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Spectrum Management: Auctions

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Summary

Spectrum policy issues before Congress are characterized by economic, technological and regulatory complexity. Of particular interest to policy makers are the allocation of spectrum for specific types of use (such as TV broadcasting, radio, advanced wireless services, or unlicensed) and the assignment of licenses for exclusive or shared use of specific frequencies. Today, most frequencies allocated for commercial uses are assigned through auctions, with licenses going to the highest bidder. Many wireless companies and most broadcasters hold licenses received at little cost before the introduction of auctions. Another important allocation of spectrum is for unlicensed use. Both commercial and non-commercial entities use unlicensed spectrum to meet a wide variety of monitoring and communications needs. Suppliers of wireless devices must meet requirements for certification to operate on frequency bands designated for unlicensed use. Examples of unlicensed use include baby monitors, garage door openers, and wi-fi communications.

Proceeds from spectrum sales are presently attributed to general revenue in the U.S. Budget. In the 108th Congress, however, a precedent was established with the creation of a Spectrum Relocation Fund. This fund will hold proceeds from specified sales of spectrum currently allocated to federal use; federal agencies vacating spectrum to be auctioned for commercial use will be compensated from the fund for costs of relocation. In the 109th Congress, the Deficit Reduction Act (P.L. 109-171) includes provisions that will hold part of certain auction proceeds (700 MHz band) in a Digital Television Transition and Public Safety Fund. The fund mainly would assist the transition from analog televison broadcasting to digital broadcasting, and would contribute to programs for public safety. Over $7 billion would go toward deficit reduction. Auctions would be required to begin not later than January 28, 2008. A bill to fund public safety communications through auction revenues was previously introduced by Congressman Bart Stupak (H.R. 1323).

Among proposed bills that would influence spectrum management are H.R.1661 (Representative Rush) and S. 1767 (Senator Snowe). H.R. 1661 would create a new category of loan within the Small Business Administration to help qualifying companies bid in spectrum auctions or buy spectrum in the secondary market. S. 1767 would require the Federal Communications Commission to reconfigure the 700 MHz band plan (allocation of frequencies to be auctioned) to include spectrum to be licensed for small geographic areas, with special consideration for the needs of regional and smaller wireless carriers. S. 2327 (Senator Allen) and S. 2332 (Senator Stevens) with its companion bill (H.R. 5085, Representative Inslee) would allocate new frequencies for unlicensed use, notably wireless broadband.

This report will be updated.

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Spectrum policy covers both satellite and terrestrial (primarily antenna broadcast) transmissions. The issues discussed here refer principally to spectrum management for terrestrial technologies. International satellite frequencies are not allocated by the auction process.

Radio frequency spectrum is used for all forms of wireless communications, including cellular telephony, paging, personal communications service, radio and television broadcast, telephone radio relay, aeronautical and maritime radio navigation, and satellite command and control. Wireless (radio frequency) spectrum is measured in cycles per second, or hertz (Hz).[1] Spectrum allocations are assigned within bands that are divided into bandwidths or channels with assigned frequencies.

Spectrum is a natural resource[2] with a combination of characteristics that differentiate it from other resources. For example, spectrum is:

- **Finite**. Today's technology can only operate on certain frequencies; commercially viable frequencies are a scarce commodity.
- **Renewable**. Airwaves used to broadcast any transmission can be reused after the broadcast is completed.
- **Technology dependent**. Most natural resources can be harvested manually, albeit inefficiently. Spectrum is in the atmosphere and is usable because technology has been developed to exploit the properties of electromagnetic waves for sound, data and video transmission.
- **A national asset with international rules and regulations**. For example, most domestic uses of spectrum are assigned bands of operation through the International Telecommunications Union, an agency of the United Nations; satellites for broadcasting are governed by international treaty.
- **Administered**. To avoid interference from competing broadcast transmissions, frequency assignments are managed by recognized authorities.

The development and implementation of better wireless communications technologies are critical to maximizing the efficiency of spectrum resources.

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[1] Standard abbreviations for measuring frequencies include kHz — kilohertz or thousands of hertz; MHz — megahertz, or millions of hertz; and GHz — gigahertz, or billions of hertz.

[2] The Code of Federal Regulations defines natural resources as "land, fish, wildlife, biota, air, water, ground water, drinking water supplies and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States..." (15 CFR 990, Section 990.30).

Spectrum management policies ideally should take into account the impact of new technology, or — since it is difficult to predict the development paths of new technologies — allow for flexibility and accommodation in spectrum allocation. Although flexibility may be desirable in policy-making, most existing wireless technologies are inflexibly constructed to work on a limited range of specific frequencies. Relocation from one part of the spectrum to another can require costly equipment changes. Therefore, reallocation of spectrum to new uses is often expensive as well as technically and administratively difficult. Additionally, some uses of spectrum are governed by international regulations.

Spectrum policy to manage frequency allocation and license assignments has evolved over the years in response to changes in technology and market demand, among other factors. Auctions are a market-driven solution to assigning licenses to use specific frequencies and are a recent innovation in spectrum management and policy. The auction process assigns a monetary value to spectrum through competitive bidding. The Federal Communications Commission (FCC) manages all non-federal spectrum, including that used by state and local governments. Among other responsibilities, the FCC supervises spectrum auctions. The National Telecommunications and Information Administration (NTIA) manages all spectrum used by the federal government, including the Department of Defense (DOD). The NTIA — part of the Department of Commerce — also serves as the principal adviser to the executive branch on domestic and international telecommunications issues. The NTIA and the FCC work together to coordinate spectrum policy.

Some have suggested that the commercial policies followed by the FCC to conduct auctions are not compatible with the management of spectrum for non-commercial use. It has been proposed that the NTIA take over the management of frequencies used by public safety agencies, critical infrastructure industries, and other non-federal entities where the use of wireless communications is essential to protecting life and property. This action, it is argued, would enable the NTIA to work more closely with the Department of Defense, federal departments such as Homeland Security, and local and state agencies to develop band plans for emergency communications. Although this does not change the role of congressional jurisdiction, such a move could streamline the coordination of public policy for interoperable communications and other goals Congress has set for improving emergency preparedness and response.

Many economic models for providing the "highest and best use" for spectrum exist and have been tried, both in the United States and worldwide. Spectrum for what is widely described as "prime" frequencies (300 MHz - 3000 MHz) is judged by many to be the most commercially desirable and is widely sought after at auction by competing interests.[3] Several lucrative auctions have added billions to the federal treasury, applied to general revenue.

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[3] Federal Communications Commission, Office of Plans and Policy, OPP Working Paper Series No. 38, "A Proposal for a Rapid Transition to Market Allocation of Spectrum," November 2002 [http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228552A1.pdf]. Viewed January 19, 2006.

Spectrum Auctions

Because two or more signal transmissions over the same frequency in the same location at the same time could cause interference (a distortion of the signals), the FCC, over many years, has developed and refined a system of exclusive licenses for users of specific frequencies.[4] In the recent past, the FCC has granted licenses using a process known as "comparative hearings" and used lotteries. After years of debate over the idea of using competitive bidding (i.e., auctions) to assign spectrum licenses, the Omnibus Budget Reconciliation Act of 1993 (47 U.S.C. 927) added Section 309(j) to the Communications Act, authorizing the FCC to use auctions to award spectrum licenses for certain wireless communications services. Additional provisions concerning auctions were included in the Balanced Budget Act of 1997, the Auction Reform Act of 2002, the Commercial Spectrum Enhancement Act, and the Deficit Reduction Act of 2005 — all discussed below. The main category of services for which licenses may be auctioned are called Commercial Mobile Radio Services (CMRS), which include Advanced Wireless Services (AWS), Personal Communications Service (PCS), cellular, and most Specialized Mobile Radio (SMR) and Mobile Satellite Services (MSS). With some exceptions, CMRS providers are regulated as common carriers to ensure regulatory parity among similar services that will compete against one another for subscribers. The FCC has the authority to conduct auctions only when applications are mutually exclusive (i.e., two licensees in the same frequency band would be unable to operate without causing interference with each other), and when services are primarily subscription-based. The FCC does not have authority to reclaim licenses awarded prior to the decision to permit auctions. In accordance with the Budget Enforcement Act of 1990, and provisions in the Communications Act of 1934, as amended, auction proceeds cannot be used for funding other programs.[5] Creation of two important trust funds — the Spectrum Relocation Fund and the Digital Television and Public safety Fund — required new language and amendments to existing law.

Auction Rules. The Communications Act of 1934, as amended, directs the FCC to develop a competitive bidding methodology.[6] The FCC initially developed rules for each auction separately (with some common elements), but after several years of trial and error it has developed a set of general auction rules and procedures. While there may be special requirements for specific auctions, the following rules generally apply. As a screening mechanism, all auctions require bidders to submit applications and up-front payments prior to the auction. Most auctions are conducted in simultaneous multiple-round bidding in which the FCC accepts bids on a large set of related licenses simultaneously, using electronic communications. Bidders can bid in consecutive rounds on any license offered until all bidding has stopped on all licenses. Even though licenses must be renewed periodically, it is generally

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[4] Technically, two signals will interfere with each other even if they are not at the same exact frequency, but are close in frequency. To avoid harmful interference, the frequencies must have frequencies that are sufficiently different, known as a "minimum separation."

[5] 47 U.S.C. 309 (j) (8).

[6] Communications Act of 1934, 47 U.S.C. 309 (j) (3).

understood that license winners will be able to keep the license perpetually, as long as they comply with FCC rules.[7]

For some auctions, the FCC gives bidding credits to smaller companies, called entrepreneurs, defined as having annual gross revenues of less than $125 million and total assets of less than $500 million. In the first year or so of auctions, the FCC originally also gave special provisions to women-owned, minority-owned, and rural telephone companies (called designated entities). After a 1995 Supreme Court decision determined that government affirmative action policies must pass a "strict scrutiny" test to demonstrate past discrimination, the FCC removed minority-owned and women-owned groups from its list of businesses qualifying for bidding credits as designated entities.[8] Many industry observers have expressed concern that some of the small businesses participating in auctions actually represent larger companies.[9]

Service Rules. The FCC also develops service rules for each new service for which a license will be used. Licenses are granted according to the amount of spectrum and the geographic area of coverage. The FCC's plan for the amount of spectrum per license, the number of licenses, and the conditions for use of the designated spectrum, known as the "band plan," is developed for each new wireless service. Licenses can cover small areas, large regions, or the entire nation. Terms used for coverage areas include basic trading areas (BTAs) which correspond roughly to metropolitan areas; major trading areas (MTAs), which are combinations of BTAs dividing the United States into 51 geographic regions of similar levels of commercial activity; and regions, which are combinations of MTAs. Metropolitan statistical areas (MSAs), rural service areas (RSAs), economic areas (EAs), and major economic areas (MEAs) — defined by the Department of Commerce for economic forecasts — are also used by the FCC to describe areas of coverage for some spectrum auctions.

The FCC has also modified some wireless service rules to help new spectrum licensees maximize the value from their licenses. Changes include allowing licensees to partition licenses for greater efficiency, sharing regions among licensees, and expediting the relocation of incumbent microwave licensees from spectrum purchased in the PCS auctions.

NextWave. The auction of one of the blocks of spectrum allocated for PCS, known as the C-block, presented legal problems for the FCC. In the original C-block auction, also called the entrepreneur's auction, the FCC gave bidding credits to small businesses to help them compete with larger entities in the auction. Winning bidders only had to pay 10% down and the remainder could be paid over ten years at below-market interest rates. At auction in 1996, broadband C- block licenses were sold for

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[7] The FCC provides information on auctions at [http://wireless.fcc.gov/auctions/]. Viewed January 23, 2006.

[8] Adarand Constructors Inc., petitioner v. Federico Pena, Secretary of Transportation, et al. Docket No. 93-1841, decided June 1995.

[9] *Communications Daily*, "FCC Pushing Hard to Make June AWS Auction Goal," January 23, 2006 and "FCC Scrutinizing Carrier-DE Ties in Advance of Rulemaking, January 23, 2006.

bids totaling $10.2 billion. By mid-1997, however, many of the license winners (most notably NextWave Telecom Inc.) had defaulted. In September 1997, the FCC offered a set of options for C-block licensees to restructure their debt (that offer was modified in March 1998). Some licensees opted to maintain their bankrupt status, however, preventing the C-block spectrum from being re-auctioned. Based on its interpretation of a series of decisions in 1999 and 2000 by a U.S. Court of Appeals, the FCC cancelled the licenses that had not been paid for and re-auctioned that spectrum. The auction (Auction 35) for the defaulted licenses was completed January 26, 2001, and booked $16.86 billion in projected revenue for the general treasury.[10]

On June 22, 2001, the United States Court of Appeals for the District of Columbia found that the FCC did not have the legal right to take back NextWave's licenses and that 216 of the licenses (worth $15.85 billion) still belonged to NextWave rather than to the winners of the later auction, such as Verizon Wireless.[11] The U.S. Supreme Court agreed to hear the case, essentially weighing NextWave's right to protection under bankruptcy laws against the FCC's right to allocate spectrum. On January 27, 2003, the Supreme Court ruled in favor of NextWave, agreeing with the earlier Court of Appeals decision that the FCC did not have the authority to recover the licenses.[12] Subsequently, NextWave agreed to return some of the disputed spectrum to the FCC for re-auction in January 2005.[13]

Spectrum Value

Spectrum value depends on many factors, such as the amount of spectrum, its frequencies (since signal transmission characteristics vary along different parts of the spectrum), the geographic area covered, the services permitted by FCC rules, the availability of equipment that can operate at those frequencies, the demand for services that do not interfere with other bands, the amount of alternative spectrum already available for similar services, the number of incumbents presently occupying the spectrum, and whether incumbents will remain in that spectrum or be relocated to other spectrum. Spectrum value may be greater if adjacent bands can be aggregated to form larger blocks and if the given spectrum is not encumbered by other licensees using the same frequencies.

The Congressional Budget Office (CBO) annually scores the anticipated receipts from planned spectrum auctions, and includes the revenue estimate in its annual report, *The Budget and Economic Outlook*. The estimate provided in the January 2006 report does not include estimates for the auction of spectrum at 700 MHz,

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[10] Summarized in *Associated Press Online*, "Feds Ordered to Return Wireless Licenses," January 28, 2003.

[11] 254 Federal Report, 3d Series, p. 130.

[12] U.S. Supreme Court, Docket No. 01-653 at [http://www.supremecourtus.gov/docket/01-653.htm]. Viewed January 19, 2006.

[13] See FCC Report No. AUC-03-58 (Auction No. 58), "Broadband PCS Spectrum Auction Scheduled for January 12, 2005," available at [http://wireless.fcc.gov/auctions/]. The results of Auction 58 are also at this site.

released by the Deficit Reduction Act. Taking this planned auction into account, CBO projects auction receipts of $25 billion in the period 2006-2010.[14]

To date, the FCC has garnered over $14 billion from completed auctions, most of which has been deposited in the U.S. Treasury as general revenue to the federal government. (The FCC keeps a small portion of auction proceeds to cover the expenses of the auctions.) This total does not include approximately $10 billion for contested licenses in the C and F Blocks awarded to NextWave and others in 1996 — some of which may be recovered. NextWave, which owes $4.6 billion for licenses, has agreed to repay its creditors in full, including the FCC, as part of the reorganization plan that will allow it to emerge from bankruptcy.[15] It has concluded sales of some of the contested licenses to Verizon Wireless ($3.93 billion) and Cingular Wireless ($1.4 billion).[16] The spectrum that NextWave returned to the FCC for re-auction grossed $2.2 billion before bidding credits of approximately $2 million.[17]

Unlicensed Spectrum

Unlicensed spectrum is not sold to the highest bidder and used for the services chosen by the license-holder but is instead accessible to anyone using wireless equipment certified by the FCC for those frequencies. Among the advantages of unlicensed spectrum is the opportunity to test new technology directly with consumers instead of going through spectrum license-holders. One of the disadvantages of unlicensed spectrum is the possibility of interference among the transmissions of the various users, both within the assigned bandwidth and with other bandwidths.

Some advocates for unlicensed spectrum would like to see spectrum set aside in the 700 MHz band, where channels will be released by television broadcasters as they move from analog to digital transmission. An alternative proposal for providing unlicensed spectrum as part of the DTV transition is to designate so-called "white spaces" among the new digital TV channels. To avoid interference among TV station broadcasts, channels are assigned in one market area and left vacant in adjoining areas. For example, channel 7 is used in the New York City area and in the Washington, DC area, but not in Baltimore. In Baltimore, spectrum designated for channel 7 is vacant and could be used for unlicensed purposes. Beginning in May

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[14] *The Budget and Economic Outlook: Fiscal Years 2007-2016*, Table 3-5, January 2006, does not take into account passage of the Deficit Reduction Act, which will add another $10 billion to $15 billion. Revised estimates for the period 2006-2010 are in Congressional Budget Office Cost Estimate, S. 1932, Deficit Reduction Act of 2005, January 27, 2006, page 22, at [http://www.cbo.gov/showdoc.cfm?index=7028&sequence=0].

[15] "FCC Approves NextWave License Sale," by Shannon D. Murray, *Daily Deal/The Deal*, March 7, 2005.

[16] NextWave Bankruptcy Plan Approved," by Jason Ankeny, *Telephony Online*, March 2, 2005.

[17] FCC News, February 16, 2005, "Broadband PCS Spectrum Auction Closes, Raising Over $2 Billion," Headlines at [http://www.fcc.gov].

2004, the FCC requested comment on proposals for considering the use of spectrum in television broadcast bands (Docket No. 04-186) but has yet to reach a decision. Representatives of the televison broadcast industry have filed comments containing engineering studies that suggest harmful interference would occur; other studies suggest no significant interference would occur.

Technology

Several technological advances could affect the outcome and prospects for spectrum auctions and how the spectrum is managed. The usable spectrum for communications purposes is currently considered to be below 300 GHz. Higher frequencies present limitations such as a greater absorption of signals by the atmosphere and difficulties in high frequency reception. As the technology for radio transmission and reception improves, higher frequencies will likely become available for use. Technology improvements may, in turn, spur increased consumer demand for spectrum.

Some of the problems with high-frequency signal transmission and signal interference at all frequencies are being solved by engineering techniques which could make better use of the spectrum, thus reducing some of the need for more spectrum. Technologies include methods of digital signal compression, which increases the carrying capacity of currently used bands; error detection and correction, which maintain the signal integrity even in high levels of noise; and other digital techniques such as frequency hopping, in which the transmitted signal avoids frequencies that are already being used.

Advances in software defined radio (SDR) and cognitive radio, in particular, may in time change the nature of spectrum allocation policies. Software defined networks (radios, base stations, antennae) move wireless communications away from hard-wired equipment, where functionality is built into the components at the factory, by allowing changes in parameters to be downloaded remotely. Parameters that can be changed include standards and frequency assignments. Cognitive radio has the potential to eliminate entirely the need for frequency assignments. Simply put, cognitive radio is able to seek out and use any available frequency through miniaturized software programs contained within radio equipment. Advanced versions of software-defined radio (SDR) being tested today are the building blocks for commercial applications of cognitive radio.

The Department of Defense (DOD), its agencies, and military departments have been leaders in research and development for software-programmable radios and base centers. A key program is the Joint Tactical Radio System (JTRS), designed to help the military migrate from its current wireless technology to SDR.[18] DOD is promoting the use of JTRS and its software communications architecture for homeland security, public safety, and commercial applications.[19]

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[18] See [http://jtrs.army.mil/]. Viewed January 9, 2006.

[19] Overview at [http://jtrs.army.mil/sections/overview/fset_overview.html]. Viewed February 9, 2006.

Recent Congressional Actions Regarding Spectrum Auctions

Congress uses its oversight authority of the FCC to correct the agency's course or to steer it in new directions. Notable laws that deal with spectrum policy and auctions are the Balanced Budget Act of 1997, the Auction Reform Act of 2002 and the Commercial Spectrum Enhancement Act of 2004. The Balanced Budget Act also directs FCC actions concerning the transition to digital televison, an event with significant impact on spectrum management.

The Balanced Budget Act of 1997. The Balanced Budget Act of 1997 (47 U.S.C. 153) contained several spectrum management provisions. It amended Section 309(j) of the Communications Act to expand and broaden the FCC's auction authority and to modify other aspects of spectrum management. Whereas previous statutes gave the FCC the authority to conduct auctions, the Balanced Budget Act required the FCC to use auctions to award ownership in mutually exclusive applications for most types of spectrum licenses. It directed the FCC to experiment with combinatorial bidding (i.e., allowing bidders to place single bids on groups of licenses simultaneously), and to establish minimum opening bids and reasonable reserve prices in future auctions unless the FCC determined that it was not in the public interest. This amendment also gave the FCC auction authority until September 30, 2007. (Extended to September 30, 2011 by Deficit Reduction Act.[20]) Furthermore, the act directed the FCC to allocate spectrum for "flexible use," which means defining new services broadly so that services can change as telecommunications technology evolves.

> Exempted from auctions are licenses or construction permits for
> (A) public safety radio services, including private internal radio services used by state and local governments and non-government entities and including emergency road services provided by not-for-profit organizations, that —
> (I) are used to protect the safety of life, health , or property; and
> (ii) are not made commercially available to the public;
> (B) digital television service given to existing terrestrial broadcast licensees to replace their analog television service licenses; or
> (C) noncommercial educational broadcast stations and public broadcast stations.

Examples of services exempted from auctions include utilities, railroads, metropolitan transit systems, pipelines, private ambulances, volunteer fire departments, and not-for-profit emergency road services.

The act directed the FCC to auction 120 MHz of spectrum, most of which had already been transferred by NTIA from federal to non-federal assignment and to allocate another 55 MHz located below 3 GHz for auction not later than September 2002.[21] These deadlines were subsequently eliminated by the Auction Reform Act.

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[20] P.L. 109-171, Title III, Section 3003 (b).

[21] Demand for this spectrum is discussed in CRS Report RS20993, *Wireless Technology and Spectrum Demand: Advanced Wireless Services*, by Linda K. Moore.

Auctions of Spectrum Used for Television Broadcasting. The Balanced Budget Act of 1997 required the FCC to conduct auctions for 78 MHz of the analog television spectrum planned to be reclaimed from television broadcasters at the completion of the transition to digital television and to allocate 24 MHz for public safety services. For administrative purpose, the FCC divided the spectrum into "Upper 700 MHz" and "Lower 700 MHz"bands. Congress instructed the FCC to hold auctions for the 700 MHz frequencies not later than 2002. The spectrum was to have been auctioned in 2002 but not reclaimed from broadcasters until at least 2006. The act directed the FCC to grant extensions to stations — allowing them to keep the spectrum — in television markets where any one of the following three conditions exist: (1) if one or more of the television stations affiliated with the four national networks are not broadcasting a digital television signal, (2) if digital-to-analog converter technology is not generally available in the market of the licensee, or (3) if at least 15% of the television households in the market served by the station do not subscribe to a digital "multi-channel video programming distributor" (e.g., cable or satellite services) and do not have a digital television set or converter. Until these conditions are met, broadcasters are not required to surrender the spectrum.[22]

Auction Reform Act of 2002. Concerns about spectrum management, including spectrum used for public safety, prompted the introduction of the Auction Reform Act of 2002 (P.L. 107-195). Among the purposes of the act is the elimination of deadlines for auctions of Upper and Lower 700 MHz frequencies originally scheduled by the FCC for 2002. Specifically, the law stopped auctions in the Upper 700 MHz band that might have impacted efforts to increase the amount of spectrum available for public safety use, while requiring that some auctions in the Lower 700 MHz band take place. The broad language of the law gives the FCC discretion in setting auction dates for all auctionable spectrum by eliminating deadlines established by the Balanced Budget Act of 1997.

Commercial Spectrum Enhancement Act. This act created the Spectrum Relocation Fund to provide a mechanism whereby federal agencies can recover the costs of moving from one spectrum band to another. The interest in relocating federal users — and accelerating the process by assuring reimbursement for the costs of moving — centers on valuable spectrum (relative to auction prices for comparable spectrum in the United States and other countries) now used by federal agencies, especially the Department of Defense. In particular, spectrum in bands within the 1710-1850 MHz range is sought by wireless telecommunications companies to facilitate the implementation of next-generation wireless technologies, including high-speed mobile services (3G).[23] After much study, the NTIA and the FCC, aided by an Intra-Government 3G Planning Group, announced plans to provide for the transfer of spectrum in the 1710-1755 MHz range from federal agencies. Frequencies in this band would be made available to the private sector through spectrum auctions conducted by the FCC. As part of the effort, the need was identified for new legislation that would permit affected federal agencies to recover

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[22] See CRS Report RS22217, *The Digital TV Transition: A Brief Overview*, by Lennard G. Kruger and Linda K. Moore.

[23] Discussed in CRS Report RS20993, *Wireless Technology and Spectrum Demand: Advanced Wireless Services*, by Linda K. Moore.

costs directly from these auction proceeds. In mid-2002, the Department of Commerce proposed the creation of a Spectrum Relocation Fund. This fund could provide a means to make it possible for federal agencies to recover relocation costs directly from auction proceeds when they are required to vacate spectrum slated for commercial auction. In effect, successful commercial bidders would be covering the costs of relocation. To accomplish the NTIA and FCC goals, the Communications Act of 1934 would need to be modified to permit the agencies direct access to auction funds. This was accomplished with the passage of the Commercial Spectrum Enhancement Act, Title II of P.L. 108-494. Following the requirements of the act, the FCC has announced that it wants to schedule these auctions beginning as early as June 2006.[24]

Budget Reconciliation. The Deficit Reduction Act of 2005 (P.L. 109-171) covers aspects of spectrum auctions for 700 MHz. Among its provisions are:

- Set a definite date of February 17, 2009 for the release of spectrum at 700 MHz currently held by broadcasters.
- Require auctions by the Federal Communications Commission (FCC) of the freed spectrum to begin not later than January 28, 2008 with funds deposited not later than June 30, 2008.
- Extend the FCC's authority to hold auctions, which currently expires in 2007, until September 30, 2011.
- Create a fund, the Digital Television Transition and Public Safety Fund, to receive spectrum auction proceeds and disburse designated sums to the Treasury and for other purposes. The fund and disbursements are to be administered by the National Telecommunications and Information Administration (NTIA).

Effective October 1, 2006, the NTIA will be able to borrow some of the authorized funds from the Treasury, secured by the expected proceeds of the auction required by the bill. These funds can be used to implement transition programs for digital television and for some public safety projects.

Spectrum Management and the 109th Congress

Several laws and policy initiatives taken in recent years could have an effect on proposals for legislation in Congress. For example, both Congress and the Administration have asked for studies that evaluate the role of spectrum management in national policy and the ways in which it is put to use.

Intelligence Reform and Terrorism Prevention Act. Several passages of the act (P.L. 108-458) deal with spectrum policy. For example, Title VII, Subtitle E — Public Safety Spectrum recognizes the merits of arguments for increasing the

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[24] See CRS Report RS21508, *Spectrum Management and Special Funds*, by Linda K. Moore.

amount of spectrum at 700 MHz available for public safety and homeland security. It requires the FCC, in consultation with the Secretary of Homeland Security and the NTIA, to conduct a study on the spectrum needs for public safety, including the possibility of increasing the amount of spectrum at 700 MHz.[25] The study was submitted to Congress in late 2005. In a study requested by Congress.[26] To prepare it, the FCC sought comment on whether additional spectrum should be made available for public safety, possibly from the 700 MHz band. Comments received from the public safety community overwhelmingly supported the need for additional spectrum, although other bands besides 700 MHz were also mentioned. The FCC did not make a specific recommendation for additional spectrum allocations in the short-term although it stated that it agreed that public safety "could make use of such an allocation in the long-term to provide broadband services."[27] It qualified this statement by observing that spectrum is only one factor in assuring access to mobile broadband services for emergency response.

Administration Plans for Spectrum Policy. On November 30, 2004, President George W. Bush issued a memorandum to the heads of Executive Departments and agencies regarding steps to be taken to improve the management of spectrum assigned for federal use.[28] Most of these steps are to implement recommendations made by the Federal Government Spectrum Task Force in its report to the President in June 2004.[29] The memorandum states,

> The existing legal and policy framework for spectrum management has not kept pace with the dramatic changes in technology and spectrum use. Under the existing framework, the Federal Government generally reviews every change in spectrum use. This process is often slow and inflexible and can discourage the introduction of new technologies. Some spectrum users, including Government agencies, have argued that the existing spectrum process is insufficiently responsive to the need to protect current critical uses.

To address this, a multi-step planning process will pull together analyses of spectrum needs. Notably the Secretary of Homeland Security will lead the preparation of a Spectrum Needs Plan, "to address issues related to communication spectrum used by the public safety community, as well as the continuity of Government operations." Concurrently, the Secretary of Commerce will be developing a Federal Strategic Spectrum Plan. These two plans will form the backbone of a National Strategic Spectrum Plan.

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[25] P.L. 108-458, Title VII, Subtitle E, Sec. 7502 (a).

[26] P.L. 108-458, Title VII, Subtitle E, Sec. 7502 (a).

[27] *op. cit.* FCC, *Report to Congress* paragraph 99.

[28] "Presidential Determination: Memorandum for the Heads of Executive Departments and Agencies," November 30, 2004, Office of the Press Secretary, News & Policies, at [http://www.whitehouse.gov/news/releases/2004/11/20041130-8.html]. Viewed January 19, 2006.

[29] *Spectrum Policy for the 21st Century: The President's Spectrum Policy Initiative*.

License Fees and Spectrum Prices. The President's budget for FY2007 proposed that the FCC be given the authority to levy user fees on unauctioned licensed spectrum.[30] The purpose would be promote more efficient use of spectrum; the proposal estimates that $3.6 billion would be collected over 10 years beginning in 2007. Similar provisions were included in budget proposals for 2004, 2005, 2nd 2006. Congress, in the Commercial Spectrum Enhancement Act, required the Comptroller General of the Government Accountability Office (GAO) to examine "national commercial spectrum policy as implemented by the Federal Communications Commission" and to report to Congress on its finding.[31] The study[32] concluded that auctions were generally perceived as a desirable way to allocate spectrum and recommended the extension of the FCC's auction authority past the current expiration date of September 30, 2007. The GAO could not find evidence that market participants that had bought spectrum were at a disadvantage in competing with service providers who had been assigned spectrum. It found that the high cost of developing infrastructure was a barrier to market entry and that this cost was more significant in shaping competition and pricing decisions than the cost of spectrum. Many findings were inconclusive and the GAO recalled that in an earlier study it had recommended the creation of an independent commission to examine spectrum management.[33]

Other Trust Fund Proposals. Representative Stupak has introduced the Public Safety Interoperability Implementation Act (H.R. 1323), a bill that would place some auction proceeds in trust for grants to improve public safety communications. The introduction of other bills creating trust funds for specific purposes is anticipated.[34] The Public Safety Interoperability Implementation Act[35] would establish in the U.S. Treasury a Public Safety Communications Trust Fund[36] to be funded in part with annual appropriations of $500 million for each of three fiscal years,[37] and in part with a percentage of certain spectrum auction proceeds.[38] The fund is to be administered by the NTIA, in consultation with a board of five directors appointed by the Secretary of Commerce. The board is to consult with the Department of Homeland Security, which may also be represented by one or more

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[30] Budget of the U. S. Government, Fiscal Year 2007, pp. 299-30.

[31] P.L. 108-494, Title II, Sec. 209 (a).

[32] *Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*, December 2005, GAO-06-236.

[33] *Comprehensive Review of U.S. Spectrum Management with Broad Stakeholder Involvement is Needed*, January 2003, GAO-03-277.

[34] "Democrats Again Seek to Pump Spectrum Money into Education Technology," by Joelle Tessler, *CQ Today - Technology & Communications*, February 25, 2005.

[35] For a discussion of interoperability and its role in public safety communications, see CRS Report RL32594, *Public Safety Communications Policy*, by Linda K. Moore.

[36] H.R. 1323, Sec. 3, "Sec. 106 "(a) "(1).

[37] H.R. 1323, Sec. 3, "Sec. 106 "(f).

[38] H.R. 1323, Sec. 3, "Sec. 106 "(a) "(2).

members on the board.[39] The NTIA Administrator is to make grants from the fund "to implement interoperability and modernization . . . for the communications needs" of public safety organizations and related agencies or entities.[40] Preference for grants is to be given to those proposing inter-agency or regional and multi-jurisdictional interoperability programs.[41]

Small Business Loans. Legislation proposed by Congressman Bobby L. Rush would create within the Small Business Administration a Telecommunications Finance Office[42] and a Telecommunications Spectrum Installment Loan Program[43] to provide direct loans for the purchase of spectrum at auction.[44] Loans guarantees would also be provided for spectrum purchases at auction or in the secondary market and for needed equipment.[45] The Communications Act of 1934 would be amended to allow the FCC to accept letters of credit, instead of cash, from auction participants that are qualified telecommunications borrowers, as defined by an amended Small Business Act.[46]

Rebanding Plans. The Digital Television Transition Act of 2005, which appears as Title III, Subtitle D of the Budget Reduction Act of 2005 (H.R. 4241), contains several provisions regarding band plans. Under Section 3411, the FCC would be required to review the need to create different channels from those designated in the current band plan, in order to accommodate wireless broadband technologies in the Upper 700 MHz channels. Section 3413 (a) would require the FCC to reevaluate the band plan for the lower 700 MHz channels (Blocks A, B and E). Section 3413 (b) would order the FCC to revise its plan for licensing spectrum in Block B in ways that would encourage regional and local wireless companies to participate. A Senate bill (S. 1767, Senator Snowe) would require the FCC to create a new band plan for Blocks A, B and E with the similar objective of favoring smaller wireless companies.

Unlicensed Spectrum. The American Broadband for Communications Act (S. 2332, Senator Stevens and H.R. 5085, Representative Inslee) would amend the Communications Act to provide that certain "unused television broadcast spectrum" could be used for unlicensed purposes, "including wireless broadband devices;" the bill specifies that the spectrum covered are available channels in 72 - 698 MHz, except for channels within 608 - 614 MHz. The bill also specifies the rules that the FCC would establish to prevent interference to licensed (TV) channels. The Wireless Innovation Act (S. 2327 Senator Allen) would require the FCC to complete

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[39] H.R. 1323, Sec. 3, "Sec. 106 "(b) "(1).

[40] H.R. 1323, Sec. 3, "Sec. 106 "(c) "(1).

[41] H.R. 1323, Sec. 3, "Sec. 106 "(c) "(2).

[42] H.R. 1661, Sec. 3, "Sec. 37 (a).

[43] H.R. 1661, Sec. 3, "Sec. 38 (a).

[44] H.R. 1661, Sec. 3, "Sec. 38 (a) (1).

[45] H.R. 1661, Sec. 3, "Sec. 39 (a).

[46] H.R. 1661, Sec. 5.

Docket No. 04-186 and, at a minimum, permit unlicensed use of unassigned channels in 54 - 698 MHz and establish the rules to prevent interference between licensed and unlicensed users.

Conclusion

Spectrum, a valuable resource governed by available technology, is regulated by the federal government with the primary objectives of maximizing its usefulness and efficiency, and to prevent interference among spectrum users. A key component of spectrum policy is the allocation of bands for specific uses and the assignment of frequencies within those bands. Auctions, a fairly recent innovation in frequency assignment, are regarded as a market-based mechanism for allocating spectrum. Other market-driven policies include licensing fees based on fair-market valuations of spectrum and flexibility in spectrum usage within assigned bandwidths. Today, spectrum for commercial applications is typically auctioned to the highest bidder, but many commercial users have spectrum acquired before the present-day auction process was implemented.

Auctions as a means of allocating spectrum are considered a success by many observers because of the federal revenue generated, as well as for the speed with which licenses auctioned have gone to the companies that value them the most and are most likely to put them to use. Moreover, many prefer letting businesses determine whether to invest in a new service rather than relying on the government to decide who receives a spectrum license. The FCC has concluded that auctioning of spectrum licenses has contributed to the rapid deployment of new wireless technologies, increased competition in the marketplace, and encouraged participation by small businesses.[47] However, many have questioned whether auction policy should be supplemented more aggressively with other market-driven solutions such as licensing fees and whether the existing auction process and administration can be improved.

Spectrum management is an exercise in reconciling divergent interests. Over time, developments in technology may significantly increase the amount of useable spectrum and consequently the ease with which a policy of equitable allocation and use can be crafted. For the immediate future, Congress may choose to debate and act on questions such as reforming spectrum management and allocation mechanisms. Some observers argue that a fully-developed policy should take into account issues such as international competitiveness, the communications needs of public safety agencies and the military, the role of wireless technology in economic growth, and the encouragement of new technologies that make spectrum use more efficient and more beneficial to society as a whole. The stated objective of many policy reformers is a coherent national policy that provides the proper balance for existing applications while at the same time providing opportunities for future growth and development. Auctioning spectrum to help close existing budget deficits is being advocated by some as a desirable policy choice.

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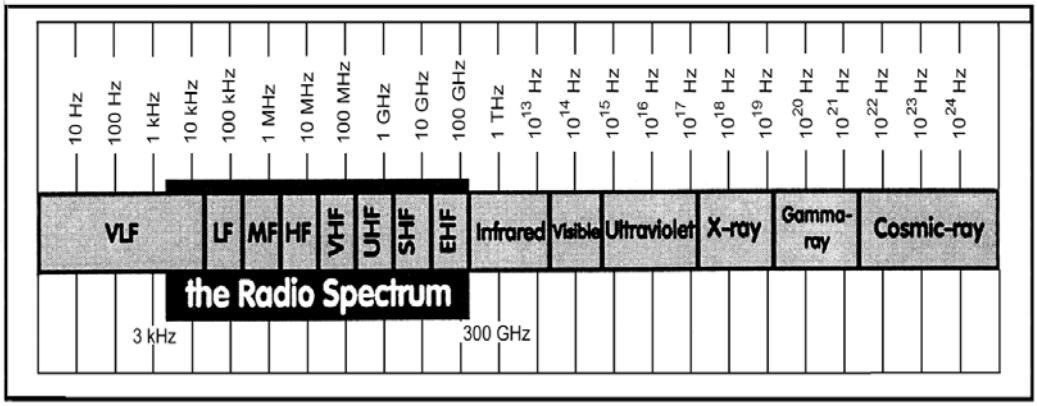
[47] FCC 97-353, *FCC Report to Congress on Spectrum Auctions*, WT Docket No. 97-150, released October 9, 1997.

Appendix: Spectrum Technology Basics

Electromagnetic radiation is the propagation of energy that travels through space in the form of waves. The most familiar form is light, called the visible spectrum. The radio frequency spectrum is the portion of electromagnetic spectrum that carries radio waves. **Figure 1** shows the radio spectrum as part of the measured electromagnetic spectrum. Wavelength is the distance a wave takes to complete one cycle. Frequency is the number of waves traveling by a given point per unit of time, in cycles per second, or hertz (Hz).[48]

Figure 1. The Electromagnetic Spectrum



The relationship between frequency (*f*) and wavelength (λ) is depicted in **Figure 2**. Bandwidth is a measure of how fast data are transmitted or received whether through wires, air or space. Signals are transmitted over a range of frequencies which determines the bandwidth of the signal. Thus a system that operates on frequencies between 150 and 200 MHZ has a bandwidth of 50 MHz.[49] In general, the greater the bandwidth, the more information that can be transmitted.

An important distinction in spectrum technology is the difference between narrowband and broadband. Narrowband signals have a smaller bandwidth (on the order of kHz) and are used for limited services such as paging and low-speed data transmission. Broadband signals have a large bandwidth (on the order of MHz) and can support many advanced telecommunications services such as high-speed data and video transmission. The precise dividing line between broadband and narrowband is not always clear, and changes as technology evolves.

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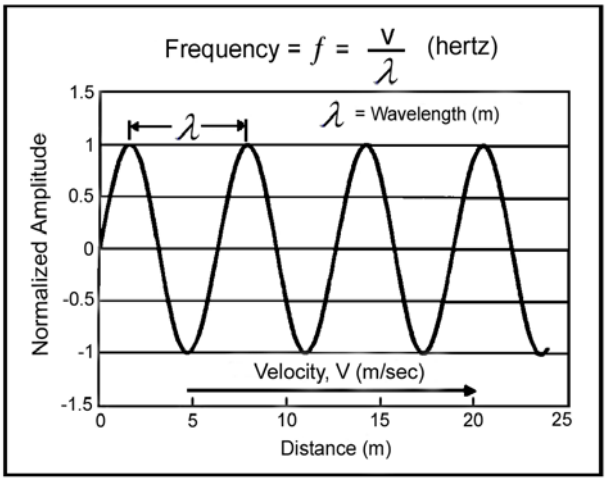
[48] Radiofrequency is usually measured in kilohertz (kHz), which is thousands of hertz, megahertz (MHz) which is millions of hertz, and gigahertz (GHz) which is billions of hertz.

[49] Bandwidth is also measured in bits per second (bps) instead of cycles per second. especially in digital systems.

Two other important terms are analog signals and digital signals, depicted in **Figure 3**. In analog signal transmissions, information (sound, video, or data) travels in a continuous wave whose strength and frequency vary directly with a changing physical quantity at the source (i.e., the signal is directly analogous to the source). In digital signals, information is converted to ones and zeros which are formatted and sent as electrical impulses. Advantages of using digital signals include greater accuracy, reduction in noise (unwanted signals) and a greater capacity for sending information. Analog signals have the advantage of greater fidelity to the source, although that advantage can be made very small by increasing the rate at which signals are digitized. Digital signals are acknowledged to be superior to analog signals for the majority of applications.

Figure 2. Frequency vs. Wavelength



Electromagnetic waves have many characteristics that govern how spectrum can be used in telecommunications systems. For example, antennas are used for transmitting and receiving signals, and can be designed to transmit in all directions or can be directed toward specific receivers. Receiving antennas are typically aligned with the transmitting antenna to maximize signal reception, but unintended signals can still interfere with the reception of the information sent. To avoid signal interference from stray signals, more than one radio signal usually cannot be transmitted in the same frequency range, at the same time, in the same area. Another characteristic is that the spectrum, unlike other natural resources, is not destroyed by use. As soon as one user stops transmitting signals over a portion of the spectrum, another can immediately re-use it. The spectrum is scarce, however, because at any given time and place, one use of a frequency precludes its use for any other purpose.

Figure 3. Schematic Comparing Analog vs. Digital Signals