximately 5 years	Annual reports to the Congress	Evaluate Amtrak performance and make recommendations for achieving cost containment, productivity improvements, and financial reforms
National Gambling Impact Study Commission	Act of Congress	August 1996	Approximately 2 years	Report issued no later than 2 years after the date of the Commission's first meeting	Conduct a comprehensive study of the social and economic impacts of gambling in the United States.

Source: GAO.

To ensure that various views and opinions are incorporated, many of the past commissions have been set up so that their members include a broad variety of stakeholders. In a majority of the commissions highlighted in table 3, the right to appoint commission members was divided between the executive and legislative branches, and in several cases further divided in the Congress between majority and minority party appointments in each house. Furthermore, when creating commissions, the Congress has chosen, at times, to stipulate certain requirements for panel members. For example, the legislation setting up the Amtrak Reform Council stipulated that presidential appointments should include representatives from both labor and management. The commissions above were generally made up of between 8 and 15 members.

In addition to the commissions discussed above, there is a historical precedent for having a commission examine the spectrum-management process; the First National Annual Radio Conference was established in 1922 by Secretary of Commerce Herbert Hoover. The group, made up of manufacturers, broadcasters, amateur radio representatives, civilian and military government radio communications personnel, and others, was charged with studying radio interference caused by the rise of radio broadcasting and the limitations of the Radio Act of 1912. The conference made recommendations to alleviate the overcrowding of the radio waves. Three subsequent conferences were held in each of the following years, and legislation was introduced to implement various recommendations of the conferences throughout this period. In 1927 a compromise was reached that led to a bifurcated framework for the management of radiofrequency spectrum by the federal government.

As spectrum management becomes more complex and difficult around the world, several other countries we examined are also finding a need to undertake a major reevaluation of their spectrum policies. Several countries we reviewed are engaged in high-level examinations of their spectrum-management systems. Canada is currently updating its 1993 Spectrum Policy Management Framework; spectrum managers there told us that the review will take between 2 and 3 years. In the past few years several other countries have completed comprehensive reviews of their policies. Australia and the United Kingdom have each recently completed a 1-year review and are in the process of addressing some of the recommendations made in these studies. Officials in Finland, Italy, and Japan also told us that they are currently involved in or have recently completed some form of spectrum-management review.

Conclusions

The availability of spectrum for a myriad of applications is of central importance to the U.S. economy and to the fulfillment of key government functions. In the past, the spectrum-management structure in the United States has served our interests well: spectrum for innumerable applications has been allocated and assigned, government's many important missions are being fulfilled, and domestic wireless markets have grown considerably. However, technology, consumer demand, and government needs are growing rapidly. And as the world becomes more globally connected, new spectrum needs are putting increased stress on the spectrum-management structure. The need for attention to this problem is becoming acute.

We found that many countries have been responding to pressing spectrum-management requirements in recent years by undertaking major reviews of spectrum issues and by instituting new policies and approaches. In the United States, numerous discussions and reviews are underway, and this activity is playing a vital role in drawing attention to and stimulating discussion of options for change to the current spectrum-management system. While spectrum reform is increasingly being discussed, debated, and reviewed, it does not appear likely that timely reforms can be agreed upon amid the diversity of views held by stakeholders. Moreover, no single agency has been given ultimate decisionmaking authority over all spectrum in the United States or the authority to impose fundamental reform. FCC's recent Spectrum Policy Task Force recommendations illustrate that even a major initiative such as this, when conducted by one regulatory agency, will focus on policies and issues under the jurisdiction of that agency. That is, despite the forward-looking nature of FCC's recommendations, these policies impact only procedures of FCC and the stakeholders it oversees; none of the task force's recommendations addresses the overarching structure of spectrum management or the possible need for comprehensive reform. As such, a major independent examination of spectrum-management policies and structure is needed.

Recommendations for Executive Action

In order to develop solutions to key spectrum-management issues, this report recommends that the Chairman of FCC and the Assistant Secretary of Commerce for Communications and Information, in consultation with officials from the Department of State, Office of Management and Budget, Office of Science and Technology Policy, and pertinent congressional committees, work together to develop and implement a plan for the establishment of a commission that would conduct a comprehensive examination of current U.S. spectrum management. This commission would examine, among other things, whether structural reform of our

current system is needed. The commission should be independent and should involve all relevant stakeholders—including commercial interests, government agencies, regulators, and others—to ensure that the diversity of views on key spectrum-management issues are represented. The review should be time-limited and, if change is needed, have as its primary objective the establishment of a framework to implement that change. Although the commission could be established by statute, executive order, or other means, a statutory basis for the commission may provide the most appropriate framework for achieving a wide-ranging review of issues that may ultimately need legislative solutions. In appendix IV, we have presented possible issues and stakeholder concerns that a commission could consider as part of its comprehensive examination.

Agency Comments

We provided a draft of this report to the National Telecommunications and Information Administration of the Department of Commerce, the Department of State, and FCC for their review and comment. Both the Department of Commerce and FCC stated that they are taking steps to coordinate their spectrum-management processes and that each agency, on its own, is making progress in developing spectrum policies that will be more responsive to the rapidly changing environment. Regarding our recommendation for an independent commission to evaluate the need for overarching spectrum reform, both of these agencies stated that they would take our recommendation into consideration. Additionally, the Department of Commerce and FCC provided technical comments on our report that were incorporated as appropriate. The comments of the Department of Commerce appear in appendix VII and the comments of FCC appear in appendix VIII. The Department of State did not provide comments on this report.

Matter for Congressional Consideration

Because neither FCC nor the Department of Commerce specifically agreed to implement our recommendation, the Congress may wish to consider taking appropriate actions to address spectrum-management concerns. For example, the Congress may consider holding hearings on this matter or enacting legislation to establish an independent commission that would conduct a comprehensive examination of current U.S. spectrum management.

We are sending copies of this report to the appropriate congressional committees. We are also sending this report to the Secretary of State, the

Chairman of the Federal Communications Commission, and the Secretary of Commerce. We will also make copies available to others upon request.

In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov. If you have any questions about this report, please contact me at 202-512-2834 or guerrerop@gao.gov. Key contacts and major contributors to this report are listed in appendix IX.

Peter Guerrero
Director, Physical Infrastructure Issues

Appendix I: Scope and Methodology

To respond to the objectives of this report, we gathered information from a variety of sources. In particular, we gathered information by (1) reviewing economic, legal, and public policy material relevant to spectrum issues; (2) interviewing regulatory agencies at state, local, and federal levels; (3) interviewing experts familiar with spectrum issues; (4) interviewing 17 companies that hold spectrum licenses in the United States; (5) interviewing spectrum managers in 12 foreign countries as well as other spectrum stakeholders in the United Kingdom and Canada; and (6) convening an expert panel to discuss several spectrum-policy issues.

To better understand the regulatory process and the differences in how spectrum is managed for commercial companies and government users, we interviewed officials who oversee spectrum allocation at both the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA) and obtained relevant documents from both agencies. To acquire a more in-depth understanding of how spectrum is managed within government agencies, we conducted interviews with officials at the Department of Justice (DOJ), Federal Aviation Administration (FAA), Federal Emergency Management Agency (FEMA), and Department of Defense (DOD). We also distributed a survey to the Interdepartment Radio Advisory Committee (IRAC) member agencies' representatives, excluding NTIA and FCC.[32] The survey asked questions about federal agencies' ability to meet mission needs, their anticipated spectrum needs, and their views on several policy issues. Of the 20 surveys we distributed at an IRAC meeting, 17 were returned to us. At the state and local levels, we talked to a national trade association representing public safety officials, as well as officials managing state and local public safety systems.

To get a more thorough understanding of the spectrum auction process, including how companies value spectrum and determine their bidding strategy, we conducted interviews with two financial companies that specialize in spectrum auction consulting and one that specializes in

[32]The following agencies are IRAC members: FEMA, Broadcasting Board of Governors, Department of Veterans Affairs, DOJ, U.S. Postal Service, Department of State, General Services Administration, National Science Foundation, National Aeronautics and Space Administration, Department of Interior, Department of Commerce, Department of the Treasury, NTIA, Department of Energy, U.S. Army, Department of Agriculture, U.S. Navy, Department of Health and Human Services, FAA, U.S. Coast Guard, and U.S. Air Force, as well as FCC, in a nonvoting capacity.

bringing wireless technologies to market. We also interviewed two academics who have written and published articles on the subject.

To better understand how companies value spectrum and whether the cost of their spectrum is a significant factor in setting end-user prices and determining the deployment of new products and services, we interviewed representatives of 17 commercial companies that have spectrum licenses. These companies provide services in both urban and rural markets. Of the 17 companies, 2 were radio or television broadcasters, 11 were wireless communications companies, 2 provided services via satellite, 1 provided local telephone service using wireless rather than wire connections, and 1 was a paging company. The selection of companies was based on those discussed in an FCC report concerning wireless issues.

To obtain information about spectrum management in other countries, we interviewed officials in Australia, Canada, Finland, France, Hong Kong, Italy, Japan, Mexico, New Zealand, Spain, Sweden, and the United Kingdom. The criteria we used to select the countries included geographic size, gross national product per capita, population density, level of mobile telephone penetration, primary methods for assigning spectrum, and whether the country uses market incentives to encourage government conservation of spectrum. In choosing the countries, we also consulted with NTIA and Department of State officials. For all countries, we were interested in learning about the regulatory structure governing spectrum management. We asked about the basic aspects of their management of the spectrum, including how the resource is allocated and assigned to government and commercial users, the mechanisms and regulatory structure they have in place for reaching agreement on spectrum-management issues, how they see the level of competition in their wireless industry, and whether they have employed market-based mechanisms in managing the spectrum. For Canada and the United Kingdom, we conducted more in-depth case studies of spectrum management by interviewing not only spectrum managers but also government users and commercial service providers. In these two countries—as well as in the United States—we interviewed officials who manage spectrum for air traffic control, national law enforcement, and local emergency service. We also interviewed commercial wireless providers. For many of the countries studied, the information in this report is based on statements provided by spectrum managers during interviews and could not always be verified through documents or other means.

To determine the validity of our preliminary research findings, we assembled an expert panel. To identify potential panelists with recognized

expertise in spectrum-management issues, we solicited recommendations from officials at FCC and reviewed research on spectrum-management issues. From a pool of over 35 potential panelists, we selected 10 panelists who represented a cross-section of spectrum experts, including federal regulators, government and commercial users, band managers, financial analysts, economists, and engineers. The name and organizational affiliation of each panel member is listed in appendix VI. During a day-long meeting at GAO headquarters, the panelists discussed six topics that we provided in advance: (1) spectrum assignment and payment methods, (2) flexibility of use and secondary markets, (3) the scarcity of spectrum, (4) incentives for improving the technical efficiency of spectrum use, (5) the competitiveness of wireless and wireless equipment markets, and (6) ways to balance the needs of commercial and government users. After discussing each topic, we asked the panelists to answer specific questions on an anonymous ballot. The meeting was recorded and transcribed to ensure that we had accurately captured the panel members' statements.

In addition to the information collected through the work efforts described above, we also reviewed technical, legal and regulatory, and economic research on relevant spectrum-management issues.

Appendix II: Stakeholders' Views on Auctions and Spectrum Royalties

This appendix provides information on (1) the positive attributes of auctions identified by stakeholders; (2) concerns about the effect of auctions on consumer prices for wireless services, the rapidity of deployment of new technology, and the ability of small business to participate in the provision of wireless services; and (3) stakeholders' views on the merits of spectrum royalties.

Stakeholders Identified Several Positive Attributes of Auctions

Wireless companies that we spoke with and members of our expert panel generally perceive auctions to be an improvement over comparative hearings and lotteries for the assignment of spectrum. Auctions are generally perceived to be faster and more transparent than comparative hearings. Also, auctions were seen as promoting economic efficiency by assigning spectrum to the party that values it the most. Finally, in contrast with comparative hearings and lotteries, auctions capture part of the value of the spectrum for the government in the form of winning bids. The companies that we spoke with generally characterized auctions as being superior to comparative hearings. Some companies described auctions as quick, efficient, certain, and the best available mechanism. Alternatively, some companies described comparative hearings as slow, arbitrary, and uncertain. Participants in our expert panel also were generally positive about auctions. For example, one participant noted that no one has figured out a better mechanism for the initial assignment of licenses.

Despite Success in Wireless Markets, Concerns Have Been Raised about Certain Possible Effects of Auctions

Despite the growth and competitiveness of wireless markets, some concerns have been expressed about whether the use of auctions as the primary spectrum-assignment method has had a detrimental effect on certain economic factors. In particular, some observers are concerned that the use of auctions will raise consumer prices for wireless services, will slow the deployment of wireless networks, and will make it difficult for smaller businesses to compete for wireless licenses.

The effect of auctions on consumer prices. Some concerns have been raised that the price companies are paying for spectrum under auctions could drive up end-user customer prices. Some economists suggest that one-time license payments—such as those associated with auctions or with participation in comparative hearings—should not influence customer prices, because these fixed costs do not vary with a firm's output. As such, they do not influence a firm's decisions about how to set its prices; such decisions are based on the firms' marginal, or incremental, costs. However, other economists have pointed to reasons why auction payments could influence consumer prices in certain cases. For example,

some or all companies might, because of an increased need to borrow funds to participate in an auction, see their cost of financial capital rise. Moreover, these economists argue that while firms may temporarily set prices based on marginal costs, firms cannot survive in the long run without considering fixed costs, and hence auction payments will be reflected in consumer prices.

Views among those we spoke with on this issue were mixed. Officials at six of the companies we spoke with said that the assignment mechanism does not influence prices. Similarly, three of the panel members reported that the price paid for spectrum had "little/no" influence on customer prices. Additionally, two FCC studies that examined consumer prices for wireless services found that the introduction of auctions for spectrum assignment did not raise consumer prices.[33] On the other side, officials at eight companies we interviewed suggested that the assignment mechanism does influence prices; three of these companies reported that they must set prices high enough to cover their debt and maintain margins. Additionally, four of our expert panelists said that spectrum price had "some" influence, and three said it had a "great" influence on customer prices.

While there is clear disagreement among those we spoke with about the effect of auctions on consumer prices, the competitiveness of the market is generally seen as a very important factor in determining consumer prices. The companies that we spoke with overwhelmingly cited competition as an important factor when setting consumer prices. Competitive factors were more commonly cited as an important influence on price than was the influence of auction payments. Similarly, participants in our expert panel also indicated that competition was an important consideration for companies when determining what prices they would charge consumers.

The effect of auctions on the rate of infrastructure deployment. Some observers argue that payment at auction for spectrum licenses would encourage companies to deploy technologies and services faster, because the companies would have devoted their own resources for the licenses and would need to recoup the investment by using the spectrum in a

[33]See http://wireless.FCC.gov/auctions/data/papersAndStudies/aucspec.pdf, Evan Kwerel and Walt Strack, "Auctioning Spectrum Rights" (February 2001), and Evan Kwerel, "Spectrum Auctions Do Not Raise the Price of Wireless Services: Theory and Evidence" (October 2000), FCC Staff Paper.

productive and innovative manner. Others, however, argue that the auction payments for spectrum licenses could slow the deployment of new technologies and services by diverting financial resources away from direct investments in infrastructure.

Officials at nine of the companies we spoke with said that the assignment mechanism can influence the rate of deployment of new technologies and services, because, for example, high auction prices can affect the firm's access to financial capital. Alternatively, five companies said that the assignment mechanism does not influence the deployment of new technologies or services. Panel members' views on whether the rate of deployment of wireless infrastructure is affected by purchase of licenses in an auction were also mixed. Six panelists generally reported that payments for spectrum had "little/no" or only "some" influence on the deployment of new wireless technology, while four panelists reported that these payments could have a greater influence on the rate of deployment. Finally, the United Kingdom's National Audit Office found that while companies paid unprecedented amounts for 3G spectrum in that country, there was no strong evidence that the level of proceeds from the auction would have a negative impact on the wider economic benefit of 3G.

The companies that we spoke with told us that a number of other issues have an influence on the rate of deployment of wireless infrastructures, in addition to the purchase of spectrum licenses through auctions. These issues include (1) difficulty with citing cell towers because of problems associated with local zoning; (2) FCC mandates for items such as emergency 911 service, which require large financial investments that divert resources away from the deployment of the firm's network;[34] and (3) FCC procedures, such as licensing spectrum that is encumbered (that is, currently used by another licensee), that increase business uncertainty. Finally, the United Kingdom's National Audit Office noted that the remaining difficulties to be overcome for the roll-out of 3G services in that country are mainly technical: for example, the development of suitable base station and hand-set equipment.

The effect of auctions on the ability of small businesses to obtain spectrum licenses. Another concern about the adoption of auctions for the

[34]Two rural companies that we spoke with said that FCC mandates are especially burdensome on small companies, because the costs must be recovered from a smaller customer base.

assignment of spectrum licenses is that smaller companies will not be able to compete for licenses with larger businesses. FCC addressed this concern in a few ways. FCC allowed partitioning of some licenses into relatively small pieces to facilitate small business participation in wireless markets. Additionally, for some auctions, FCC provided special bidding credits, allowed long-term installment payments, or designated certain licenses as available only for acquisition by smaller companies, in order to facilitate their participation and increase their opportunity to acquire spectrum licenses.

Among the companies and experts that we spoke with, several suggested alternatives to the current spectrum-assignment mechanism to facilitate small business participation. These alternatives included small geographic areas, which can be better suited to the business models of small companies, and revenue sharing. Alternatively, while FCC has taken steps to promote small businesses in certain auctions, some observers do not believe this necessarily leads to viable small business participation in wireless markets.[35] Those who take this view argue that certain wireless services have large economies of scale in their provision because of the large costs associated with constructing wireless networks.

Few Stakeholders Favor Royalty System of Spectrum Auctions

In response to concerns about auctions, some stakeholders have suggested royalties as an alternative mechanism for assigning spectrum licenses. With a royalty mechanism, a company would pay the government a percentage of revenue on an ongoing basis, rather than pay the government a one-time fee to obtain a spectrum license. For example, Hong Kong spectrum managers reported that they used a royalty auction for 3G spectrum in which companies bid on a percentage of their revenue to be paid to the government. Spectrum managers in Hong Kong told us that a royalty structure enables the financial risk associated with purchasing spectrum at an auction to be shared between the government and commercial sector.

We found little support for royalties among the companies that we spoke with, the spectrum managers in other countries, or participants on our expert panel. Officials at only four of the domestic companies that we

[35]In the Personal Communications Service C-Block auction, participation was limited to small businesses, and auction winners were permitted to pay off their bids over a 10-year period at a low rate of interest. A number of bidders, including the largest winner, NextWave Personal Communications, have defaulted on their payments.

spoke with thought the royalty method merited consideration. These companies told us that royalties—in lieu of upfront auction payments—could help small businesses enter the wireless market by reducing the financial resources associated with acquiring spectrum licenses in an auction. However, eight companies that we spoke with did not favor royalties. Some of these companies noted that royalties would effectively function as a tax that would raise consumer prices and possibly increase business uncertainty. Participants on our expert panel were uniformly opposed to a royalty mechanism. Finally, officials with most foreign governments that we spoke with told us that their governments had considered and decided against royalties or had not considered royalties at all.

Appendix III: Technological Advancements Could Help to Relieve Spectrum Scarcity

Because spectrum is a finite resource and demand for it is rising, it is increasingly scarce. The radiofrequency bands most usable for new wireless services in land mobile radio, wireless telephony, and ultrawideband applications are the most congested portions of the radio spectrum. But advances in technology hold promise for enabling greater efficiency in the use of this prime spectrum.

The move from analog to digital technologies has already greatly conserved the use of prime spectrum and holds further promise for the future. Digital technologies increase the amount of information that can be transmitted within a given amount of bandwidth. For example, by using certain digital techniques, wireless telephony networks can now handle more calls in a given bandwidth than was possible with analog cellular. These benefits are also spreading to other applications. Similarly, the transition from analog to digital television will eventually release some portion of the broadcast spectrum to be available for other uses. Federal users are also required to adopt narrowbanding techniques by 2008—a move that will economize on the use of spectrum.

Ultrawideband technologies also offer opportunities to conserve on spectrum use, by allowing a given band to be allocated to multiple uses. After a number of years of research and development in the use of wideband transmission for surveillance, obstacle detection, and ground-penetrating radars, and after consultation with NTIA, FCC agreed to allow experimental wideband systems on an unlicensed basis. Because these technologies use low power over wide swaths of spectrum, they are able to share bands currently in use by many federal and nonfederal systems that are using higher power levels and compatible transmission techniques.

In the more distant future, users and experts are looking to the development of software-defined radios to more effectively use spectrum. As many experts have noted, much of the radio spectrum is not actually being used at a given time. Software-defined radio technology, in which a radio receiver searches for unused frequencies at a given time and tunes to an available channel, offers the opportunity to use temporarily unused spectrum by allowing spectrum to be allocated to various uses and assigned to various users dynamically—minute by minute. Software-defined radio technology promises to offer a way for numerous radio systems that are operating in varied frequency bands and different modes (push-to-talk, broadcast, secure, and so forth) to operate on a common platform. Not only will software-defined radio allow spectrum to be assigned on a minute-by-minute basis, but it may also help solve some of

the problems related to the interoperability of various systems, a well-recognized problem in public safety and search-and-rescue applications.

Appendix IV: Suggestions for Issues for Consideration by a Commission

This appendix discusses issues that would need to be considered in setting up a commission if one is established. This is not intended to be an exhaustive list of possible topics for consideration, nor should it be interpreted as recommending any specific course of action for spectrum management.

Commission Structure Considerations

When designing a commission to examine the U.S. spectrum-management process, the following should be considered:

- Appointment authority: Commissions often have both Congress and the President designate members to serve. Several have gone further to achieve political balance, allowing both majority and minority congressional leadership to make appointments.
- Federal Advisory Committee Act: Consideration should be given to whether the commission will be established as a federal advisory committee.
- Eligibility: In order to ensure that all of the diverse stakeholders' opinions are heard, there should be broad representation on the commission. For example, the commission should include representation from the government, commercial, and technical sectors.
- Staff, timeframe, and budget: The size and qualifications of the staff, the budget for the commission, as well as the time frame of the commission's work will need to be considered.
- Commission status: A decision on whether the commission should expire upon the issuance of its report or have a predetermined recurring status should be considered.

Potential Goals and Objectives of Commission

- Promote technically efficient use of spectrum;
- Promote economically efficient use of spectrum;
- Ensure that government missions requiring spectrum are accomplished;
- Promote growth of the private sector;
- Minimize interference among users;
- Maximize the rapidity with which spectrum management can respond to changing needs; and
- Recommend future policy and management structures.

Possible Policies to Consider

- Whether the current policies should be continued;
- Whether mechanisms that create economic incentives to encourage users to use spectrum more efficiently could be developed:
  - If it is appropriate to apply these mechanisms to all users or only to subsets of users, including government users;

- Possible mechanisms to consider include:
  - —Requiring users to pay for spectrum licenses in the marketplace;
  - —Allowing users to sell spectrum in the market place;
  - —Allowing users to lease spectrum from other users;
  - —Charging an incentive-based fee that is designed to mimic a market where one does not exist;
  - —Increasing the flexibility of use embedded in a license;
  - —Providing more spectrum for experimental and unlicensed uses;
  - —Increasing the use of band managers.

- Increasing the information available to policy makers and regulators regarding spectrum use by:
  - Auditing its use on a regular basis;
  - Measuring its value through some form of accounting.
- Making spectrum conservation a high level policy goal throughout the government;
- Funding research on technologies that are spectrally efficient;
- Establishing rules for determining spectrum-use priorities;
- Setting up a formal spectrum-planning process;
- Determining whether there should be a major one-time reallocation of spectrum; and
- Developing rules for reallocating spectrum both within and across regulatory jurisdictions.

Potential Regulatory Structure Options to Explore

- Determining whether the current regulatory structure should be continued;
- Creating a mechanism for better coordination of NTIA, FCC, and IRAC functions by any of the following means:
  - Requiring agencies to develop a single spectrum plan that would be reviewed regularly;
  - Making coordination among spectrum-management agencies a critical objective in the strategic plan of each agency;
  - Establishing other policies and procedures that require ongoing coordination;
- Creating a single agency to manage spectrum; and
- Letting the federal agencies manage their own spectrum.

Lessons Learned

When examining landmark commissions that led to government reforms in the past,[36] we have cited three main lessons learned that those looking to examine the spectrum-management structure should keep in mind:

- Successful commissions have established useful goals for what is to be achieved and have had a narrow focus;
- Reorganization efforts need to recognize the unique federal government purpose/structure (that is, that policies have political, legal, and organizational facets to them); and
- Efforts have to be made for the congressional and executive branches to reach agreement about the need for and type of reform. Furthermore, it is best when the Congress and executive agencies work in cooperation to implement these reforms.

[36]These commissions include the Brownlow Commission (1936–1937), First and Second Hoover Commissions (1947–1949, 1953–1955), Ash Council (1969–1971), Carter Reorganization Project (1977–1979), Grace Commission (1982–1984), and National Performance Review I (1993–1994).

Appendix V: More Details on Spectrum Management in Foreign Countries Studied

Each of the 12 foreign countries we studied was asked a variety of questions relating to its management of the spectrum. We asked each country general questions about its spectrum-management structure and methods for resolving conflicts, about how it assigns spectrum to government and commercial users, and for specific details of other aspects of its spectrum-management system. Some of the information gathered from these countries has been reported in the body of this report and thus is not included in this appendix.

Spectrum Management and Conflict Resolution

Table 4 lists the government entities primarily responsible for the management of the spectrum in each country.

Table 4: National Spectrum Regulators

Country	National spectrum regulators
Australia	Australian Communications Authority (ACA)
Canada	Industry Canada
Finland	Finnish Communications Regulatory Authority (FICORA)
France	National Agency for Frequencies
Hong Kong, China	Office of the Telecommunications Authority (OFTA)
Italy	General Direction for Frequencies Allocation and Management, General Direction for Licensing and Assignment
Japan	Ministry of Public Management, Home Affairs, Posts, and Telecommunications
Mexico	Comision Federal de Telecomunicaciones
New Zealand	Ministry of Economic Development
Spain	General Directorate for Telecommunications
Sweden	Swedish Post and Telecom Agency (PTS)
United Kingdom	Radiocommunications Agency

Source: Spectrum managers interviewed in each country.

We asked spectrum managers how they resolve conflicts that arise regarding spectrum allocations and assignments. Many countries told us that they have one agency that makes all final spectrum decisions. Other countries reported that they have advisory boards or committees that help resolve disputes. Table 5 summarizes responses to this question.

Table 5: Spectrum-Decision Authority and Techniques for Resolving Disagreements Regarding Spectrum Management

Country	Spectrum-decision authority and techniques for resolving disagreements regarding spectrum management
Australia	The Australian Communications Authority regulates the radiofrequency spectrum and reports to the Australian Minister for Communications. Potentially contentious issues are resolved by the ACA or the Minister in consultation with users, or among users within an ACA framework.
Canada	Industry Canada makes all final decisions with the help of the Radio Advisory Board of Canada. The Radio Advisory Board of Canada, which consists of representatives from most spectrum users in Canada, provides the government with broadly based advice regarding spectrum management.
Finland	FICORA, an agency within the same administrative sector as the Ministry of Transportation and Communications, is responsible for managing both military and civil use. FICORA depends on national level advisory boards to function as discussion forums and to provide opportunities for cooperation. One particular board, the Radio Advisory Board, advises the Ministry on spectrum policy and creates working groups to address specific spectrum-management issues.
France	The National Agency for Frequencies makes final decisions regarding all spectrum policy, and the Prime Minister formally approves these proposals. If necessary, arbitration is available for agencies to reach agreement; however, officials told us that arbitration is very rare.
Hong Kong, China	The Office of the Telecommunications Authority manages spectrum for all users with the help of the Radio Spectrum Advisory Committee. The committee—which consists of representatives of public network operators, major radiocommunications users, and independent professionals—provides advice to OFTA regarding spectrum-management strategies, policies, and procedures.
Italy	The two agencies involved in spectrum management have independent responsibilities and make final decisions on spectrum management for issues under their jurisdiction.
Japan	The Radio Regulatory Council acts as an advisory body to the Ministry of Public Management, Home Affairs, Posts, and Telecommunications, which makes all final spectrum-management decisions.
Mexico	Secretariat of Communications and Transportation makes all final decisions.
New Zealand	The Radio Spectrum Management Group, a part of the Ministry of Economic Development, allocates and assigns all spectrum, including spectrum for government users.
Spain	General Directorate for Telecommunications makes all decisions.
Sweden	The Swedish Post and Telecom Agency makes final decisions for all users (except broadcasters). It is possible to appeal PTS decisions in court.
United Kingdom	The Radiocommunications Agency makes spectrum decisions for commercial users, and the spectrum managers in each government agency set policy for their individual functions. However, a single committee—the United Kingdom Spectrum Strategy Committee—exists to prioritize and make final decisions about spectrum needs when any conflicts arise. In particular, this committee—which is a Cabinet Office committee jointly chaired by the Chief Executive of the Radiocommunications Agency and a representative from the Ministry of Defence—addresses strategic spectrum-management issues that affect the interest of more than one government department and those that revolve around balancing spectrum needs of government and commercial users.

Source: Spectrum managers interviewed in each country.

We asked spectrum managers whether spectrum users in their country have been forced to move to different bands and if the government provided funding for relocating users.[37] Countries reported many examples

[37]This question refers to funding provided by spectrum managers in the form of a trust fund or other mechanism, rather than by individual agencies paying their own relocation expenses.

of moving certain users to make room for new services or uses of the spectrum. These cases often involved moving government users out of spectrum to make room for new technologies. Table 6 includes information on government funding for moves, as well as other information about funding arrangements.

Table 6: Funding for Relocation

Country	Provides government funding for relocation	Other funding information
Australia	No	Auction winners can pay for incumbents to be relocated.
Canada	No	New licensees may pay incumbents—both commercial and government users—to relocate.
Finland	No	New spectrum holders have compensated incumbents for their relocation costs. When the relocation has been a result of national implementation of an internationally approved frequency usage plan, compensation has not been paid.
France	Yes	Government users are completely reimbursed for relocation costs. Commercial users can be funded to upgrade technology to accelerate relocation timelines.
Hong Kong, China	No	
Italy	No	Some users have had to compensate the Ministry of Defense for spectrum relocation costs.
Japan	No	A study group recently looked into funding relocation.
Mexico	No	If equipment from the previous user is less than 10 years old, the new user needs to indemnify the previous user for relocation costs.
New Zealand	No	One move was facilitated by the government offering new spectrum rights to the incumbent in exchange for displacement.
Spain	No	In some cases, the new user has paid for the cost of relocation.
Sweden	No	
United Kingdom	No	Officials are exploring funding options for relocations.

Source: Spectrum managers interviewed in each country.

We asked spectrum managers whether they were in the process of completing or had recently completed a review of spectrum management in their country. Some countries were undergoing or had recently conducted comprehensive reviews and others were involved in more focused studies. Table 7 summarizes the responses to our question on spectrum-management reviews.

Table 7: Spectrum-Management Reviews

Country	Spectrum management reviews
Australia	In 2002, the Productivity Commission completed a comprehensive spectrum-management review, which took 12 months.
Canada	The Canadian government is in the process of updating its Spectrum Policy Management Framework. The original framework was developed in 1993 and has been amended somewhat since that time. The current study is expected to extensively revise and create a new framework for spectrum management in the next 2–3 years.
Finland	Managers reported that they are involved in a continuous process to review their spectrum-management policies and working methods. They are currently involved in a comprehensive project to change their fee structure.
France	The National Agency for Frequencies has an ongoing process to review the use of the spectrum and make proposals to improve spectrum management.
Hong Kong, China	OFTA does not see a need to conduct a comprehensive spectrum-management review for the time being.
Italy	There is currently a study on implementing fees being conducted.
Japan	In 2002 a study group examined certain issues, including reallocation and financial help for relocations.
Mexico	Managers reported that in 2003 they plan to review the rules for frequency grants and the status of the spectrum.
New Zealand	In 1987, National Economic Research Associates was hired as a consultant to the Ministry to conduct a review of spectrum management and make recommendations. The Ministry received the report and, after public consultation, used the work to craft the Telecommunications Act of 1989. In the mid-1990s, the Ministry reviewed the impact of the new law and passed an amendment based on its findings.
Spain	None
Sweden	Managers reported that they are not doing or planning to do any large-scale studies at the moment. However, they noted that spectrum-management policies are continually reviewed.
United Kingdom	In March 2002 the United Kingdom released the results of its independent review of spectrum management.

Source: Spectrum managers interviewed in each country.

Appendix VI: Participants in GAO's Expert Panel on Spectrum Issues

Rudy Baca	Vice President & Global Strategist, Precursor Group (a company providing investment research)
Diane Cornell	Vice President, Regulatory Policy, Cellular Telecommunications & Internet Association
Mark Crosby	President, Access Spectrum (a company providing band-management services)
Michele Farquhar	Attorney, Hogan & Hartson (a law firm with expertise in government regulation and policy)
Dale Hatfield	Chair, Department of Interdisciplinary Telecommunications, University of Colorado at Boulder
Glen Nash	President, Association of Public Safety Communications Officials – International
Robert Pepper	Chief, Office of Plans and Policy, Federal Communications Commission
Steven Price	Deputy Assistant Secretary of Defense for Spectrum and C3 Policy, Office of the Secretary of Defense
David Salant	Senior Vice President, National Economic Research Associates
Fred Wentland	Associate Administrator (Acting), Office of Spectrum Management, National Telecommunications and Information Administration, Department of Commerce

Appendix VII: Comments from the Department of Commerce

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

JAN 10 2003

Mr. Peter Guerrero
Director, Physical Infrastructure Issues
United States General Accounting Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Guerrero:

Thank you for providing the Department with a copy of the General Accounting Office's draft report entitled "Comprehensive Review of U.S. Spectrum Management With Broad Stakeholder Involvement is Needed." The report makes one recommendation that pertains to the National Telecommunications and Information Administration (NTIA), an agency within the Department of Commerce: *the Chairman of the FCC and the Assistant Secretary for Communications and Information (NTIA), in consultation with officials from relevant agencies and pertinent congressional committees, work together to develop and implement a plan for the establishment of an independent Commission with representation from all relevant stakeholders that would conduct a comprehensive examination of current U.S. spectrum management.*

As you know, spectrum management is a complicated process with multiple stakeholders with different views on very technical issues. This Administration is committed to exploring new ideas to develop and implement spectrum policy and management approaches that will make more efficient use of the spectrum, provide spectrum for new technologies, and improve the effectiveness of domestic and international spectrum management processes. The guide post for spectrum policy in the Administration is to meet the needs of both economic and national security.

The NTIA and the Federal Communications Commission (FCC) have met the challenge of this directive by making spectrum available for new ultrawideband technology and for expanded advanced wireless communications. Yet, at the same time, the agencies have ensured protection for key federal government radiocommunications. Nancy J. Victory, Assistant Secretary for Communications and Information, has met periodically with FCC Chairman Michael Powell to address spectrum issues and means for improving spectrum management processes. The most recent of these meetings occurred on December 10, 2002, and their staffs are also meeting together to further these discussions.

The President's Fiscal Year 2003 Budget includes an initiative designed to make the spectrum management process more responsive, effective, and efficient so that new technologies can be implemented more promptly, critical public safety radio communication needs can be satisfied,

economic growth can be increased, and unnecessary regulation can be eliminated. Consistent with your previous recommendations, the Department is committed to find additional mechanisms and policies to further these objectives.

As NTIA continues to explore new ideas for the effective management of radio frequency spectrum, the Department will take your recommendation with respect to the establishment of an independent commission under advisement. Thank you again for this opportunity to review the draft report.

Sincerely,

Donald L. Evans

Appendix VIII: Comments from the Federal Communications Commission

CHAIRMAN

Federal Communications Commission

Washington, D.C.

January 8, 2003

Mr. Peter Guerrero
Director, Physical Infrastructure Issues
United States General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Guerrero:

Thank you for sharing the General Accounting Office's ("GAO's") draft report, entitled "Comprehensive Review of U.S. Spectrum Management With Broad Stakeholder Involvement Is Needed." GAO's draft report recommends that the Federal Communications Commission ("FCC") and the Department of Commerce's National Telecommunications and Information Administration ("NTIA"), in consultation with other government entities, work together regarding a plan for the establishment of an independent commission that would conduct a comprehensive review of U.S. spectrum management. We value GAO's analysis as a way to build upon our existing work and cooperative efforts already underway with NTIA.

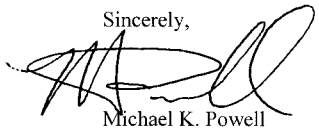
As GAO recognizes in its draft report, the ever-increasing demand for access to spectrum and continuing advances in wireless technology and applications pose significant challenges for policymakers involved in spectrum management issues. Recognizing the need for a fundamental re-evaluation of spectrum policy in a fast-moving world, I established a Spectrum Policy Task Force ("SPTF") staffed by senior agency personnel to identify outmoded procedures and policies, and evaluate changes in spectrum policy that could increase the public benefits derived from the use of the radio spectrum. The SPTF's work resulted in a report published in November that presents many important new recommendations for spectrum policy reform. We are seeking comment on the report's recommendations, and look forward to building on the work of the task force in the coming months.

NTIA Assistant Secretary Nancy J. Victory and I share a belief in the importance of effective coordination between our two agencies to ensure a common focus in our governmental efforts to manage a critical national asset, our radio spectrum. Most recently, Assistant Secretary Victory and I met on December 10th, along with senior spectrum policy teams from both organizations, to institutionalize and elevate the coordination between the two agencies beyond historical levels. The next formal spectrum leadership meeting will occur in the early summer of 2003, and coordination at the staff level of our agencies has occurred and will continue to occur regularly. For example, the Commission routinely coordinates its policy decisions with other

governmental agencies that have a stake in spectrum management through NTIA's Interdepartment Radio Advisory Committee. The Commission and NTIA staffs are also working together to produce a new Memorandum of Understanding to ensure that our coordination processes continue to work smoothly.

I commend you and your staff for your hard work in helping to develop ideas for improving U.S. spectrum management policies in a manner that ensures that the radio resource will be effectively and efficiently employed for the benefit of the American people. We support any effort to continue to improve our policies in this area, and will work with our colleagues at NTIA to assess how best to incorporate the report's findings and recommendations in our future work.

Sincerely,



Michael K. Powell
Chairman

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