Spectrum Policy in the Age of Broadband: Issues for Congress

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Summary

The convergence of wireless telecommunications technology with the Internet Protocol (IP) is fostering new generations of mobile technologies. This transformation has created new demands for advanced communications infrastructure and radio frequency spectrum capacity that can support high-speed, content-rich uses. Furthermore, a number of services, in addition to consumer and business communications, rely at least in part on wireless links to broadband (high-speed/high-capacity) infrastructure such as the Internet and IP-enabled networks. Policies to provide additional spectrum for fixed or mobile broadband services are generally viewed as drivers that would stimulate technological innovation and economic growth.

In the 112th Congress, the House of Representatives and the Senate have announced plans to address job creation and deficit reduction in bills that may include provisions to expedite the availability of spectrum for commercial use. Bills under consideration address deficit reduction, spectrum policy, public safety communications, and research and development for emerging communications technologies.

In December 2011, the House of Representatives approved the Middle Class Tax Relief and Job Creation Act of 2011 (H.R. 3630, Representative Camp). H.R. 3630, Title IV contains spectrum reallocation and assignment provisions from the Discussion Draft of the Jumpstarting Opportunity with Broadband Spectrum (JOBS) Act of 2011, as amended, approved in markup on December 1, 2011, by the Subcommittee on Communications and Technology, House Committee on Energy and Commerce. H.R. 3630 is under consideration by a conference committee for which a major focus of discussion is an extension of payroll tax cuts and how to fund them. On the Senate side, some provisions for compromise legislation may come from the American Jobs Act of 2011 (S. 1549, S. 1660) and from the Public Safety and Wireless Innovation Act (S. 911, as amended, Senator Rockefeller). S. 911 received bipartisan approval by the Committee on Commerce, Science, and Transportation.

These bills would, among other provisions: address incentive auctions, which would permit television broadcasters to receive compensation for steps they might take to release some of their airwaves for mobile broadband; require that specified federal holdings be auctioned or reassigned for commercial use; apply future spectrum license auction revenues toward deficit reduction; establish a planning and governance structure to deploy public safety broadband networks, using some auction proceeds for that purpose; and reassign spectrum resources available for public safety. The bills include provisions that would affect the development of new technologies and the availability of spectrum for unlicensed use and for shared use.

This report discusses key spectrum policy provisions in the bills, as well as other spectrum policy issues that are being considered in the 112th Congress, such as the role of wholesale networks like that being deployed by LightSquared.

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The Role of Spectrum Policy

The purpose of spectrum policy, law, and regulation is to manage a natural resource[1] for the maximum possible benefit of the public. Access to radio frequency spectrum is managed; the assignment of spectrum rights does not convey ownership. Radio frequency spectrum is managed by the Federal Communications Commission (FCC) for commercial and other non-federal uses and by the National Telecommunications and Information Administration (NTIA) for federal government use.

Wireless broadband,[2] with its rich array of services and content, requires new spectrum capacity to accommodate growth. Spectrum capacity is necessary to deliver mobile broadband to consumers and businesses and also to support the communications needs of industries that use fixed wireless broadband to transmit large quantities of information quickly and reliably.

Policy tools that might be used to increase the availability of radio frequency spectrum for wireless broadband include allocating additional spectrum, reassigning spectrum to new users, requiring that wireless network infrastructure be shared, pooling radio frequency channels, moving to more spectrum-efficient technologies, and changing the cost structure of spectrum access.

Although radio frequency spectrum is abundant, usable spectrum is currently limited by the constraints of applied technology. Spectrum policy therefore requires making decisions about how radio frequencies will be allocated and who will have access to them.[3] Spectrum policy also entails encouraging innovation in wireless technologies and their applications. Arguably, the role of technology policy in crafting spectrum policy has increased with the need to reduce or eliminate capacity constraints that may deter the expansion of broadband mobile services.

Spectrum Policy Legislation in the 112th Congress

There are a number of bills before Congress that address the interlaced issues of spectrum policy and deficit reduction. The two issues are connected because, when radio frequency spectrum licenses are auctioned for commercial purposes by the FCC, the net proceeds are deposited in the U.S. Treasury.[4]

[1] 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, §990.30).

[2] Broadband refers here to the capacity of the radio frequency channel. A broadband channel can quickly transmit live video, complex graphics, and other data-rich information as well as voice and text messages, whereas a narrowband channel might be limited to handling voice, text, and some graphics.

[3] Spectrum allocation and assignment is addressed in **Appendix B**, Competition.

[4] 47 USC §308 (j) (8). Net proceeds are the auction revenues minus the FCC's expenses. Congress has twice in the past amended the provision in order to use auction proceeds for other purposes by creating special funds to hold and disburse auction proceeds. The Commercial Spectrum Enhancement Act, Title II of P.L. 108-494 created the Spectrum Relocation Fund; the Deficit Reduction Act of 2005 created the Public Safety and Digital Television Transition Fund.

The legislation that first authorized the FCC to establish "competitive bidding systems"[5] was included in the Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66). Requirements to release radio frequency spectrum used for analog television broadcasting, and to auction licenses in part of the cleared spectrum were included in the Balanced Budget Act of 1997 (P.L. 105-33). The Deficit Reduction Act of 2005 (P.L. 109-171) provided a deadline for the release of the frequencies used for analog TV and expanded the range of frequencies to be auctioned. The Deficit Reduction Act specifically required that $7.363 billion of auction proceeds be applied to deficit reduction, based on an estimate of predicted auction revenues provided by the Congressional Budget Office (CBO). Because the auction results exceeded expectations, over $15 billion in revenue was deposited with the Treasury.

The Balanced Budget Act of 1997 gave the FCC auction authority until September 30, 2007. This authority was extended to September 30, 2011, by the Deficit Reduction Act of 2005 and to 2012 by the DTV Delay Act (P.L. 111-4). Revenue from auctions held after FY2012 is therefore considered new revenue.

The Balanced Budget Act of 1993 and the Deficit Reduction Act of 2005 also included measures to provide additional resources for public safety communications. The 1993 act required the FCC to identify 24 MHz of spectrum to assign for public safety use within the 700 MHz band[6]—the band that was to be released in the transition from analog to digital television. The Deficit Reduction Act of 2005 specified a deadline for the release of spectrum within the 700 MHz band and provided $1 billion for a grant program to assist in improving public safety communications. In the 112th Congress, several bills have been introduced that would fund a new wireless network for public safety communications using proceeds from spectrum license auctions.

The House of Representatives, on December 13, 2011, approved the Middle Class Tax Relief and Job Creation Act of 2011 (H.R. 3630, Representative Camp). H.R. 3630, Title IV contains provisions from the Discussion Draft of the Jumpstarting Opportunity with Broadband Spectrum (JOBS) Act of 2011, as amended, approved in markup on December 1, 2011, by the Subcommittee on Communications and Technology, House Committee on Energy and Commerce. H.R. 3630 is under consideration by a conference committee for which a major focus of discussion is an extension of payroll tax cuts and how to fund them.

In the Senate, the legislative response to H.R. 3630 may include provisions from the American Jobs Act of 2011 (S. 1549 and others) and from the Public Safety and Wireless Innovation Act (S. 911, as amended, Senator Rockefeller). S. 911 received bipartisan approval by the Committee on Commerce, Science, and Transportation.

Spectrum policy issues, discussed below, that may be actively debated in the second session of the 112th Congress include extension of the auction authority of the FCC in order to generate revenue toward deficit reduction; directed auctions of specific frequencies; unlicensed spectrum; incentive auctions for spectrum assigned to television broadcasters; reallocation of federal

[5] 47 USC §308 (j) (3).

[6] Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz. 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. The 700 MHz band includes radio frequencies from 698 MHz to 806 MHz.

spectrum to commercial use, licensing spectrum now used for satellite services; wholesale networks; the assignment and use of spectrum for public safety; and new fees on license-holders.[7]

Directed Auctions

In its 2010 National Broadband Plan (NBP),[8] the Federal Communications Commission (FCC) established the need to increase the amount of spectrum available for commercial mobile broadband services. It has proposed taking steps to add 300 MHz of licensed spectrum for broadband within 5 years and a total of 500 MHz of new frequencies in 10 years. The FCC anticipated that much of this spectrum would be auctioned. The likely sources for the additional capacity would include spectrum already available to the FCC for licensing; licenses held by the federal government that could be released or shared; and new licenses that encourage spectrum efficiency through incentive auctions. At the request of Congress, the Government Accountability Office (GAO) prepared a study about key spectrum policy recommendations in the NBP. [9]

Bills actively under consideration by Congress would provide new authorities to the FCC to carry out the plan and direct FCC actions in identifying and auctioning spectrum.

Advanced Wireless Services

The FCC has identified approximately 50 MHz of radio frequency spectrum to be released for mobile broadband in the immediate future by the completion of existing auction plans. For example, in 2007 the FCC issued a Notice of Proposed Rulemaking to establish service rules for the auction of a license or licenses at 2155-2175 MHz, designated as Auction AWS-3.[10] The FCC did not act on the AWS-3 auction proposal but announced new plans in the NBP that included the 2155-2175 MHz frequencies.[11] As outlined in the NBP, the FCC would seek to pair the 2155-2175 MHz frequencies with an additional 20 MHz of frequencies reassigned from federal use. The plan had proposed using federal frequencies in the 1755-1780 MHz range for this purpose, but the NTIA offered instead to assess the feasibility of using frequencies in the 1675-1710 MHz band.[12] The FCC is also working with the NTIA to identify spectrum used by federal agencies that might be made available for commercial use. The NTIA has produced a Ten-Year Plan and Timetable that identifies bands of spectrum that might be available for commercial wireless broadband service. As part of its planning efforts, NTIA prepared a "Fast Track Evaluation"[13] of spectrum resources that might be repurposed in the near future. Specific recommendations were to make available 15 MHz of spectrum from frequencies between 1695-1710 MHz and 100 MHz

[7] Additional information is provided in Congressional Distribution Memoranda, "Spectrum Policy and Deficit Reduction: Administration-Sponsored Bills," December 7, 2011, and "Public Safety and Spectrum Policy Provision in H.R. 3630 and Other Bills," December 14, 2011, available on request to the author.

[8] *Connecting America: The National Broadband Plan, 2010* at http://www.broadband.gov.

[9] GAO, Commercial Spectrum: Plans and Actions to Meet Future Needs, Including Continued Use of Auctions, November 23, 2011, GAO-12-118 at http://www.gao.gov/assets/590/587319.pdf.

[10] FCC, *Notice of Proposed Rulemaking*, WT Docket No. 07-195, released September 19, 2007.

[11] *Connecting America*, Recommendation 5.8.3.

[12] NTIA, "Plan and Timetable" at http://www.ntia.doc.gov/reports/2010/TenYearPlan_11152010.pdf.

[13] NTIA, An Assessment of Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHZ, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHZ Bands (President's Spectrum Plan Report), November 15, 2010, at http://www.ntia.doc.gov/report/2010/assessment-near-term-viability-accommodating-wireless-broadband-systems-1675-1710-mhz-17.

of spectrum within bands from 3550-3650 MHz. The Fast Track Evaluation also recommended studying two 20 MHz bands to be identified within 4200-4400 MHz for possible repurposing.

In addition to the AWS-3 frequencies, there are two blocks of spectrum under the designation of AWS-2 "H" and "J" that have been under consideration by the FCC for auction since 2004. The AWS-2 "J" band, with paired frequency assignment at 2020-2025 MHZ and 2175-2180 MHz, might be paired with AWS-3 or with an adjacent Mobile Satellite Service band.

Satellite Spectrum

In the NBP, the FCC proposed to expand terrestrial wireless networks in frequency bands designated for Mobile Satellite Services (MSS). Of the four bands allocated for MSS since 1986, the FCC has identified three bands that are "broadband capable." The bands are known as the L-Band (1225-1559 MHz and 1626.5-1160.5 MHz), the S-band (2000-2020 MHz and 2180-2200 MHz), and Big LEO (1610-1626.5 MHz and 2483.5-2500 MHz). Since February 2003, the FCC has permitted selected MSS license-holders such as LightSquared to construct and operate Ancillary Terrestrial Components that allow the deployment of terrestrial broadband networks using MSS frequency assignments. The FCC has proposed developing a new ruling on terrestrial use of MSS frequencies that have the potential of adding 90 MHz of capacity for broadband services. Additionally, the FCC might pair unassigned frequencies at 2020-2025 MHz and 2175-2180 MHz with an adjacent MSS band.

Wholesale Networks

In the 2008 auction of spectrum licenses at 700 MHz,[14] several companies associated with Silicon Valley and Internet ventures petitioned the FCC to set aside a block of spectrum as a national license with a requirement that the network be available—open—to all.[15] The FCC was also petitioned to designate spectrum licenses at 700 MHz for networks that would operate on a wholesale business model. It was argued that the wholesale business model would be the most viable for new entrants and that the auction rules and conditions adopted by the FCC were prejudicial to small business.[16]

Proponents of open access argue that only an open network that anyone can use—not just subscribers of one wireless company—can provide consumer choice. From this perspective, a wholesale network could provide more market opportunities for new wireless devices, especially wireless devices that could provide unrestricted access to the Internet. A wholesale network would allow customers to choose their own wireless devices without necessarily committing to a service plan from a single provider. The network owner would operate along the same principles used for shopping malls, providing the infrastructure for others to retail their own products and services.

[14] For information, see Auction 73 at http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=73.

[15] Comments, for example, made by Ram Shriram and Vanu Bose at the Frontline Town Hall, July 12, 2007, Washington, DC, and by Jason Devitt at a panel discussion during the State of the Net conference, January 30, 2008, Washington, DC.

[16] Petition for Reconsideration of Frontline Wireless, LLC, WT Docket No. 96-86.

LightSquared

In early 2010, the mobile satellite service operator SkyTerrra Communications was acquired by the private equity group Harbinger Capital Partners. With FCC approval of the merger, Harbinger began construction of a nationwide fourth-generation wireless broadband network that will be integrated with satellite service, called LightSquared.[17] The business model adopted for LightSquared is based on selling wholesale access to the network's infrastructure. Projected customers include retailers, cable operators, device manufacturers, web players, contents providers, and telecommunications companies. Customers will have the choice of terrestrial-only, satellite-only, or integrated communications support. An advantage for potential customers is the opportunity to move a new wireless product to market in a short time (once the network is in place). Advantages to LightSquared include costs savings by using only Internet-Protocol (IP) enabled Long Term Evolution (LTE) technology. Also, the wholesale customers of LightSquared will effectively be leasing a location from which to sell to individual customers, thereby assuming the cost of marketing, customers service, and billing and payment—all of which are expensive components of operating costs. LightSquared, if successful, will be building a giant national mall in the "cloud," referring to the concept of remote services sometimes called cloud computing.[18] The frequencies that LightSquared intends to use are adjacent to spectrum bands used for Global Positioning System (GPS) devices of many types, and by the U.S. Department of Defense. Potential interference on these frequencies is being addressed by the FCC but remains a major concern for Congress and has prompted a number of hearings. [19]

Television Broadcast Spectrum and Incentive Auctions

Bills being actively considered by Congress would give the FCC authority to conduct incentive auctions, that is, to establish a mechanism whereby spectrum capacity could be relinquished for auction by some license-holders, who would then share in the proceeds. Many commercial wireless licenses can be resold directly by their license-holders for comparable uses; the purpose of incentive auctions is to reward license-holders, such as television broadcasters, who repurpose their spectrum for a different use.

The Balanced Budget Act of 1997, which mandated the eventual transition to digital television, represented the legislative culmination of over a decade of policy debates and negotiations between the FCC and the television broadcast industry on how to move the industry from analog to digital broadcasting technologies. To facilitate the transition, the FCC provided each qualified broadcaster with 6 MHz of spectrum for digital broadcasting to replace licenses of 6 MHz that were used for analog broadcasting. The analog licenses would be yielded back when the transition to digital television was concluded. The completed transition freed up the 700 MHz band for commercial and public safety communications in 2009.

The FCC has revisited the assumptions reflected in the 1997 act and has made new proposals, and decisions based on, among other factors, changes in technology and consumer habits. The NBP announced that a new proceeding would be initiated to recapture up to 120 MHz of spectrum from broadcast TV allocations for reassignment to broadband communications. This proceeding

[17] The FCC approval of the acquisition is Release DA 10-535, 25 FCC Record 3059, adopted March 26, 2010.

[18] A discussion of these technologies appears in **Appendix A**, Spectrum-Hungry Technologies.

[19] Current information is at http://www.pnt.gov/interference/lightsquared/.

would propose four sets of actions to achieve the goal; a fifth set of actions to increase efficiency would be pursued separately.[20] The FCC stipulated in the NBP that its recommendations "seek to preserve [over-the-air television] as a healthy, viable medium going forward, in a way that would not harm consumers overall, while establishing mechanisms to make available additional spectrum for flexible broadband uses."[21]

Many of the proposals for redirecting TV broadcast capacity are based on refinements in the way frequencies are managed and are procedural in nature. Because over-the-air digital broadcasting does not necessarily require 6 MHz of spectrum, the NBP has proposed that some stations could share a single 6 MHz band without significantly reducing service to over-the-air TV viewers. Among the proposals for how broadcasters might make better use of their TV licenses, the NBP has raised the possibility of auctioning unneeded spectrum and sharing the proceeds between the TV license-holder and the U.S. Treasury. The FCC and the NTIA have called on Congress to provide new legislation that would allow this type of incentive auction.

Repurposing Federal Spectrum

The Commercial Spectrum Enhancement Act (Title II of P.L. 108-494) put in place, in 2004, statutory rules for covering the costs to federal agencies of relocating wireless communications facilities to new spectrum assignments. The act created the Spectrum Relocation Fund to provide a means for federal agencies to recover relocation costs directly from auction proceeds when they are required to vacate spectrum slated for auction. In effect, successful commercial bidders would cover the costs of relocation. Among key provisions of the act were requirements that the auctions must recoup at least 110% of the costs projected by the NTIA, and that unused funds would revert to the Treasury after eight years. Specific frequencies were designated for immediate auction[22] but the law applies to other federally used frequencies scheduled for reallocation and possible auction.

Bills actively under consideration would require that additional frequencies be reallocated from federal to commercial use and would provide amendments to the Commercial Spectrum Enhancement Act. The bills would address how spectrum resources would be repurposed through auction or sharing, and how costs would be defined and compensated, among other provisions. Planning for potential or planned auctions would be included as a reimbursable cost. Other reimbursable costs would apply across a wide range of technical options, including spectrum sharing.

[20] *Connecting America*, Recommendation 5.8.5. The first Notice of Proposed Rulemaking to address implementation of these proposals was released November 30, 10, ET Docket No. 10-235 at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1130/FCC-10-196A1.pdf.

[21] *Connecting America*, p. 89.

[22] Following the procedures required by the act, the FCC scheduled an auction for Advanced Wireless Services (AWS), designated Auction 66, which was completed on September 18, 2006. The AWS auction attracted nearly $13.9 billion in completed bids, substantially above the cost established by the NTIA of almost $936 million for the move.

Shared Spectrum

The NTIA, as outlined in its "Plan and Timetable," has recommended policies that would encourage sharing among federal agencies, between federal agencies and private users, and among private users.

The NBP recommends that the FCC identify and free up a "new, contiguous nationwide band for unlicensed use" by 2020;[23] and provide spectrum and take other steps to "further development and deployment" of new technologies that facilitate sharing.[24]

From a policy perspective, actions to speed the arrival of new, spectrally efficient technologies might have significant impact on achieving broadband policy goals over the long term. In particular, support for technologies that enable sharing could pave the way for dramatically different ways of managing the nation's spectrum resources. Among the technologies that facilitate spectrum sharing are cognitive radio and Dynamic Spectrum Access (DSA).[25] Enabling technologies such as these allow communications to switch instantly among network frequencies that are not in use and therefore available to any radio device equipped with cognitive technology.

Unlicensed Use

Another policy option for increasing the amount of spectrum available for commercial broadband is to allocate spectrum for unlicensed use. 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. 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 garage door openers and WiFi communications.

New technologies, sometimes referred to as Super WiFi, are being developed to expand the amount of unlicensed spectrum without causing interference. Technology is being put in place to use vacant spectrum, known as white spaces, between broadcasting signals of digital television. On September 11, 2006, the FCC announced a timetable for allowing access to the spectrum so that devices could be developed.[26] An order issued in September 2010 allowed plans for new technology to move forward.[27] Super WiFi devices are expected to reach the market by 2013.[28]

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[23] *Connecting America,* Recommendation 5.11.

[24] *Connecting America*, Recommendation 5.13.

[25] Dynamic Spectrum Access, Content-Based Networking, and Delay and Disruption Technology Networking, along with cognitive radio, and decision-making software, are examples of technologies that can enable Internet-like management of spectrum resources. DSA is part of the neXt Generation program, or XG, a technology development project sponsored by the Strategic Technology Office of the Defense Advanced Research Projects Agency (DARPA). The main goals of the program include developing both the enabling technologies and system concepts that dynamically redistribute allocated spectrum.

[26] FCC, *First Report and Order and Further Notice of Proposed Rule Making*, ET Docket No. 04-186, released October 18, 2006 at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-06-156A1.pdf.

[27] FCC, *Second Memorandum Opinion and Order*, ET Docket No. 04-186, released September 23, 2010, at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1025/FCC-10-174A1.pdf.

[28] "Spectrum Bridge Gains Final FCC Approval, White Spaces Broadband Era to Begin," by Joan Engebretson, telecompetitor.com, December 22, 2011.

Similar technologies are being used to expand the availability of spectrum for unlicensed use at 5 GHz by sharing with existing federal users in those frequencies.[29]

Public Safety Spectrum Assignment and Use

The FCC is responsible for assigning spectrum for public safety wireless communications. The end of analog television broadcasting in the 700 MHz band freed up 24 MHz of spectrum for public safety use within that band. Of this, half has been designated for narrowband (voice) networks. 10 MHz is to be used for broadband (data) networks and 2 MHz are designated as guard bands. The announced intention of public safety agencies is to combine the D Block with 12 MHz of adjacent spectrum already assigned for public safety use, referred to as the Public Safety Broadband License, to build a broadband network, or networks, for nationwide coverage. The Public Safety Broadband License was originally assigned by the FCC to the Public Safety Spectrum Trust (PSST), a not-for-profit corporation created for that purpose.

Planning and implementation of broadband networks for public safety communications are still in the early stages. Among the barriers to moving forward are incomplete development of technology and standards; inadequate planning; insufficient coordination among public safety agencies; lack of governance structure to direct and administer a nationwide, interoperable network; and lack of sufficient funding.

Bills under active consideration would require the FCC to assign an additional 10 MHz of radio frequency spectrum in the 700 MHz band for public safety use. These frequencies—at 758-763 MHz and 788-793 MHz—are known as the D Block. The bills would combine the existing Public Safety Broadband License and the D Block in a single license. The bills would also provide mechanisms for planning and governance and would establish grants programs for financial assistance.

Spectrum License Fee Provisions

The Obama Administration has proposed that the FCC be given the authority to levy fees, and to use other economic mechanisms, as a spectrum management tool.[30] Similar proposals were made in budget proposals during the Administration of President George W. Bush.[31]

The FCC's statutory authority to impose new spectrum user fees is limited. The FCC was authorized by Congress to set license application fees[32] and regulatory fees to recover costs.[33] A

[29] These and other frequencies for unlicensed use are discussed in *The Economic Value Generated by Existing and Future Allocations of Unlicensed Spectrum,* Perspective, Ingenious Consulting Network, September 28, 2009; sponsored by Microsoft, Inc.

[30] Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2011*, *Appendix*, "Other Independent Agencies," p. 1263. See also, FCC, *Fiscal Year 2011 Budget Estimates Submitted to Congress,* February 2010 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296111A1.pdf.

[31] For example, the President's budget for FY2004 and again for 2006 proposed that (1) the FCC's authority to conduct auctions be extended indefinitely; (2) user fees be levied on unauctioned licensed spectrum; and (3) broadcasters pay an annual lease fee on analog TV spectrum that they are holding as part of the Congressionally-mandated transition to digital television. In his budget for 2005, the President supported proposals for indefinitely extending the FCC's auction authority and giving the FCC the authority to set user fees on unauctioned spectrum.

[32] 47 USC §158 (a).

[33] 47 USC §159 (a).

new fee structure seeking recovery beyond costs would require congressional authorization, either through an appropriations bill or through new legislation.

In the NBP, the FCC asked Congress to consider granting it authority to impose spectrum fees on license holders as a means of addressing inefficient use.[34] The report presented the hypothesis that "Fees may help to free spectrum for new uses such as broadband, since licensees who use spectrum inefficiently may reduce their holdings once they bear the opportunity cost" of holding the spectrum.[35]

In response to Bush Administration proposals, the 108th Congress instructed the GAO to take note of the possible impact of changing the spectrum license fee structure. In the Commercial Spectrum Enhancement Act, the GAO was instructed to examine "national commercial spectrum policy as implemented by the Federal Communications Commission" and report on its findings in 2005.[36] The GAO was to examine the impact of auctioning licenses on the economic climate for broadcast and wireless technologies and to assess whether the holders of spectrum licenses received before the auction process was instituted (i.e., largely for free) have an economic advantage over license holders that purchased spectrum rights through the auction process. The GAO was also to evaluate whether the disparate methods of allocating spectrum had an adverse impact on the introduction of new services. The conclusions of the study were to be reviewed in the context of an Administration proposal to introduce license user fees on licenses that had not been auctioned. The GAO was also to provide an evaluation for Congress regarding the impact of assessing license fees on the competitive climate in the wireless and broadcast industries.

After consultation with the committees of jurisdiction, the GAO did not include an analysis of license fees in its report. Instead it focused on the impact of auctions on factors such as end-user prices, investment in infrastructure, and competition. One of the report's conclusions was that the cost of purchasing licenses did not affect price and competition in the long run because the cost was a one-time, sunk cost.[37] New licensing regimes were mentioned in the report as a possible means of increasing spectral efficiency but the suggestion received no discussion in the report.[38]

Competition and Technology Policy

With the introduction of auctions for spectrum licenses in 1994, the United States began to shift away from assigning spectrum licenses based on regulatory decisions and toward competitive market mechanisms. One objective of the Telecommunications Act of 1996 was to open up the communications industry to greater competition among different sectors. One outcome of the growth of competition was the establishment of different regulatory regimes for information networks and for telecommunications.[39] As a consequence of these and other legislative and

[34] *Connecting America*, Recommendation 5.6.

[35] *Connecting America*, p. 82.

[36] P.L. 108-494, Title II, §209 (a).

[37] GAO, *Telecommunications: Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*," December 20, 2005, GAO-06-236, p. 2.

[38] *Ibid*., p. 10, footnote 15.

[39] For a discussion of policy issues, see CRS Report R40234, *The FCC's Authority to Regulate Net Neutrality After Comcast v. FCC* , by Kathleen Ann Ruane, and CRS Report R40616, *Access to Broadband Networks: The Net Neutrality Debate*, by Angele A. Gilroy.

regulatory changes, the wireless industry has areas of competition (e.g. for spectrum licenses) within a regulatory shell, such as the rules governing the Public Switched Telephone Network (PSTN).[40] As the bulk of wireless communications traffic moves from voice to data, companies will likely modify their business plans in order to remain competitive in the new environment. A shift in infrastructure technology and regulatory environment[41] might open wireless competition to companies with business plans that are not modeled on pre-existing telecommunications industry formulae. Future providers of wireless broadband might include any company with a robust network for carrying data and a business case for serving broadband consumers. Potential new entrants, however, may lack access to radio frequency spectrum, the essential resource for wireless broadband.

Current spectrum policy relies heavily on auctions to assign spectrum rights through licensing. However, the adoption of spectrum-efficient technologies is likely to require a rethinking of spectrum management policies and tools. The assignment and supervision of licenses might give way to policies and procedures for managing pooled resources. Auctioning licenses might be replaced by auctioning access; the static event of selling a license replaced by the dynamic auctioning of spectrum access on a moment-by-moment basis.

Spectrum-Efficient Technology

Mobile communications became generally available to businesses and consumers in the 1980s. The pioneering cell phone technologies were analog.[42] Second-generation (2G) wireless devices were characterized by digitized delivery systems. Third-generation (3G) wireless technology represents significant advances in the ability to deliver data and images. The first commercial release of 3G was in Japan in 2001; the technology successfully debuted in the United States in 2003. 3G technologies can support multi-function devices, such as the BlackBerry and the iPhone. Successor technologies, often referred to as 4G, are expected to support broadband speeds that will rival wireline connections such as fiber optic cable, with the advantage of complete mobility. 4G wireless broadband technologies include WiMAX[43] and Long Term Evolution (LTE) networks. Both are based on TCP/IP, the core protocol of the Internet.[44]

Wireless technologies to facilitate broadband deployment for which spectrum may need to be allocated that were identified by the NBP include 4G networks; fixed wireless as an alternative to fiber optic cable; and broadband on unlicensed frequencies.

The NBP spectrum assignment proposals are based on managing radio channels as the way to maximize spectral efficiency while meeting common goals such as minimizing interference among devices operating on the same or nearby frequencies. Today, channel management is a

[40] PSTN is a global system; rights of access and usage in the United States are regulated by the FCC.

[41] On December 1, 2009, the FCC published a public notice seeking comments on the "appropriate policy framework to facilitate and respond to the market-led transition in technology and services, from the circuit-switched PSTN system to an IP-based communications world." "Comment Sought on Transition from Circuit-Switched Network to All-IP Network," NBP Public Notice #25, DA 09-2517 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2517A1.pdf.

[42] A wireless analog signal uses a continuous transmission form. Digital signals are discontinuous (discrete) transmissions.

[43] WiMAX stands for Worldwide Interoperability for Microwave Access.

[44] Key technologies for mobile broadband are summarized in **Appendix A**, Spectrum-Hungry Technologies.

significant part of spectrum management; many of the FCC dockets deal with assigning channels and resolving the issues raised by these decisions. In the future, channel management is likely to be replaced by technologies that operate without the need for designated channels. In the NBP, the FCC refers to these spectrum-seeking technologies as opportunistic. Identifying an opportunity to move to an open radio frequency is more flexible—and therefore more productive—than operating on a set of pre-determined frequencies. The primary benefit from these new technologies will be the significant increase in available spectrum but new efficiencies in operational and regulatory costs will also be realized.

The concept of channel management dates to the development of the radio telegraph by Guglielmo Marconi and his contemporaries. In the age of the Internet, however, channel management is an inefficient way to provide spectrum capacity for mobile broadband. Innovation points to network-centric spectrum management as an effective way to provide spectrum capacity to meet the bandwidth needs of fourth-generation wireless devices.[45] Network-centric technologies organize the transmission of radio signals along the same principle as the Internet. A transmission moves from origination to destination not along a fixed path but by passing from one available node to the next. Pooling resources, one of the concepts that powers the Internet now, is likely to become the dominant principle for spectrum management in the future.

The latest generation of smartphones provides examples of how the Internet is likely to change wireless communications as more and more of the underlying network infrastructure is converted to IP-based standards. The arriving generation of wireless networks, 4G, for Fourth Generation, will be supported by technologies structured and managed to emulate the Internet. Smartphones use the Internet Protocol to perform many of their functions; these require time and space—spectrum capacity—to operate. The wireless devices that use these new, IP-powered networks will be able to share spectrum capacity in ways not currently available on commercial networks, greatly increasing network availability on licensed bandwidths. Another technological boost will come from improved ways to use unlicensed spectrum.

More efficient spectrum use can be realized by integrating adaptive networking technologies, such as DSA, with IP-based, 4G commercial network technologies such as LTE. Adaptive networking has the potential to organize wireless communications to achieve the same kinds of benefits that have been seen to accrue with the transition from proprietary data networks to the Internet. These enabling technologies allow communications to switch instantly among network frequencies that are not in use and therefore available to any wireless device equipped with cognitive technology. Adaptive technologies are designed to use pooled spectrum resources. Pooling spectrum licenses goes beyond sharing. Licenses are aggregated and specific ownership of channels becomes secondary to the common goal of maximizing network performance.

Conclusion

Telephone service was once considered a natural monopoly, and regulated accordingly. The presumption was that redundant telephone infrastructure was inefficient and not in the public

[45] A leading advocate for replacing channel management of radio frequency with network-centric management is Preston Marshall, the source for much of the information about network-centric technologies in this report. Mr. Marshall is Director, Information Sciences Institute, University of Southern California, Viterbi School of Engineering, Arlington, Virginia.

interest. State and federal regulators favored granting operating rights to a single company, within a specific facilities territory, to benefit from economies of scale, facilitate interoperability, and maximize other benefits. In return for the monopoly position, the selected provider was expected to fulfill a number of requirements intended to benefit society. Thus, for decades, the regulated monopoly was seen by most policy-makers as (1) ensuring that costly infrastructure was put in place and (2) meeting society's needs, as interpreted by regulations and the law.[46] Past policies to regulate a monopolistic market may have influenced current policies for promoting competition. The FCC's emphasis on efficiency for delivering services to a pre-determined market could be leading wireless competition toward monopoly; new regulatory regimes might be a consequence of this trend, if it continues.

Current spectrum policy seeks to maximize the value of spectrum by encouraging economies of scale and appears to treat spectrum assets as an extension of existing infrastructure (spectrum license ownership and network management, for example) instead of an alternative infrastructure (WiFi and wireless backhaul are examples). This policy course has provided a form of workable competition that has brought wireless services (until 2006, almost exclusively voice) at affordable prices to most of the country. However, wireless technology has reached an inflection point and is shifting from voice to data. Some argue that wireless policy should also shift, placing a greater value on innovation to achieve goals deemed to be in the public interest. A policy that prioritizes providing spectrum to spur innovation, for example, could create new markets, new models for competition, and new competitors. If spectrum policy serves broadband policy and broadband policy serves multiple sectors of the economy, then perhaps spectrum should be more readily available for a wider pool of economic participants.

The amount of spectrum needed for fully realized wireless access to broadband is such that meeting the needs of broadband policy goals could be difficult to achieve through the market-driven auction process unless large amounts of new radio frequencies can be identified and released for that purpose.[47] Without abandoning competitive auctions, spectrum policy could benefit from including additional ways to assign or manage spectrum that might better serve the deployment of wireless broadband and the implementation of a national broadband policy.

Legislation geared to improve auction mechanisms might benefit from the consideration of measures that would use technology to increase the amount of spectrum available, thereby opening the field to new players, fostering competition, and spurring innovation.

[46] The original Communications Act of 1934 codified many regulations for monopolies as practiced at the time.

[47] International Telecommunications Union projects an estimated need for additional spectrum capacity that could reach nearly 1,000 MHz in the United States, as reported in "Summary of Results of ITU-R Report M. 2079," p. 13, presented by Cengiz Evci, Chief Frequency Officer, Wireless Business Group, Alcatel-Lucent, August 28, 2007. Available at http://standards.nortel.com/spectrum4IMT/Geneva/R03-WRCAFR07-C-0024.pdf. See also CTIA-The Wireless Association, *Written Ex Parte Communication,* FCC, GN Docket No. 09-51, September 29, 2009, which suggests a goal of at least 800 MHz, based on extrapolations from the ITU research.

Appendix A. Spectrum-Hungry Technologies

Enabling technologies that are fueling both the demand for mobile broadband services and the need for radio frequency spectrum include Long Term Evolution (LTE); WiMAX; fixed wireless; WiFi; high performance mobile devices such as smartphones and netbooks; and cloud computing. Fixed wireless and WiFi are not new technologies but mobile broadband has given them new roles in meeting consumer demand. Future technologies include network-centric technologies, which include opportunistic solutions such as Dynamic Spectrum Access (DSA).

Long Term Evolution (LTE)

LTE is the projected development of existing 3G networks built on Universal Mobile Telephone System (UMTS) standards.[48] Like all fourth-generation wireless technologies, LTE's core network uses Internet protocols. The network architecture is intended to facilitate mobile broadband deployment with capabilities that can deliver large amounts of data, quickly and efficiently, to large numbers of simultaneous users. LTE will likely be implemented in stages through modifications to networks using frequencies in bands already allocated for commercial wireless networks.[49] LTE might operate on spectrum bands at 700 MHz, 1.7 GHz, 2.3 GHz, 2.5 GHz, and 3.4 GHz.[50]

WiMAX

WiMAX provides mobile broadband but its earliest applications were for fixed wireless services. WiMAX (Worldwide Interoperability for Microwave Access) refers to both a technology and an industry standard, the work of an industry coalition of network and equipment suppliers.[51] WiMAX uses multiple frequencies around the world in ranges from 700 MHz to 66 GHz. In the United States, available frequencies include 700 MHz, 1.9 GHz, 2.3 GHz, 2.5 GHz and 2.7 GHz. The introduction of WiMAX in the United States is being jointly led by Sprint Nextel Corporation and Clearwire Corporation.

Fixed Wireless Services

Fixed wireless services have taken on new importance as a "backhaul" link for 4G. Backhaul is the telecommunications industry term that refers to connections between a core system and a subsidiary node. An example of backhaul is the link between a network—which could be the Internet or an internetwork that can connect to the Internet—and the cell tower base stations that route traffic from wireless to wired systems. Two backhaul technologies well-suited for mobile

[48] See, for example, "Mobile Broadband Evolution: the roadmap from HSPA to LTE," UMTS Forum, February 2009, Universal Mobile Telephone System Forum at http://www.umts-forum.org/.

[49] Implementation summarized in *Connecting America*, Exhibit 5-B, p. 77.

[50] Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz. 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.

[51] Founding members of the WiMAX Forum include Airspan, Alvarion, Analog Devices, Aperto Networks, Ensemble Communications, Fujitsu, Intel, Nokia, Proxim, and Wi-LAN. For additional information, see http://www.wimaxforum.org/.

Internet access are fiber optic cable and point-to-point microwave radio relay transmissions.[52] Network expansion plans for WiMAX and LTE include microwave links as a cost-effective substitute for fiber optic wire under certain conditions. Radio frequencies available in the United States for microwave technologies of different types start in the 930 MHz band and range as high as the 90 GHz band.

WiFi

The popularity of WiFi is often cited as a successful innovation that was implemented using unlicensed frequencies.[53] WiFi provides wireless Internet access for personal computers and handheld devices and is also used by businesses to link computer-based communications within a local area. Links are connected to a high-speed landline either at a business location or through hotspots. Hotspots are typically located in homes or convenient public locations, including airports and café environments such as Starbucks. WiFi uses radio frequencies in the free 2.4 GHz and 5.4/5.7GHz spectrum bands. Many 3G and 4G wireless devices that operate on licensed frequencies can also use the unlicensed frequencies set aside for WiFi.[54]

Cloud Computing

Cloud computing is a catch-all term that is popularly used to describe a range of information technology resources that are separately stored for access through a network, including the Internet. An Internet search on Google, for example, is using cloud computing to access a rich resource of data and information processing. Network connectivity to services is another resource provided by cloud computing. Google Inc., for example, offers word processing, e-mail, and other services through Google Docs. Although off-site data processing and information storage are not new concepts, cloud computing benefits from the significant advances in network technology and capacity that are hallmarks of the broadband era. Cloud computing can provide economies of scale to businesses of all sizes. Small businesses in particular can benefit from forgoing the costs of installing and managing hardware and software by buying what they need from the cloud. Consumers also can benefit because they no longer need to buy personal computers in order to run complex programs or store large amounts of data. The convergence of 4G wireless technology—with its smartphones and netbooks—and the growing accessibility of cloud computing to businesses and consumers alike will contribute to the predicted explosive growth in demand for wireless bandwidth.

Network-Centric Technologies

More efficient spectrum use can be realized by integrating adaptive networking technologies, such as dynamic spectrum access, with IP-based commercial network technologies such as LTE. Radios using DSA chipsets are more effective at managing interference and congestion than the

[52] A discussion of backhaul technology is part of the testimony of Ravi Potharlanka, Chief Operating Officer, Fiber Tower Corp., at House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications, Technology, and the Internet, "An Examination of Competition in the Wireless Industry," May 7, 2009.

[53] Unlicensed frequencies are bands set aside for devices approved by the FCC. The frequencies are effectively managed by the FCC instead of by a license-holder.

[54] "Wi-Fi Popular Now in Smartphones, Set to Boom," by Matt Hamblen, Computerworld, April 1, 2009.

channel management techniques currently in use. If a channel's link fails, the radio is cut off. When radios are networked using DSA, individual communications nodes continue to operate and can compensate for failed links. The effects of interference are manageable rather than catastrophic. The network is used to overcome radio limitations.

Adaptive networking has the potential to organize radio communications to achieve the same kinds of benefits that have been seen to accrue with the transition from proprietary data networks to the Internet. Adaptive technologies are designed to use pooled spectrum resources. Pooling spectrum licenses goes beyond sharing. Licenses are aggregated and specific ownership of channels becomes secondary to the common goal of maximizing network performance.

The Department of Defense (DOD) is working to implement network-centric operations (NCO) through a number of initiatives.[55] Leadership and support to achieve DOD goals in the crucial area of spectrum management is provided by the Defense Spectrum Organization (DSO) created in 2006 within the Defense Information Systems Agency (DISA). The DSO is leading DOD efforts to transform spectrum management in support of future net-centric operations and warfare, and to meet military needs for dynamic, agile, and adaptive access to spectrum. The DSO is guiding DOD spectrum management along a path that envisions moving away from stove-piped systems to network-centric spectrum management and, ideally, to bandwidth on demand and cognitive self-synching spectrum use.

Among the steps to advance toward the goal of spectrum access that is fully adaptable to any situation is the testing of network-centric technologies developed by the Defense Advanced Research Projects Agency (DARPA) within the Wireless Network After Next (WNaN) program. WNaN is evaluating DSA, Disruptive Tolerant Networking, and other tools, possibly to replace the existing Joint Tactical Radio System (JTRS) now in use. JTRS uses software-programmable radios to provide interoperability, among other features.[56]

[55] A discussion of the goals of NCO is included in CRS Report RL32411, *Network Centric Operations: Background and Oversight Issues for Congress*, by Clay Wilson.

[56] Information at http://jpeojtrs.mil/.

Appendix B. Competition

In formulating spectrum policy, mainstream viewpoints generally diverge on whether to give priority to market economics or social goals. Regarding access to spectrum, economic policy looks to harness market forces to allocate spectrum efficiently, with spectrum license auctions as the driver. Social policy favors ensuring wireless access to support a variety of social objectives where economic return is not easily quantified, such as improving education, health services, and public safety. Both approaches can stimulate economic growth and job creation.

The National Broadband Plan (NBP) has concluded that an effective way to improve competition among wireless broadband providers is to increase the amount of spectrum available.[57] This approach was validated by a number of filings with the FCC; for example, the Department of Justice provided arguments as to why the "primary tool for promoting broadband competition should be freeing up spectrum."[58]

One of the management tools available to the FCC is its power to assign spectrum licenses through auctions. Auctions are regarded as a market-based mechanism for rationing spectrum rights. Economy of scale in wireless communications has increasingly become an important determinant in the outcome of these auctions. Companies that have already made substantial investments in infrastructure have been well placed to maximize the value of new spectrum acquisitions. Corporate mergers and acquisitions represent another way to improve scale economies. Efficiencies through economy of scale have contributed to creating a market for wireless services where four companies—Verizon Wireless LLC, AT&T Inc., Sprint Nextel Corporation, and T-Mobile USA Inc.—had approximately 90% of the customer base of subscribers at the end of 2010. These companies also own significant numbers of spectrum licenses covering major markets nationwide.

The leading position of these few companies in providing a critical distribution channel—wireless—for information and services may need to be considered in plans for national broadband deployment. One approach to ensuring wireless access to meet national broadband goals might be to tighten the regulatory structure under which wireless communications are managed. Other approaches might seek ways to modify spectrum policies to increase market competition and to accommodate the age of broadband.

In evaluating competition within an industry, economists and policy makers examine barriers to entry, among other factors.[59] Barriers might come from high costs for market entry such as investment in infrastructure or there might be legal and regulatory barriers to entry. As part of its evaluation of competition for mobile services, the FCC has identified three factors that could constitute barriers to entry to the commercial mobile communications industry. These barriers affect not only competitiveness but also access to networks and investment in new technology. The factors are "first-mover advantages, large sunk costs, and access to spectrum."[60] All three of

[57] *Connecting America*, Chapter 5.1.

[58] *Ex Parte* Submission of the United States Department of Justice, In the matter of Economic Issues in Broadband Competition: A National Broadband Plan for Our Future, GN Docket 09-51, January 4, 2010, p. 21 at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020355122.

[59] For example, U.S. Department of Justice and the Federal Trade Commission, "Horizontal Merger Guidelines," Jointly issued April 2, 1992, revised April 8, 1997.

[60] FCC, "Wireless Telecommunications Bureau Seeks Comment on Commercial Mobile Radio Services Market (continued...)

these factors are subject to regulations that have been influenced by past or existing policies regarding spectrum allocation and assignment.

First-mover advantages[61] have accrued primarily to the early entrants in the wireless industry. Early in the development of the cell phone industry, the FCC created cellular markets and assigned two spectrum licenses to each market; one license went automatically to the incumbent provider in that market. The second license was made available to a competing service provider (not the market incumbent); the difficulties in choosing the competitors that would receive licenses contributed to the subsequent move to auctions as a means for assigning spectrum rights.[62] These early entrants, and the successor companies that acquired them and their licenses, have maintained their core customer base and benefit from early investments in infrastructure. Many first movers into the wireless market, therefore, acquired their market-leader status through regulatory decisions that provided them with spectrum licenses, not through market competition.

Large sunk costs refer to the high levels of investment needed to enter the wireless market. Not including the price of purchasing spectrum, billions of dollars are required to build new infrastructure. The sunk costs of incumbent wireless service providers set a high bar for new entrants to match if they are to compete effectively in major markets. In the mobile telephone industry, the FCC has observed that most capital expenditures are spent on existing networks: to expand and improve geographic coverage; to increase capacity of existing networks; and to improve network capabilities. Performance requirements for spectrum license-holders, such as the size of a market that must be served or deadlines for completing infrastructure build-outs, are some of the policy decisions that can add to the cost of entry.

Spectrum Auctions and Competition

The FCC, acting on the statutory authority given to it by Congress, has broad regulatory powers for spectrum management. The FCC was created as part of the Communications Act of 1934[63] as the successor to the Federal Radio Commission, which was formed under the Radio Act of 1927.[64] The first statute covering the regulation of airwaves in the United States was the Radio Act of 1912, which gave the authority to assign usage rights (licenses) to the Secretary of the Department of Commerce and Labor.[65] Licensing was necessary in part because, as radio communications grew, it became crucial that frequencies be reserved for specific uses or users, to minimize interference among wireless transmissions.[66] A key component of spectrum policy is the

(...continued)

Competition," Public Notice, February 25, 2008, DA 08-453, WT Docket No. 08-27 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-453A1.pdf. Earlier annual reports have also cited these barriers.

[61] The initial occupant of a market segment may benefit from a number of advantages such as preemption of resources, advantageous relationships with customers and suppliers, and early profits for reinvestment in infrastructure.

[62] The distribution of licenses for cell phone networks from the early days of the technology until the introduction of auctions is described in *Wireless Nation: The Frenzied Launch of the Cellular Revolution in America*, by James B. Murray, Jr., Perseus Press, 2001, 2002.

[63] 47 U.S.C. §151.

[64] P.L. 632, §3.

[65] P.L. 264, "License."

[66] An "Act to regulate radio communications," usually referred to as the Radio Act of 1912, was passed partly in response to radio problems—including interference—associated with the sinking of the *Titanic*. Hearings Before a Subcommittee of the Committee on Commerce, 62nd Congress, 2nd Session, pursuant to S. Res. 283, "Directing the (continued...)

allocation of bands of frequencies for specific uses and the assignment of licenses within those bands. Allocation refers to the decisions, sometimes reached at the international level, that set aside bands of frequencies for categories of uses or users; assignment refers to the transfer of spectrum rights to specific license-holders.

Auctions are regarded as a market-based mechanism for assigning spectrum. The FCC was authorized to organize auctions to award spectrum licenses for certain wireless communications services in the Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66). The act amended the Communications Act of 1934 with a number of important provisions affecting the availability of spectrum. The Licensing Improvement section[67] of the act laid out the general requirements for the FCC to establish a competitive bidding methodology and consider, in the process, objectives such as the development and rapid deployment of new technologies.[68] The law prohibited the FCC from making spectrum allocation decisions based "solely or predominately on the expectation of Federal revenues...."[69] The Emerging Telecommunications Technologies section[70] directed the NTIA to identify not less than 200 MHz of radio frequencies used by the federal government that could be transferred to the commercial sector through auctions.[71] The FCC was directed to allocate and assign these released frequencies over a period of at least 10 years, and to reserve a significant portion of the frequencies for allocation after the 10-year time span.[72] Similar to the requirements for competitive bidding, the FCC was instructed to ensure the availability of frequencies for new technologies and services, and also the availability of frequencies to stimulate the development of wireless technologies.[73] The FCC was further required to address "the feasibility of reallocating portions of the spectrum from current commercial and other non-federal uses to provide for more efficient use of spectrum" and for "innovation and marketplace developments that may affect the relative efficiencies of different spectrum allocations."[74] Over time, auction rules have been modified in accordance with the changing policy goals of the FCC and Congress but subsequent amendments to the Communications Act of 1934 have not substantively changed the above-noted provisions regarding spectrum allocation.[75]

The rules set by the FCC for using spectrum licenses (service rules) may have been oriented toward the concepts of building and managing networks that were formed in the days of the telephone, favoring traditional telecommunications business plans over those of companies with different business models. Some companies that might be well suited to meet social goals, such as access in rural areas, might have been precluded from bidding at all because of constraints not considered relevant to market-driven allocations. For example, public utilities, municipal co-operatives, commuter railroads, and other public or quasi-public entities face a variety of legal,

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Committee on Commerce to Investigate the Cause Leading to the Wreck of the White Star Liner 'Titanic,'" testimony of Guglielmo Marconi et al.

[67] P.L. 103-66 Title III, Subtitle C, Chapter 1.

[68] 47 U.S.C. §309 (j), especially (1), (3), and (4).

[69] 47 U.S.C. §309 (j) (7) (A).

[70] P.L. 103-66 Title III, Subtitle C, Chapter 2.

[71] 47 U.S.C. §923 (b) (1).

[72] 47 U.S.C. §925 (b) (1).

[73] 47 U.S.C. §925 (b) (2).

[74] 47 U.S.C. §925 (b) (3).

[75] See United States Code Annotated, Title 47, sections as footnoted, WEST Group, 2001 and the 2007 Cumulative Annual Pocket Part.

regulatory, and structural constraints that limit or prohibit their ability to participate in an auction or buy spectrum licenses. Many of these constraints exist at the state level but federal spectrum policy plays a role in perpetuating the status quo.

Auction winners are deemed to be the companies that can maximize the value of the spectrum to society by maximizing its value as a corporate asset. However, auction-centric spectrum policies appear to have generally focused on assigning licenses to commercial competitors in traditional markets that serve consumers and businesses. Auctioning spectrum licenses may direct assets to end-use customers instead of providing wireless services where the consumer may be the beneficiary but not the customer. Wireless networks are an important component of smart grid communications. Spectrum resources are also needed for railroad safety,[76] for water conservation,[77] for the safe maintenance of critical infrastructure industries,[78] and for many other applications that may not have an immediate commercial value but can provide long-lasting value to society as a whole.

Spectrum Caps

As part of its preparations for the first spectrum license auctions, the FCC decided to set caps on the amount of spectrum any one company could control in any geographically designated market.[79] The theory behind spectrum capping is that each license has an economic value and a foreclosure value. The economic value is derived from the return on investment in spectrum licenses and network infrastructure. The foreclosure value is the value to a wireless company that already has substantial market share and wants to keep its dominant position by precluding competition. Spectrum caps were chosen as the method to prevent foreclosure bidding. The intent was to ensure multiple competitors in each market and to restrict bidding to only the licenses that could be used in the near term.

Beginning in 2001, spectrum policy placed increased emphasis on promoting spectrum and market efficiency through consolidation. The FCC ruled to end spectrum caps, citing greater spectral efficiency from larger networks as one benefit of the ruling. Spectrum caps were seen as barriers to mergers within the wireless industry, to the growth of existing wireless companies, and to the benefits of scale economies. The spectrum caps were eliminated on January 1, 2003.[80] Auction rules requiring the timely build-out of networks became a key policy tool to deter hoarding. The FCC instituted a policy for evaluating spectrum holdings on a market-by-market, case-by-case basis—a practice referred to as spectrum screening—as a measure of competitiveness.

[76] The railroad industry uses wireless communications as part of their information networks to monitor activity.

[77] For example, sensors buried at the level of plant roots recognize when watering is needed and communicate this information over wireless networks.

[78] In general, critical infrastructure industries facilitate the production of critical goods and services such as safe drinking water, fuel, telecommunications, financial services, and emergency response. A discussion of key issues appears in CRS Report RL30153, *Critical Infrastructures: Background, Policy, and Implementation*, by John D. Moteff.

[79] Licenses are designated for a specific geographic area, such as rural areas, metropolitan areas, regions, or the entire nation.

[80] FCC News, "FCC Announces Wireless Spectrum Cap to Sunset Effective January 1, 2003," November 8, 2001. Report and Order FCC-01-328. See Docket No. 01-14, *Notice of Proposed Rulemaking*, released January 23, 2001, at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-01-28A1.pdf.

In 2008, the Rural Telecommunications Group, Inc. (RTG) petitioned the FCC to impose a spectrum cap of 110 MHz for holdings below 2.3 GHz. In October 2008, the FCC sought comments on the RTG petition for rulemaking.[81] RTG argued that competition in the industry was declining as it became more concentrated. It claimed that the larger carriers were warehousing their spectrum holdings in rural areas while rural carriers were struggling to acquire spectrum capacity for mobile broadband and expansion. Rural carriers, RTG reported, were being shut out of opportunities to acquire new spectrum holdings and were being outbid in spectrum auctions.[82] Opponents to the spectrum cap cited data to support their claims that the wireless communications market is competitive. They argued that additional amounts of spectrum are needed to support the growth in mobile broadband and that a spectrum cap could cut off growth and innovation.[83] Implementing spectrum caps as a tool for regulating competition would represent a significant shift in policy for the FCC, were it to take that course.

In comments filed regarding the National Broadband Plan, the Department of Justice considered the possibility that "the foreclosure value for incumbents in a given locale could be very high."[84] Although it recognized some form of spectrum caps as an option for assuring new market entrants, it observed that "there are substantial advantages to deploying newly available spectrum in order to enable additional providers to mount stronger challenges to broadband incumbents."[85]

Market Competition

There are many ways to view competition. Although competitiveness may be evaluated by factors such as barriers to entry or number of market participants, a key measure of whether market competition is working is an assessment of the dynamic of a specific market: its prices, variety, level of service, and other indicators that are considered hallmarks of competitive behavior. The Federal Trade Commission, for example, promotes competition as "the best way to reduce costs, encourage innovation, and expand choices for consumers."[86] Viewpoints about the level of competitiveness in providing wireless services to the U.S. market differ.[87] However, telecommunications business analysts generally describe the U.S. market for wireless services as competitive because consumers benefit in many ways from competition on price, service, coverage, and the availability of new devices.

[81] FCC RM No. 11498, October 10, 2008. Comments supporting and opposing the petition are published in this proceeding.

[82] Those supporting the RTG petition included the Organization for the Promotion and Advancement of Small Telecommunications Companies (OPASTCO), the National Telecommunications Cooperative Association, the Public Interest Spectrum Coalition, and a number of smaller (non-dominant) wireless carriers.

[83] Opponents to spectrum caps that filed comments were AT&T Inc., Verizon Wireless, CTIA—The Wireless Association, the Telecommunications Industry Association, and the Wireless Communications Association International.

[84] *Ex Parte* Submission of the United States Department of Justice, In the matter of Economic Issues in Broadband Competition: A National Broadband Plan for Our Future, GN Docket 09-51, January 4, 2010, p. 23 at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020355122.

[85] Ibid., p. 24.

[86] "Competition in the Technology Marketplace" at http://www.ftc.gov/bc/tech/index.htm.

[87] Different assessments of competition in the wireless market have been filed as comments in FCC Docket No. 09-66, part of the process for the preparation of the FCC's *Fourteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services.*

Both the wireless industry and its regulator have focused on "wireless consumer welfare"[88] in evaluating competition and the effectiveness of spectrum policies for assigning spectrum licenses. Auctions are judged to be an efficient way of assigning spectrum for commercial uses that adhere to traditional business plans.[89]

Competition in Rural Markets

Over the years, various legislative and policy initiatives have created a number of requirements to help small and rural carriers acquire spectrum licenses.[90] Some of the FCC's efforts to encourage spectrum license ownership for small, rural, or entrepreneurial businesses are in response to congressional mandates.[91] These and other statutory and regulatory programs may have allowed many small carriers to remain in business even though many others have been absorbed by larger carriers.[92] As wireless traffic, revenue, and profits migrate to broadband, business models that were effective for voice traffic may no longer be viable, especially for companies that have relied on the regulatory environment to protect their markets. This change in operating environment may have disproportionately affected the ability of rural wireless carriers, in particular, to compete effectively.[93] A study of how new technologies might be affecting the competitiveness of small and rural carriers might be useful in reviewing the effectiveness of policies intended to aid them.[94]

[88] This phrase is used in the written statement of AT&T Inc. submitted for a hearing before the House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications, Technology, and the Internet, "An Examination of Competition in the Wireless Industry," May 7, 2009. In written testimony submitted by Verizon Wireless for the same hearing, comments stated that wireless providers need suitable and sufficient spectrum because of "consumers' reliance on broadband services."

[89] The GAO has reported this viewpoint in several reports, including *Telecommunications: Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*," December 20, 2005, GAO-06-236 and *Telecommunications: Options for and Barriers to Spectrum Reform,* March 14, 2006, GAO-06-526T.

[90] For example, most auctions have provided bidding credits for small businesses.

[91] In 47 USC §309 (j) (3) (B), the FCC is instructed to promote "economic opportunity and competition and ensuring that new and innovative technologies are readily available to the American people by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants...."

[92] The Congressional Budget Office (CBO) reported in a 2005 study that a significant number of small companies that acquired spectrum licenses through preferential programs later transferred the licenses to larger companies*: Small Businesses in License Auctions for Wireless Personal Communications Services*, A CBO Paper, October 2005, at http://www.cbo.gov/ftpdocs/68xx/doc6808/10-24-FCC.pdf.

[93] A number of rural wireless carriers and their associations have filed comments on the increasing difficulties they face in competing for wireless customers. Comments are in a number of FCC dockets, such as RM11498, regarding spectrum caps, and WT Docket No. 09-66, on the state of wireless competition.

[94] The CBO study cited above was prepared at the request of the Senate Budget Committee to examine the impact of small-bidder preferences on federal revenue and was completed before data traffic became a significant factor in providing wireless services.

Appendix C. International Policies for Spectrum Management

Wireless companies also compete as providers in global markets. Although international traffic may be a small part of wireless voice communications, competition in providing services is global.[95] AT&T, Verizon, and T-Mobile are major players internationally as well as in the United States.[96] Corporate decisions such as the introduction of new technologies and services are made for both the United States and international markets. Actions taken for domestic markets may influence decisions made to enhance global competition and vice versa. Therefore, policies for assigning spectrum assets might incorporate U.S. goals for global competiveness.

Spectrum allocation is not a uniquely domestic process. Some spectrum allocations are governed by international treaty. Additionally, there is a trend to harmonize spectrum allocations for commercial use across countries through international agreements. Harmonization of radio frequencies is achieved by designating specific bands for the same category of use worldwide. With harmonization, consumers and businesses are able to benefit from the convenience and efficiency of having common frequencies for similar uses, thus promoting development of a seamless, global communications market. Spectrum allocation at the national level, therefore, is sometimes coordinated with international spectrum allocation agreements. The Advanced Wireless Services (AWS) auction in the United States, completed in 2006,[97] was the conclusion of a process initiated by an agreement for international harmonization of spectrum bands.[98] At this auction, T-Mobile was able to acquire new spectrum licenses that improved its competitiveness in the United States[99] and, consequently, the worldwide competiveness of its owner, Deutsche Telekom.[100]

The International Telecommunications Union (ITU), the lead United Nations agency for information and communication technologies, has been vested with responsibility to ensure interference-free operations of wireless communication through implementation of international agreements.[101] The ITU adopts a Table of Frequency Allocations in conjunction with International Radio Regulations. This International Table allocates spectrum for various radio services and

[95] The international framework for spectrum management and wireless competition is summarized in **Appendix C**, International Policies for Spectrum Management.

[96] Verizon Wireless is 45% owned by the British telecommunications giant Vodafone, PLC. T-Mobile is 100% owned by Deutsche Telecom.

[97] FCC News, "FCC's Advanced Wireless Services (AWS) Spectrum Auction Concludes," September 18, 2006.

[98] The WRC-2000 agreed on spectrum bands to be harmonized for advanced wireless services, referred to as IMT 2000. See FCC News, "International Bureau Reports on Success of the 2000 World Radio Communications Conference," June 8, 2000, http://www.fcc.gov/Bureaus/International/News_Releases/2000/nrin0009.html.

[99] FCC, *Twelfth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, Docket No. 07-71, released February 4, 2008, p. 9 and paragraph 75, at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-453A1.pdf.

[100] Deutsche Telekom owns 100% of T-Mobile International, which includes T-Mobile USA. For information see "Global Player on the Mobile Communications Market" at http://www.telekom.com/dtag/cms/content/dt/en/530494.

[101] The GAO notes that "The federal government considers ITU the principal, competent, and appropriate international organization for the purpose of formulating international treaties and understandings regarding certain telecommunications matters*." Better Coordination and Enhanced Accountability Needed to Improve Spectrum Management*, GAO-02-906, September 2003, p. 19, fn. 26.

includes, directly or indirectly, conditions for the use of the allocated spectrum.[102] There is also a domestic table for each country. The United States Table of Allocations is maintained by the National Telecommunications and Information Administration (NTIA). The U.S. Table of Allocations is modified to correspond with changes in international spectrum allocations agreed to under the auspices of the ITU. These agreements are reached through processes such as the World Radiocommunications Conferences (WRC). Each WRC provides an opportunity to revise the International Radio Regulations and International Table of Frequency Allocations in response to changes in technology and other factors. Modifications to rules from one WRC to the next are part of an ongoing process of technical review and negotiations. WRC meetings are held approximately every two years. Provisions that require changes in frequency allocation to accommodate new technology will typically take effect 10 to 15 years after agreement is reached. These delays give time to phase out older technologies and to formulate new investment strategies.

The possibility of allocating additional spectrum for mobile broadband was among the deliberations of WRC-07 (October 22-November 16, 2007) and may be considered at the next WRC, scheduled to be held in January 2012.[103] Future decisions about spectrum allocation for broadband in the United States might be influenced by international agreements. Worldwide harmonization of frequencies for mobile broadband may be sought in bands at 3 GHz and higher.

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[102] There are 39 internationally defined wireless services, including broadcasting, meteorological satellite, and mobile services. Description of ITU-R functions are at http://www.itu.int/ITU-/index.asp?category=information&rlink=rhome&lang=en.

[103] The NTIA and FCC websites carry information about planning for WRC 2012. For FCC, see IB Docket No. 04-286, Public Notice at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-763A1.pdf. An NTIA overview is at http://www.ntia.doc.gov/osmhome/wrc/ntia.html. The ITU site is at http://www.itu.int/ITU-R/index.asp?category=conferences&rlink=wrc-11&lang=en.