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## RECLAIMING FEDERAL SPECTRUM
## Proposals and Recommendations

by Brent Skorup

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## Abstract

With the popularity of smartphones, tablets, Wi-Fi, and other wireless devices that require as an input transmissions over radio spectrum, the rising demand for bandwidth is rapidly using up the available supply of spectrum. Spectrum demand increases significantly every year with no end in sight, yet the "greenfields" of available and unallocated spectrum are gone. Redeployed spectrum must come from incumbent users. Today, the largest holder of spectrum appropriate for mobile broadband is the federal government, which uses spectrum for a variety of military and nonmilitary uses. Federal users generally use spectrum only lightly and the inefficiencies have triggered bipartisan calls for selling the spectrum used by federal agencies to the private sector, particularly to mobile broadband carriers. To date, reclaiming federal spectrum is a painfully slow process and billions of dollars of social welfare are lost with every year of delay. This paper examines proposals for reclaiming spectrum and puts forth some best practices to ensure more efficient use of spectrum. Policymakers should consider creating a commission with authority to require the sale of spectrum so that agency-controlled spectrum is quickly and easily redeployed to its highest-valued uses. In the long run, Congress should also require agencies to pay for the spectrum they possess, just as agencies pay market prices for other inputs.

***JEL* codes:** K00, K2, K23, K11, L50

**Keywords:** radio spectrum, wireless, FCC, NTIA, PCAST, reallocation, mobile broadband, regulation, policy, economics, smartphones, technology

**Reclaiming Federal Spectrum: Proposals and Recommendations**

Brent Skorup

## I. Introduction

The consumer demand in recent years for mobile broadband services—such as streaming Netflix, voice-over Internet Protocol, and Facebook use—is unprecedented and strains the current capacity of wireless carriers. Building out cell towers and networks increases capacity, but increasing the supply of radio spectrum is much more cost-efficient. These realities have caused telecommunications policymakers in the past decade to seriously reexamine spectrum management. A growing consensus among experts is that federally held spectrum is lightly used and would be better redeployed for commercial uses that accommodate consumer demands and expand the US economy. President Obama and his Federal Communications Commission (FCC) appointees have prioritized, at some political risk, making substantial amounts of spectrum, including spectrum currently used by federal agencies and the military, available for wireless broadband use. This paper discusses the history of spectrum management and the commercial and federal uses of the radio frequencies. Several policy proposals for reclaiming federal spectrum are presented, along with recommendations for rationalizing spectrum management.

## II. History of Radio Spectrum Allocation

Today the FCC and the president share spectrum management authority. The 1934 Communications Act gives the FCC authority to assign spectrum for commercial users[1] and gives the president authority to regulate government spectrum.[2] Presidents delegate this authority to the Department of Commerce, and specifically to the National Telecommunications and

[1] 47 U.S.C. § 151 et seq.
[2] 47 U.S.C. § 305.

Information Administration (NTIA).[3] Whether a band becomes "federal" or "nonfederal" spectrum is settled by informal agreement between the FCC and the NTIA.[4]

For well over a century, individuals and governments have been using radio spectrum for communications and services. Since Heinrich Hertz's first experiments with radio waves in the 1880s, people have intensively used the frequencies.[5] When governments at the beginning of the 20th century first realized that spectrum was valuable and scarce (in the economic sense), many seized spectrum as the exclusive property of the state.[6] Instead of keeping all spectrum as government property, in the years following World War I the US government segregated government-controlled spectrum and privately controlled spectrum and treated privately controlled spectrum as the collectively owned property of all Americans, with the federal government merely assuring orderly use of spectrum so as to prevent interference. Before the 1927 Radio Act, radio licensing was mostly a matter of citizens registering their use with the Department of Commerce.[7] The department had no authority to reject applications to broadcast on the airwaves.

This laissez-faire approach to regulation ended in the 1920s. By 1923, a technological marvel—broadcast radio—was sweeping the country. Consumers and the broadcasting industry

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[3] Department of Commerce, NTIA Publication 91-23, U.S. Spectrum Management Policy: An Agenda for the Future 17 (1991). Practically speaking, the Interdepartmental Radio Advisory Committee, which advises the NTIA, determines most federal spectrum policy. Its members, notably the Department of Defense, have substantial political power. MICHAEL J. MARCUS, NEW APPROACHES TO PRIVATE SECTOR SHARING OF FEDERAL GOVERNMENT SPECTRUM 2, New America Foundation Brief No. 26 (2009), http://www.newamerica.net/files/Marcus_IssueBrief26_SharingGovtSpectrum.pdf.

[4] Department of Commerce, NTIA Publication 91-23, U.S. Spectrum Management Policy: An Agenda for the Future 17 (1991).

[5] Hugh G. J. Aitken, *Allocating the Spectrum: The Origins of Radio Regulation*, 35 Tech. & Culture 686, 686 (1994).

[6] Elizabeth Kruse, *From Free Privilege to Regulation: Wireless Firms and the Competition for Spectrum Rights before World War I*, 76 Bus. Hist. R. 659, 661 (2002); Hugh G. J. Aitken, *Allocating the Spectrum: The Origins of Radio Regulation*, 35 Tech. & Culture 686, 688 (1994). In Britain, Germany, France, and Italy, for instance, the navies controlled wireless spectrum.

[7] Hugh G. J. Aitken, *Allocating the Spectrum: The Origins of Radio Regulation*, 35 Tech. & Culture 686, 688 (1994); Jora Minasian, *The Political Economy of Broadcasting in the 1920s*, 12 J. L. & Econ. 391, 393 (1969).

demanded more radio spectrum, so Congress reassigned a large portion of then-usable spectrum for commercial broadcast use, over the strenuous objections of the US Navy, which was using some of that spectrum.[8] Previously fallow spectrum became intensively used as technology improved,[9] and a new legal framework was needed to accommodate the onslaught of commercial broadcast use of radio frequencies.[10]

Courts began giving broadcasters property-like rights to use the frequencies in the 1920s, provoking Congress, at the direction of Secretary of Commerce Herbert Hoover, to pass a major new law making spectrum public property and subject to substantial regulation.[11] The ensuing 1927 Radio Act was not only a framework for commercial broadcast but an extensive regulatory regime for the management of all radio spectrum.[12] Perhaps because the rise of broadcast radio coincided with the Progressive Era, the 1927 Radio Act excessively "zoned" the frequencies according to administrative determinations of social "need" and nebulous conceptions of the "public interest."[13] In the decades that followed, the FCC held hearings and determined what wireless services were needed and how much spectrum those services required (called

[8] Hugh G. J. Aitken, *Allocating the Spectrum: The Origins of Radio Regulation*, 35 Tech. & Culture 686, 695 (1994).
[9] Namely, the development of the vacuum tube transmitter. Glen O. Robinson, Spectrum Management Policy in the United States: An Historical Account 12, OPP Working Paper Series (1985).
[10] Apparently commercial broadcast use was the sole regulatory issue. Both government users and amateur users reported in the 1920s that there were few interference problems. Glen O. Robinson, Spectrum Management Policy in the United States: An Historical Account 20, OPP Working Paper Series (1985).
[11] Senator Dill, the architect of the 1927 Radio Act, said that the possibility of private actors gaining vested rights in spectrum—which at least one state court had granted—was what compelled the Congress to make it the public's property. *See* Tribune Co. v. Oak Leaves Broadcast Station, Ct. Crt. Cook County, Illinois (1926); Hoover v. Intercity Radio Co., 286 Fed. 1003 (App. D.C. 1923). *See also* Jora Minasian, *The Political Economy of Broadcasting in the 1920s*, 12 J. L. & Econ. 391, 395 (1969).
[12] Glen O. Robinson, Spectrum Management Policy in the United States: An Historical Account 21, OPP Working Paper Series (1985).
[13] *See* Bruce M. Owen, The Internet Challenge to Television 82 (1999) ("For three-quarters of a century, the federal government has specified in great detail the way in which the airwaves can be used, for what purpose, and by whom. These rules run 1330 pages in the Code of Federal Regulations, and every one of them affects the ability of communication firms to compete and to adopt innovative methods of using the airwaves. And yet no change is possible without the elaborate and ponderous process of winning the government's approval."); Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J. L. & Tech. 335, 359 (2001).

"allocation"), and then distributed that spectrum (called "assignment") at no cost to approved licensees.[14] The Supreme Court later justified the severe regulation of spectrum because the frequencies are a "scarce resource whose use could be regulated and rationalized only by the Government."[15]

However, economist Ronald Coase famously explained in 1959 why this reasoning is faulty: virtually all resources are scarce.[16] Scarcity of spectrum is not a justification for government allocation of spectrum over market allocation any more than the scarcity of beef, grain, and fruit justifies government allocation of groceries:[17]

> It is true that some mechanism has to be employed to decide who, out of many claimants, should be allowed to use the scarce resource. But the way this is usually done in the American economic system is to employ the price mechanism.[18]

Coase's ideas slowly gained support in the ensuing decades, first among academics and then from policymakers.[19] Spectrum, like real property, is most efficiently used when in the hands of private users who (a) internalize the benefits and costs of deploying the input, and (b) can later sell it to parties who value it more.[20] The FCC has adopted Coase's market-based

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[14] John McMillan, *Selling Spectrum Rights*, 8 J. Econ. Persp. 145, 146–47 (1994).
[15] NBC v. U.S., 319 U.S. 190, 212–13 (1943). *See also* Red Lion Broadcasting Co. v. FCC, 395 U.S. 367, 375–76 (1969).
[16] Ronald H. Coase, *The Federal Communications Commission*, 2 J. L. & Econ. 1 (1959).
[17] Ronald H. Coase, *The Federal Communications Commission*, 2 J. L. & Econ. 1 (1959). *See* Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J. L. & Tech. 25, 27 (2002) (citing Coase and expressing the idea that scarcity is the normal condition of all economic goods).
[18] Ronald H. Coase, *The Federal Communications Commission*, 2 J. L. & Econ. 1, 14 (1959).
[19] Ronald Coase, upon testifying in Congress in 1959 that spectrum licenses should be auctioned, was asked if his proposal was "a big joke," and Rand refused to publish his paper on the subject. Ronald H. Coase, *Comment on Thomas W. Hazlett: Assigning Property Rights to Radio Spectrum Users: Why Did FCC Licenses Auctions Take 67 Years*, 41 J. L. & Econ. 577, 579–80 (1998). When lotteries for licenses (which were less revolutionary than auctions) were considered in the mid-1970s, two FCC commissioners opined that adoption of lotteries garnered the same odds "as those on the Easter Bunny in the Preakness." Surely the odds of auctions were even worse. In the Matter of Formulation of Policies Relating to the Broadcast Renewal Applicant, Stemming from the Comparative Hearing Process, FCC 77-204, Dkt. No. 19154, *Report and Order*, 66 FCC2nd 419, 434 n.2 (1977).
[20] *See* Harold Furchtgott-Roth, Granting Licensed Spectrum Flexibility: How to Spur Economic Growth and Innovation in America, Hudson Institute Briefing Paper (2012), http://www.hudson.org/files/publications/HFR --SpectrumFlexibility--Dec12.pdf; Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J. L. & Tech. 25, 29-30 (2002) (citing the property rights and auctions framework as "the standard economists' view").

prescriptions to some extent. Congress limited the time-consuming allocation and assignment proceedings by amending the 1934 Communications Act in 1993 and authorizing the FCC to conduct spectrum auctions.[21] Yet the FCC still regulates most spectrum under the legal framework developed over 80 years ago.[22]

The NTIA, however, has not embraced Coase's view that the federal government should pay market rates for spectrum just as it pays market rates for other indispensable inputs. As in many countries,[23] the United States government possesses a majority of the most valuable bandwidth and pays virtually nothing for this natural resource.[24] Government Accountability Office (GAO) and other independent audits make it clear that federal spectrum is used ineffectively and that reforms are long overdue.[25] With increased consumer demands for new services requiring radio transmissions, it is urgent that some of the fallow federal spectrum be brought "online" and into the mobile broadband marketplace. This paper examines some of the proposals for reclaiming federal spectrum and makes recommendations about the path forward.

Two major spectrum management problems are addressed in the recommendations section. The first is that federal agencies receive almost no price signals that would encourage efficient use of this valuable input. The FCC and the NTIA gave federal users spectrum for free,

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[21] Pub. L. No. 103-66.
[22] Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, The Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J. L. & Tech. 335, 359 (2001) ("The basic structure for allocating radio waves is still that crafted in the Radio Act of 1927.") (citation omitted).
[23] For a discussion of the United Kingdom and Canada's experiences, see Martin Cave & Adrian Foster, Solving Spectrum Gridlock: Reforms to Liberalize Radio Spectrum Management, C.D. Howe Institute (2010). *See also* Kenneth R. Carter & J. Scott Marcus, Improving the Effectiveness and Efficiency of Spectrum Use by the Public Sector: Lessons from Europe 3, TPRC (2009), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1488852.
[24] Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan,* 64 Fed. Comm. L. J. 87, 130 (2011) (citing the NTIA that federal users exclusively occupy 14 percent of bands below 3.1 GHz and share an additional 54 percent of those bands).
[25] *See* section IV.

often decades ago, and from the agencies' perspective, it is a free resource.[26] The second problem is that there exists no reliable process for reclaiming federal spectrum and selling it for more productive commercial uses in the relatively short term (the next five to ten years). These agencies are institutionally reluctant to remit any of their spectrum for commercial use, and billions of dollars of social welfare are squandered annually as a result. This paper recommends the creation of an independent spectrum management commission that has the authority to relocate federal systems and transfer federal spectrum to commercial users through auction.

## III. The Rise of Mobile Broadband and the Spectrum Crunch

A diagram of electromagnetic spectrum usage resembles a diagram of the evolution of radio technology over time (see figure 1). The low end (around 3 kHz) is allocated for long-distance maritime signals, and at the high end (300 GHz) transmissions are used for radio astronomy applications, with most mass-market technologies—AM radio, broadcast television, FM radio, mobile phones, satellite television, and many other services—in between.[27] Each generation of technology stimulated more demand for spectrum and technological advancement brought higher and higher frequencies—once believed valueless—into commercial and federal use.[28] The band between approximately 300 MHz and 3 GHz is frequently called "beachfront" spectrum by

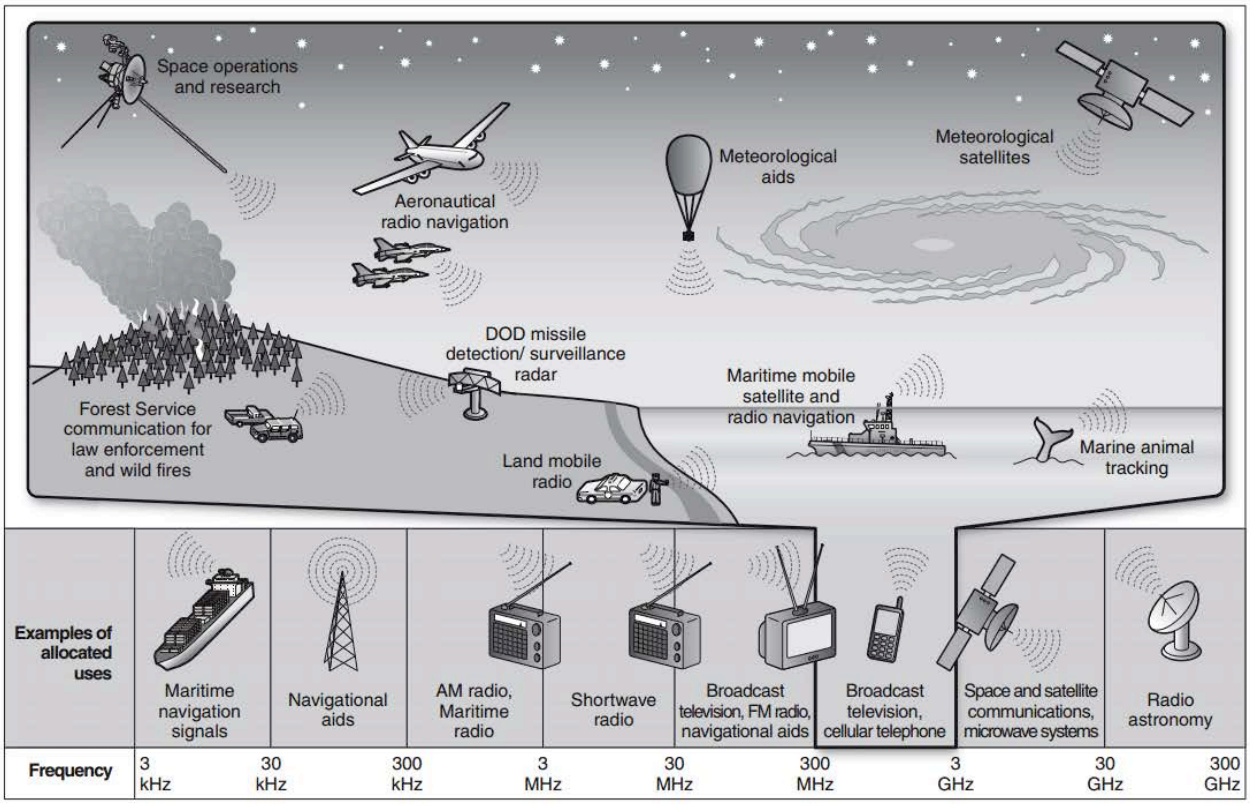
[26] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are The Options 23, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[27] *See* Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 5 Fig. 1, Congressional Report GAO-11-352 (2011). Frequencies up to 3000 GHz can transmit very low-power signals but are not included on International Telecommunications Union allocation tables and are not relevant for this discussion. *See* Michael Marcus, Where Does the Radio Spectrum End? (unpublished manuscript on file with author).

[28] Technological advances through time permitted higher and higher frequencies to be used for radio transmissions. However, signals in higher frequencies travel short distances and limit the practical viability of these high frequencies. Frequencies below 3 kHz are frequencies associated with acoustic sound waves and are unusable for electromagnetic transmissions. *See* Michael Marcus, Where Does the Radio Spectrum End? (unpublished manuscript on file with author).

wireless experts because transmissions in this bandwidth can travel long distances and through walls, making it highly desirable for wireless services like mobile phones, television broadcast, and mobile broadband.[29] Because of its favorable characteristics, this beachfront band is the focus of most proposals to reclaim federal spectrum. This 300 MHz to 3 GHz band will be the focus of this review as well.

**Figure 1. Illustration of Spectrum Allocations**




Source: GAO analysis of NTIA, federal agencies, and industry information. FCC Online Table of Frequency Allocations (2013), 47 C.F.R. § 2.106, http://transition.fcc.gov/oet/spectrum/table/fcctable.pdf.

[29] Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan*, 64 Fed. Comm. L. J. 87, 130 (2011); Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 9, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf (remarking on the valuable spectrum below 3 or 4 GHz).

The FCC has raised tens of billions of dollars through spectrum auctions in the beachfront bands, which began in the mid-1990s.[30] These are substantial sums, but the consumer and social value of today's wireless ecosystem dwarfs the auction values.[31] Tremendous economic losses occur, however, when spectrum is withheld from sale. Economists estimate the economic losses from misallocation of existing spectrum, which could be deployed for more valuable uses like mobile broadband, are hundreds of billions of dollars annually.[32] The losses from innovation are not amenable to economic calculation, but Harold Furchtgott-Roth, a former FCC commissioner, estimates they may be even greater than the substantial losses arising from zoning spectrum and not auctioning it.[33] He notes that many American firms—such as Cisco, Qualcomm, Apple, Google, Amazon, and Twitter—have a disproportionate role in driving economic value and innovation in one of the few bright spots in the US economy—the wireless sector.[34] Consumers and the economy suffer because spectrum is zoned inefficiently and possessed at virtually no cost to federal agencies. There needs to be a way of discovering the existence of and reclaiming lightly used spectrum.

[30] Thomas W. Hazlett & Roberto E. Munoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. Econ. 424, 425 (2002).
[31] A 2009 study estimated that the wireless phone market yields over $150 billion in consumer value annually. Thomas W. Hazlett & Roberto E. Munoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. Econ. 424, 425 (2002).
[32] Thomas W. Hazlett & Roberto E. Munoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. Econ. 424, 425 (2002).
[33] Harold Furchtgott-Roth, Granting Licensed Spectrum Flexibility: How to Spur Economic Growth and Innovation in America 7, Hudson Institute Briefing Paper (2012), http://www.hudson.org/files/publications/HFR--Spectrum Flexibility--Dec12.pdf.
[34] Harold Furchtgott-Roth, Granting Licensed Spectrum Flexibility: How to Spur Economic Growth and Innovation in America 8, Hudson Institute Briefing Paper (2012), http://www.hudson.org/files/publications/HFR--Spectrum Flexibility--Dec12.pdf.

Scholars and the government noted the perpetual demand for more wireless communications services since the creation of mass-market cell phones in the 1990s,[35] but scarcity has been a constant in spectrum policy from the very beginning.[36] As one scholar put it,

> Over the last hundred years, the demand for spectrum, like the supply of spectrum, has skyrocketed. No matter how much new supply of spectrum comes on the market, demand seems to increase faster.[37]

Nevertheless, these demands have increased dramatically since the mid-2000s with the ubiquity of smartphones and tablets,[38] leading some to remark that "spectrum exhaustion is here to stay."[39] Cisco estimates that a single smartphone generates about as much mobile traffic as 50 traditional cellphones, and a tablet as much as 120 cellphones.[40] In 2008, 11 percent of US wireless subscribers had smartphones.[41] Midway through 2012, smartphone

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[35] Hugh G. J. Aitken, *Allocating the Spectrum: The Origins of Radio Regulation*, 35 Tech. & Culture 686, 714 (1994) (describing the brand new "explosive growth in the demand for cellular telephones, pagers, and other wireless communication services"). Aitken recorded that it was "commonplace to suggest that in the near future we will have more communications channels for our use than we know what to do with." Id. at 716. Clearly, that view was optimistic. *See also*, Department of Commerce, NTIA Publication 91-23, U.S. Spectrum Management Policy: An Agenda for the Future 13 (1991).

[36] Department of Commerce, NTIA Publication 91-23, U.S. Spectrum Management Policy: An Agenda for the Future 14 (1991) ("Those familiar with the history of spectrum management may find that the issues we have mentioned—crowded spectrum, excess demand, technology placing pressures on the system—seem familiar. Users, engineers, and politicians have struggled with similar spectrum management issues almost since the first practical application of radio."); Keith Bradsher, *The Elbowing Is Becoming Fierce for Space on the Radio Spectrum*, N.Y. Times (June 24, 1990), http://www.nytimes.com/1990/06/24/business/the-elbowing-is-becoming-fierce-for-space-on-the-radio-spectrum.html?pagewanted=all&src=pm ("For decades, debates have flared as inventors of new products sought access to allocated frequencies.").

[37] J. H. Snider, An Explanation of the Citizens' Guide to the Airwaves 30, New America Foundation (2003).

[38] David Goldman, *Sorry, America: Your Wireless Airwaves Are Full*, CNN Money, Feb. 21, 2012, http://money.cnn.com/2012/02/21/technology/spectrum_crunch/index.htm. Globally, mobile data traffic is expected to grow thirteenfold between 2012 and 2017. *See* Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017 3 (2013), http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf.

[39] T. Randolph Beard et al., *Wireless Competition Under Spectrum Exhaustion*, 65 Fed. Comm. L. J. 79, 96 (2013).

[40] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017 8-9 (2013), http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf.

[41] Charles Golvin, *2009: Year of the Smartphone—Kinda*, FORRESTER BLOGS (Jan. 4, 2010), http://blogs.forrester.com/consumer_product_strategy/2010/01/2009-year-of-the-smartphone-kinda.html.

ownership surged past 50 percent of subscribers.[42] Bandwidth demands will intensify as more consumers upgrade to 4G-capable devices, which consume even more data than non-4G devices since 4G makes more Internet applications usable.[43] Data-heavy applications like video streaming, using applications like YouTube, Netflix, and Hulu, have overwhelmed some networks and compelled carriers to look for technological improvements and additional spectrum to cater to consumer needs.

FCC Chairman Julius Genachowski has remarked, "Demand for spectrum is rapidly outstripping supply. The networks we have today won't be able to handle consumer and business needs."[44] Industry analysts estimate that there needs to be an *additional* 40 to 150 MHz per operator to meet rising demand.[45] In 2013 there are 608 MHz being used for mobile broadband,[46] and the ITU estimates that industrialized countries like the United States need around 1300–1700 MHz for mobile broadband by 2020.[47] While experts optimistically estimate that incentive auctions—authorized by Congress in 2012—will retrieve 120 MHz from television broadcasters,

[42] comScore, comScore Reports September 2012 U.S. Mobile Subscriber Market Share, Press Release (Nov. 2, 2012), http://www.comscore.com/Insights/Press_Releases/2012/11/comScore_Reports_September_2012_U.S._Mobile_Subscriber_Market_Share.

[43] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017 16 (2013), http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf ("Currently, a 4G connection generates 19 times more traffic than a non-4G connection.").

[44] George Krebs, *Chairman Genachowski: The Clock Is Ticking*, FCC Blog, Mar. 16, 2011, http://reboot.fcc.gov/blog?entryId=1339071. Some, however, believe the spectrum crunch is exaggerated. *See* Phil Goldstein, *What Happened to the "Spectrum Crunch"?*, Fierce Wireless, Sep. 28, 2012, http://www.fiercewireless.com/story/what-happened-spectrum-crunch/2012-09-28. *But see* Tim Farrar, *The Myth of the Wireless Spectrum Crisis*, GigaOm, Oct. 21, 2012, http://gigaom.com/2012/10/21/the-myth-of-the-wireless-spectrum-crisis/ (pointing out that mobile broadband traffic has not increased as much as some predicted).

[45] FCC, National Broadband Plan 84 (2010), http://download.broadband.gov/plan/national-broadband-plan-chapter-5-spectrum.pdf (citing industry estimates of spectrum need).

[46] Another 55 MHz is "in the pipeline," which does not include spectrum made available through the incentive auctions. FCC, The Mobile Broadband Spectrum Challenge: International Comparisons 2, Wireless Telecommunications Bureau, Office of Engineering and Technology White Paper (2013), http://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db0227/DOC-318485A1.pdf.

[47] FCC, National Broadband Plan 84 (2010), http://download.broadband.gov/plan/national-broadband-plan-chapter-5-spectrum.pdf.

that amount is still well short of what is needed.[48] This shortage of spectrum surely increases prices, reduces broadband access, slows speeds, and reduces economic growth. While technology is improving and carriers are building more base stations and towers, which permit more broadband traffic, these are expensive ways to improve spectrum use.[49] The FCC estimated in 2010 that adding 275 MHz of spectrum by 2014 would save carriers more than $120 billion in capital investments.[50] The new demands require more radio spectrum.[51] As communications scholars concluded a few years ago when reviewing these increased spectrum demands, "For providers to make the large investments necessary for new wireless broadband services, they will need licenses that give them secure quasi-property rights to the spectrum."[52] Many scholars now look to the broad swaths of government spectrum to replenish much of the current and projected commercial spectrum shortfall.

[48] Middle Class Tax Relief and Job Creation Bill of 2012, PL 112-96. See Title VI. FCC, National Broadband Plan 88-93 (2010), http://download.broadband.gov/plan/national-broadband-plan-chapter-5-spectrum.pdf (recommending reallocating 120 MHz from broadcast television for mobile broadband use).

[49] By building more cell towers, carriers can "re-use" the same bands and improve capacity. The FCC, in its economic models, estimates unit cell-site costs at $550,000. This is based on initial capital costs of $130,000 and a net present value of $50,000 annual operating expenses over a 20-year period at a 10 percent discount rate. FCC, Mobile Broadband: The Benefits of Additional Spectrum 24 (2010), http://download.broadband.gov/plan/fcc-staff-technical-paper-mobile-broadband-benefits-of-additional-spectrum.pdf.

[50] FCC, Mobile Broadband: The Benefits of Additional Spectrum 20 (2010), http://download.broadband.gov/plan/fcc-staff-technical-paper-mobile-broadband-benefits-of-additional-spectrum.pdf.

[51] Coleman Bazelon, Expected Receipts From Proposed Spectrum Auctions 5-6, The Brattle Group (2011), http://www.brattle.com/_documents/UploadLibrary/Upload964.pdf ("Despite all of these other approaches to meeting future demand, additional radio spectrum allocated to mobile broadband will be needed very soon to maintain service quality and meet consumer demand at affordable prices.").

[52] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are The Options 2, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf (citation omitted).

## IV. Government Use of Spectrum

No unused "greenfield" spectrum is left, and the consensus among economists is that federal spectrum is used inefficiently relative to commercial frequencies.[53] The federal government is the largest holder of spectrum in the United States. Today, the US government possesses almost 60 percent of radio spectrum[54] and, counting exclusive and shared spectrum, possesses over half—some 1500 MHz—of the valuable 300 MHz to 3 GHz spectrum.[55] Over 60 federal agencies use these beachfront spectrum assets.[56] The most frequently reported uses of this spectrum are systems used for voice and data communications.[57] However, because there are

[53] Harvey J. Levin, *The Radio Spectrum Resource,* 11 J. L. & Econ. 433, 434 (1968) ("Many other users (like those in public safety and local or federal government radio) are not directly constrained in their use of spectrum by pressures in any 'markets' for their end products or services."); Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan*, 64 Fed. Comm. L. J. 87, 130 (2011); Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 23, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf ("There appears to be widespread consensus that spectrum in government hands is likely not being used efficiently.") (citations omitted); James Losey & Sasha Meinrath, *Free the Radio Spectrum*, IEEE Spectrum, June 2010, http://spectrum.ieee.org/telecom/wireless/free-the-radio-spectrum/0 (stating that "the 270,000 [allocations] held by government agencies . . . are woefully underutilized"); Kenneth R. Carter & J. Scott Marcus, Improving the Effectiveness and Efficiency of Spectrum Use by the Public Sector: Lessons from Europe 3, TPRC (2009), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1488852 ("To a significant degree, these [efficiency] improvements have not worked their way into spectrum use by public sector users, including the military, emergency services, or aeronautical or maritime transport.").

[54] Ajit Pai, *Too Much Government, Too Little Spectrum*, RedState.com, Jan. 3, 2013, http://www.redstate.com/ajitpai/2013/01/03/too-much-government-too-little-spectrum/.

[55] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 21, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf. One must take care when approximating percentages of spectrum "used" by federal and nonfederal users because of the technical nature of transmitting signals. MICHAEL J. MARCUS, NEW APPROACHES TO PRIVATE SECTOR SHARING OF FEDERAL GOVERNMENT SPECTRUM 2-3, New America Foundation Brief No. 26 (2009), http://www.newamerica.net/files/Marcus_IssueBrief26_SharingGovtSpectrum.pdf. According to the NTIA, federal agencies used 18 percent exclusively, nonfederal users had 30 percent, and 52 percent was shared between federal and nonfederal users. Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 2, Congressional Report GAO-11-352 (2011). Of the spectrum that is shared, 80 percent has a "dominant" federal use that precludes most commercial use of the band. President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 8, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

[56] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 20, Congressional Report GAO-11-352 (2011).

[57] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 24, Congressional Report GAO-11-352 (2011).

no market signals for federal users, it is impossible to determine the extent of "surplus" federal spectrum.[58]

Government agencies buy most inputs—things like personnel, real estate, aircraft, and tanks—at approximately the market price. Not so with spectrum, and it distorts federal usage of the resource. Spectrum is in high demand for use in millions of consumer devices and government systems and is therefore very expensive,[59] but according to the NTIA, federal agencies pay merely *$122 annually* per assignment of spectrum—a tiny fraction of the market value.[60] In 2012 the President's Council of Advisors on Science and Technology (PCAST) concluded in its influential report on making federal spectrum available to commercial users that "federal users currently have no incentives to improve the efficiency with which they use their own spectrum allocation, nor does the Federal system as a whole have incentives to improve its overall efficiency."[61]

Because they face no opportunity costs, efficient federal spectrum management is, based on the findings of government audits, essentially a nonpriority for the agencies. The cost of additional spectrum will always be below the cost of efficiency-improving technology, so agencies are predisposed to acquire more spectrum than they would acquire if they faced the

[58] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 23, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[59] For instance, in 2008, auction 73 in the 700 MHz band brought in nearly $19 billion. FCC, Auction 73: 700 Mhz Band, http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=73. It's estimated that 50 MHz of currently federal spectrum (1755–1780 MHz and 2155–2180 MHz) would fetch around $12 billion at auction. Coleman Bazelon, Expected Receipts from Proposed Spectrum Auctions 18, The Brattle Group (2011), http://www.brattle.com/_documents/UploadLibrary/Upload964.pdf.

[60] Government spectrum fees totaled about $30 million in 2012. Government Accountability Office, Spectrum Management: Incentives, Opportunities, and Testing Needed to Enhance Spectrum Sharing 11 n.14, Congressional Report GAO-13-7 (2012).

[61] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth ix, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

higher costs.[62] Since acquisition is less costly than investing in and upgrading equipment, many agencies are not careful monitors of their airwave usage. For example, GAO released a report to congressional committees in April 2011 about the NTIA's spectrum management and called for dramatic improvement.[63] The report's findings were troubling. GAO could not even begin to assess the NTIA's spectrum management capabilities because of "an antiquated data collection system" and "significant inaccuracies."[64] One agency revealed that half its assignment records in the Detroit metropolitan area were inaccurate.[65] Another agency found that 25 percent of one department's assignments were unused.[66] There was no evidence most agencies completed any site surveys or record reviews at all.[67]

The information we do have about government use of spectrum is inadequate if it exists, is often incomplete due to classified information, and likely only hints at the magnitude of inefficient use. Billions of dollars of value are squandered annually because basic information about utilization is unknown to the agencies or not accessible to auditors. When the GAO questioned government users about their management of spectrum, it became clear that even the NTIA has relatively little knowledge about whether spectrum at the agency level is used efficiently, and the federal spectrum managers have no way of knowing whether the information

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[62] *See* Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 27, Congressional Report GAO-11-352 (2011) ("Federal officials from one agency told us that approximately 30 percent of the time, program offices at the agency procure spectrum-dependent equipment without first notifying the agency spectrum managers, and in some cases before the assignment has been granted.").
[63] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 25, Congressional Report GAO-11-352 (2011).
[64] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 38, Congressional Report GAO-11-352 (2011).
[65] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 25, Congressional Report GAO-11-352 (2011).
[66] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 25, Congressional Report GAO-11-352 (2011).
[67] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 25, Congressional Report GAO-11-352 (2011).

provided to them is accurate.[68] Indicative of the chaos, GAO reported that in one case, a forgotten system emitted transmissions for an unknown number of years before a commercial user who had purchased the spectrum at auction complained of the interfering signal.[69]

Because of increasing commercial spectrum demands and the evidently inefficient use by federal agencies, President Obama issued a 2010 Presidential Memorandum requiring the federal government to make 500 MHz of federal and nonfederal spectrum available for wireless broadband use in 10 years.[70] This is a substantial demand, and reclaiming that much spectrum from the federal government means social benefits of over one trillion dollars.[71]

In addition to President Obama's Memorandum, there are two major initiatives to identify and reclaim federal spectrum for mobile broadband use—a recommendation in the National Broadband Plan and the NTIA Fast Track.[72] If history is any indication, however, those efforts will stall. Congress frequently tasks the NTIA with spectrum management improvement plans. Unfortunately, the NTIA inconsistently carries out those plans, if they're carried out at all. In 2004, federal agencies were required to update their spectrum plan information every two

[68] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 24–25, Congressional Report GAO-11-352 (2011).
[69] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 26, Congressional Report GAO-11-352 (2011).
[70] Presidential Memorandum, Unleashing the Wireless Broadband Revolution, Release, June 28, 2010, http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.
[71] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 4-5, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf. ("If, say, 300 MHz of federal government spectrum could be allocated to the market, the benefits would similarly be in the range of a trillion dollars or more.") (citation omitted).
[72] Department of Commerce, An Assessment of the 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 1–5 (2010); Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 9, Congressional Report GAO-11-352 (2011) ("NTIA has been directed to conduct several projects focused on reforming governmentwide federal spectrum management and promoting efficiency among federal users of spectrum; however, its efforts in this area have resulted in limited progress toward improved spectrum management.").

years.[73] By 2008, the NTIA canceled those requests to agencies because of limited resources.[74] Of the four programs the NTIA may employ to monitor federal spectrum use, three are not being implemented.[75]

These new initiatives are already grinding to a halt. The FCC's National Broadband Plan called for the FCC and the NTIA to coordinate and reassign 95 MHz of the federal government's spectrum—from 1755–1850 MHz—to commercial users. Unfortunately, a few months later, the NTIA reversed course and said that band could not be fast-tracked for mobile broadband service.[76] The NTIA studied *this same band* in 2001 for reallocation and those plans were abandoned.[77] This band is again slipping away. As the President's Council of Advisors on Science and Technology (PCAST) confirmed, efforts to reallocate federal spectrum are moving far too slowly for the spectrum constraints commercial users face.[78]

## V. Proposals for Reclaiming Government Spectrum

Freeing up government spectrum and transferring it for commercial use has enjoyed bipartisan support in recent years. Despite years of agency resistance to freeing up federal spectrum, as mentioned, in June 2010 President Obama issued a memorandum directing the NTIA to identify

[73] *See* President's Memorandum on Improving Spectrum Management for the 21st Century, 49 Weekly Comp. Pres. Doc. 2875 (Nov. 29, 2004).
[74] *See* Government Accountability Office, Spectrum Management: Incentives, Opportunities, and Testing Needed to Enhance Spectrum Sharing 16, Congressional Report GAO-13-7 (2012).
[75] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 15, Congressional Report GAO-11-352 (2011).
[76] Department of Commerce, An Assessment of the 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 1–5 (2010).
[77] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 31, Congressional Report GAO-11-352 (2011).
[78] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 4, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

federal spectrum that can be made available for wireless broadband by 2020.[79] Ajit Pai, the newest Republican FCC commissioner, likewise advocates allocating federal spectrum for private users.[80]

Two distinct ways to increase the use of federal spectrum are (a) clearing federal users to make way for commercial users and (b) requiring federal users to share their spectrum. Clearing federal users from their spectrum is preferred to various sharing schemes since commercial carriers can operate unhindered and bring about the dynamic wireless ecosystems seen in other liberally licensed bands they possess exclusively. Four strategies for clearing federal users are described below. In contrast, PCAST deemed clearing federal users infeasible and proposed allowing more sharing between federal and commercial users,[81] but even sharing faces substantial resistance from the affected agencies.[82] While inferior in most cases to clearing federal users, sharing can sometimes be utilized effectively. Various sharing techniques are offered below.

### *A. Strategies for Clearing and Reallocating*

Clearing and reallocating federal spectrum for commercial use is difficult to accomplish, but the removal of inefficient federal users allows wireless firms to launch new communications services and improve existing services. Rather than seeking permission from regulators and incumbent federal users—as they would in shared bands—wireless firms can win bandwidth at auction and

[79] Memorandum for the Heads of Executive Departments and Agencies, Unleashing the Wireless Broadband Revolution, 75 Fed. Reg. 38387 (2010).
[80] Ajit Pai, *Too Much Government, Too Little Spectrum*, RedState.com, Jan. 3, 2013, http://www.redstate.com/ajitpai/2013/01/03/too-much-government-too-little-spectrum/.
[81] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 29, Congressional Report GAO-11-352 (2011).
[82] Government Accountability Office, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies 31–33, Congressional Report GAO-11-352 (2011).

intensively utilize spectrum for mobile broadband and other services. Scholars and policymakers have proffered at least four reallocation plans aimed at either (a) incentivizing efficient spectrum use or (b) avoiding the intractable political problems that accompany displacing incumbent federal users.

*1. Overlay licenses*. Overlay licenses are flexible-use licenses that have few if any use restrictions. These licenses were used in the past for mobile broadband and for voice, given demand for these services.[83] The benefit to overlay licenses is that they encourage voluntary settlements between the incumbent user and the new service provider.[84] Commercial users purchase overlay licenses to a given spectrum band at an FCC auction. The auction winner receives primary rights to any unused spectrum and secondary rights to spectrum in the band that is used by an incumbent. Because overlay licensees have secondary rights for a period of time and may not enjoy full use of the band immediately, these licenses fetch less at auction than "clean" spectrum with no incumbents. These licenses are generally accompanied by a deadline for the incumbent users to move out of the band. Before that deadline, the overlay licensees must protect the existing users in the band, but they also reap the rewards if they can convince the incumbents to move or repack to another band. Purchasing an overlay license is like purchasing property that has tenants with an unexpired lease. The tenants have a superior right to use the property, but at a high enough price that they may be willing to abandon the property.

[83] *See* Jerry Brito, *The Spectrum Commons in Theory and Practice*, 2007 Stan. Tech. L. Rev. 1 ¶ 60 (2007).
[84] Peter Crampton, Evan Kwerel, & John Williams, *Efficient Relocation of Spectrum Incumbents*, 41 J. L. & Econ. 647, 649 (1998).

Overlay licenses were first used in the Personal Communications Service (PCS) license auctions in 1995, which today are used for mobile data and voice.[85] Spectrum scholars Crampton, Kwerel, and Williams wrote a detailed law review article about the PCS overlay experience, bargaining challenges, and lessons for future overlay auctions.[86] The incumbent users in the band were microwave communications systems that were critical for public safety operations and utility companies. Despite outcry that the systems and thousands of users could not be moved, PCS overlay licensees successfully moved the systems.[87] Incumbents had the right to continue operations until a certain date and could deploy similar systems at the expense of the overlay licensee.[88] The FCC took a few steps to improve bargaining relations between adverse parties, including alternative dispute resolution mandates and requiring principles of good-faith bargaining.[89]

Holdout problems—where agencies refuse to move—can scuttle many spectrum reclamation plans. Holdout is not a significant issue with overlay licenses since even near-unanimous agreement by agencies to move can permit the deployment of a commercial network,[90] so this approach is effective when there are multiple agencies using a band.

Recent congressional efforts have also achieved some success in relocating federal users through overlay licenses. In 2004, Congress passed the Commercial Spectrum Enhancement Act,

[85] Thomas W. Hazlett, Tragedy T.V.: Rights Fragmentation and the Junk Band Problem 31, George Mason University Law and Economics Research Paper Series 10-03 (2010).
[86] Peter Crampton, Evan Kwerel, & John Williams, *Efficient Relocation of Spectrum Incumbents*, 41 J. L. & Econ. 647 (1998).
[87] Thomas W. Hazlett, Tragedy T.V.: Rights Fragmentation and the Junk Band Problem 31, George Mason University Law and Economics Research Paper Series 10-03 (2010).
[88] Thomas W. Hazlett, Tragedy T.V.: Rights Fragmentation and the Junk Band Problem 31, George Mason University Law and Economics Research Paper Series 10-03 (2010).
[89] Peter Crampton, Evan Kwerel, & John Williams, *Efficient Relocation of Spectrum Incumbents*, 41 J. L. & Econ. 667 (1998).
[90] Thomas W. Hazlett, Tragedy T.V.: Rights Fragmentation and the Junk Band Problem 32, George Mason University Law and Economics Research Paper Series 10-03 (2010).

which streamlined funding for federal agencies vacating spectrum for commercial use.[91] The law facilitated the removal of two dozen federal agencies and their dozens of systems from 45 MHz of "AWS-1" high-value spectrum, now used for wireless broadband. Combined with another 45 MHz band, the auction raised nearly $14 billion in 2006.[92] The 2012 amendments to the law made spectrum-sharing costs a reimbursable cost, which will make future relocations easier on incumbents.[93] These experiences indicate that overlay licenses could successfully transfer lightly used federal spectrum to mobile broadband use.

*2. Spectrum fees*. Some countries have applied spectrum fees to users, with mixed results. The best plans attempt to approximate the opportunity cost of the spectrum so that users internalize the social value of the spectrum they occupy. If the opportunity cost fees are high, a user will be induced to use less spectrum to reduce its fees or leave the space completely and sell the cleared spectrum for higher-valued uses.[94] The National Broadband Plan requested that Congress grant the NTIA authority to levy spectrum fees on federal users so that federal users receive some sort of market signal about how valuable their spectrum is.[95]

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[91] 47 U.S.C. §§ 151, 301, 302, 303 (2004).
[92] The band was the AWS band, 1710–1755 MHz. 47 C.F.R. § 27.2(a). *See* Department of Commerce, Relocation of Federal Radio Systems From the 1710–1755 MHz Spectrum Band, Third Annual Progress Report (2010). Relocation was not carried out perfectly, and in 2010 the agencies had still not been totally cleared. T-Mobile had paid over $4 billion for its licenses but had to delay its mobile broadband deployment. Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan,* 64 Fed. Comm. L. J. 87, 115-16 (2011). There were some exclusion zones for some federal systems that could not be relocated. President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 9, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.
[93] Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6701(a).
[94] Carlo Cambini & Nicola Garelli, Evaluation of the opportunity cost of the spectrum: Application to the digital dividend, 35 Telecomm. Pol'y 633, 636 (2011).
[95] National Broadband Plan 82–83 (2010), http://download.broadband.gov/plan/national-broadband-plan-chapter-5-spectrum.pdf.

While not official policy in the United States yet, the British government has had some success with pricing government spectrum.[96] In 1998, the United Kingdom initiated Administrative Incentive Pricing (AIP), which is a tariff on spectrum designed to incentivize efficient spectrum use.[97] Originally, AIP applied to only a few services with acute in-band congestion.[98] Today, almost all public services in the United Kingdom, including defense, maritime, and public safety users, are subject to AIP, which is set at the approximate opportunity cost of the spectrum used.[99] Australia uses a similar pricing plan successfully.[100]

Critics have questioned the efficacy of spectrum fees on US government users. Several scholars are skeptical that spectrum fees on federal users would appreciably improve spectrum utilization.[101] Presumably Congress will supplement the budgets of federal agencies for any

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[96] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 24, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[97] INDEPEN, AEGIS SYSTEMS, & WARWICK BUSINESS SCHOOL, AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING 2 (2004), http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/spectrum_pricing.pdf. AIPs are based on the method developed by Smith-NERA. *See* NERA & SMITH SYSTEM ENGINEERING, RADIOCOMMUNICATIONS AGENCY (1996).

[98] INDEPEN, AEGIS SYSTEMS, & WARWICK BUSINESS SCHOOL, AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING 40 (2004), http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/spectrum_pricing.pdf.

[99] INDEPEN, AEGIS SYSTEMS, & WARWICK BUSINESS SCHOOL, AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING 40 (2004), http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/spectrum_pricing.pdf; Martin Cave, Review of Radio Spectrum Management 26–27, Department of Trade and Industry, Her Majesty's Treasury (2002), http://www.ofcom.org.uk/static/archive/ra/spectrum-review/2002review/1_whole_job.pdf. The UK report noted that the opportunity cost for some spectrum is zero because of international agreements that assign bands for defense use. Martin Cave, Review of Radio Spectrum Management 26–27, Department of Trade and Industry, Her Majesty's Treasury (2002), http://www.ofcom.org.uk/static/archive/ra/spectrum-review/2002review/1_whole_job.pdf. *See also* INDEPEN, AEGIS SYSTEMS, & WARWICK BUSINESS SCHOOL, AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING 41 (2004), http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/spectrum_pricing.pdf.

[100] Carlo Cambini & Nicola Garelli, Evaluation of the opportunity cost of the spectrum: Application to the digital dividend, 35 Telecomm. Pol'y 633, 636 (2011).

[101] Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan,* 64 Fed. Comm. L. J. 87, 133 (2011); Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 24, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf ("We are pessimistic that market or quasi-market mechanisms can be used effectively—at least in the short run—to identify and free of government spectrum. . . . Although many governments give some lip service to improving their allocation of spectrum, only the United Kingdom appears to actually have instituted a system of 'administered incentive pricing' (AIP).").

spectrum fees paid, thus eliminating the incentive effects of fees.[102] Indeed, in the United Kingdom, the Ministry of Defence's (MoD) budget was increased to offset the fees charged.[103] Federal agencies may also be disinclined to clear and sell spectrum to commercial users in order to lower their spectrum fees since Congress may see the revenues from selling federal spectrum and deduct a similar amount from their next budget.[104] Still, it isn't clear why the US experience would differ from the United Kingdom's relative successes with AIP. Today, the MoD is subject to pricing and is required to publish information about spectrum available for shared use.[105] AIP has even pried radio spectrum from the military. British journalists report that in 2014 the UK MoD will sell, for the first time, spectrum to commercial users for 4G mobile services.[106]

*3. "A BRAC for spectrum."* A way to eliminate some of the substantial political obstacles to freeing federal, particularly military, spectrum is to use a strategy crafted for closing military bases. Congress created the Base Realignment and Closure Commission (BRAC) in 1988 and BRAC comprised independent military experts tasked with the unenviable job of closing bases, many of which were the major sources of jobs in communities. There was a general consensus in Congress in the 1980s that bases needed to be closed with the winding down of the Cold War, but it was impossible to close bases one by one because congressional members could not

[102] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 23–24, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.
[103] INDEPEN, AEGIS SYSTEMS, & WARWICK BUSINESS SCHOOL, AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING 82 (2004), http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/spectrum_pricing.pdf.
[104] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 23–24, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.
[105] New Zealand Ministry of Economic Development, Review of Radio Spectrum Policy in New Zealand 2005 68 (2005), http://www.itu.int/osg/spu/stn/spectrum/spectrum_resources/general_resources/report_NewZealand.pdf.
[106] Ministry of Defence to sell part of its radio spectrum, BBC, Dec. 17, 2012, http://www.bbc.co.uk/news/business-20757040; Jon Rees, *Ministry of Defence Forced to Pay More Than Double for Airwaves*, ThisIsMoney.co.uk, Feb. 9, 2013, http://www.thisismoney.co.uk/money/markets/article-2276252/Ministry-Defence-forced-pay-double-airwaves.html#axzz2KXQbATBG.

stomach the ensuing backlash once a base was publicly considered for closure.[107] Members became adept at saving bases in their home districts.[108]

BRAC took the decision out of Congress's direct control—thus mitigating the political liability associated with base closures—and managed to close hundreds of military installations. Once BRAC made a closure decision, Congress could not undo the move absent a joint resolution of approval—a fairly difficult task, and intentionally so.[109] Mercatus scholar Jerry Brito has documented subsequent congressional attempts to use BRAC-like committees to make painful budget cuts.[110] Political entrepreneurs in Congress see similar dynamics at play in reclaiming federal spectrum—including the political liability that comes with constraining national defense resources—and crafted proposals tying congressional hands from interfering with relocating federal spectrum users.

Sen. Larry Pressler first proposed a BRAC-like commission for federal spectrum in 1996.[111] Sen. Pressler was the chairman of the Senate Commerce, Science, and Transportation Committee and authored the historic 1996 Telecommunications Act (Telecom Act). The Telecom Act largely focused on wired communications and Sen. Pressler's proposal, drafted a few months after the Telecom Act passed, represented a complete overhaul of wireless telecommunications law.[112] A notable feature of the proposal was the creation of a BRAC-like independent committee to recommend and implement the reclamation of federal spectrum. The

[107] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131, 133 (2011).
[108] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131, 137 (2011).
[109] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131, 133 (2011).
[110] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131 (2011).
[111] *See* Spectrum Bill Discussion Draft: The Electromagnetic Spectrum Management Policy Reform and Privatization Act, CR, 104th Cong., 142 Cong. Rec. S4928-4936 (May 9, 1996) (statement of Senator Pressler).
[112] Adam Thierer, Senator Pressler's Bold Proposal for Spectrum Freedom 2, Heritage Foundation Backgrounder (June 7, 1996), http://thf_media.s3.amazonaws.com/1996/pdf/bg1085.pdf.

"Advisory Committee on Withdrawal" would have comprised seven Senate-confirmed members from the government and private sector.[113] Over 10 years the committee would recommend federal spectrum for privatization.[114] The proposal also allowed federal agencies to accept compensation, including in-kind reimbursement of costs, from any firm for relocating or repacking to other bands.[115] However, the proposal never progressed beyond a staff discussion draft. After expending significant energy gaining a coalition for the 1996 act, there was little interest in Congress in making such a radical change to US radio spectrum policy. Sen. Pressler lost his reelection campaign a few months later and the proposal was never revived.

In a proposal to the 2011 "super committee" similar to Sen. Pressler's plans 15 years earlier, Rep. Adam Kinzinger and Sen. Mark Kirk offered plans to "BRAC the Spectrum."[116] In February 2012, Rep. Kinzinger introduced a bill to a House committee that would create a nine-member independent Federal Spectrum Reallocation Commission.[117] The bill would require the Commerce secretary to identify and recommend federal spectrum bands for reallocation. The Reallocation Commission would review those recommendations and submit its recommendations to the president, along with justifications for any departures from the Commerce secretary's recommendations.[118] Whatever recommendations the president approved would be implemented and the FCC would commence an auction for those bands within two

[113] Spectrum Bill Discussion Draft: The Electromagnetic Spectrum Management Policy Reform and Privatization Act, CR, 104th Cong., 142 Cong. Rec. S4934 (May 9, 1996) (statement of Senator Pressler).
[114] Spectrum Bill Discussion Draft: The Electromagnetic Spectrum Management Policy Reform and Privatization Act, CR, 104th Cong., 142 Cong. Rec. S4931 (May 9, 1996) (statement of Senator Pressler).
[115] Spectrum Bill Discussion Draft: The Electromagnetic Spectrum Management Policy Reform and Privatization Act, CR, 104th Cong., 142 Cong. Rec. S4931 (May 9, 1996) (statement of Senator Pressler).
[116] Billy House, *BRAC the Spectrum, Illinois Republicans Suggest*, Nat'l J., Oct. 14, 2011, http://www.nationaljournal.com/blogs/techdailydose/2011/10/brac-the-spectrum-illinois-republicans-suggest-14.
[117] Maximizing Spectrum Efficiency and Value Act of 2012, H.R. 4044, Sec. 119(b), http://www.gpo.gov/fdsys/pkg/BILLS-112hr4044ih/pdf/BILLS-112hr4044ih.pdf.
[118] Maximizing Spectrum Efficiency and Value Act of 2012, H.R. 4044, Sec. 119(d)(3)(B), http://www.gpo.gov/fdsys/pkg/BILLS-112hr4044ih/pdf/BILLS-112hr4044ih.pdf.

years, absent a joint resolution from Congress disapproving of the recommendations.[119] As Brito shows, a BRAC-like committee under certain circumstances can give enough cover to members to support a consensus policy improvement without voting on very unpopular instances of that policy.[120] Currently, however, the Kinzinger bill has not been brought to a vote.

*4. "A government services administration for spectrum."* Telecom scholars Thomas Lenard, Lawrence White, and James Riso proposed the creation of a "GSA for federal spectrum" in a 2010 paper.[121] This proposal is firmly rooted in Coase's simple point that federal agencies pay market prices for most of their important inputs—real property, personnel, aircraft, munitions—so why should they receive spectrum for free? The Government Services Administration (GSA), they explain, owns many buildings that it leases out or sells to federal agencies.[122] The GSA charges agencies the approximate market price—opportunity cost—of those properties.[123] In this way, federal agencies receive market signals about the costs of the property they occupy. Agencies can decide between competing priorities what to fund and what to relinquish.

Lenard et al. propose that Congress create a federal agency—the Government Spectrum Ownership Corporation (GSOC)—that "owns" all federal spectrum and leases it to government

[119] Maximizing Spectrum Efficiency and Value Act of 2012, H.R. 4044, Sec. 119(e)(2), http://www.gpo.gov/fdsys/pkg/BILLS-112hr4044ih/pdf/BILLS-112hr4044ih.pdf.
[120] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131 (2011).
[121] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.
[122] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.
[123] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

users, much as the GSA leases real property and facilities to federal agencies and takes in rental payments.[124] GSOC would approximate market prices for similarly situated spectrum and adjust annual "rents" accordingly, depositing the net proceeds in the Treasury.[125] To make this more politically palatable, Lenard et al. propose that all first year "rents" be deposited back with the agencies that paid them.[126] That way, Congress is not tempted to supplement the agency budgets and undermine the incentive effects of paying for spectrum.[127] The amount "paid back" to the agencies in subsequent years could be gradually diminished until all spectrum rent payments are paid to GSOC and into the Treasury. Eventually, the system would encourage agencies to economize on scarce spectrum, much as agencies economize on other operational inputs.

### *B. Spectrum Sharing*

Spectrum sharing is a well-known proposal because of its importance in the 2012 PCAST report.[128] The two primary ways of sharing spectrum are geographical sharing and temporal sharing.[129] Under sharing plans, government users retain their spectrum assets but permit commercial use of spectrum where or when the government user is not using it. Sharing is

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[124] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[125] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[126] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[127] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

[128] *See* President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

[129] *See* Government Accountability Office, Spectrum Management: Incentives, Opportunities, and Testing Needed to Enhance Spectrum Sharing 7-8, Congressional Report GAO-13-7 (2012).

sometimes feasible because some spectrum used by the military is lightly used much of the time and could be put to other commercial uses, but the commercial users would be preempted when the government user requires it.[130]

*1. Temporal Sharing*. Temporal sharing is theoretically feasible with cognitive radios, which can sense other users and turn off or utilize other bands to prevent interference, and could permit LTE mobile broadband in government bands.[131] The underlying idea behind temporal sharing is that federal users are not transmitting signals at all times and commercial users could use the frequencies at those "off" times. Some federal systems are "off" for hours or even days at a time.

The Commerce Spectrum Management Advisory Committee (CSMAC) is an advisory committee of about 25 spectrum policy experts, organized by statute in 2006, that makes recommendations to the NTIA on spectrum management. CSMAC explored temporal sharing in government spectrum but had significant doubts about its efficacy. CSMAC most seriously considers this option in satellite bands because satellites circle the earth and are not using the airwaves over the United States at regular intervals.[132] Even in the satellite bands, however, where feasibility is most likely, the CSMAC working group found temporal sharing to pose

[130] *See* Brian X. Chen, *How Spectrum Sharing Would Work*, NY Times Bits Blogs, May 29, 2012, http://bits.blogs.nytimes.com/2012/05/29/how-spectrum-sharing-would-work/. In January 2013, AT&T, Verizon, and T-Mobile inked a deal with the Department of Defense to experiment with sharing spectrum in the 1755–1850 MHz band. Phil Goldstein, *AT&T, Verizon, T-Mobile forge pact to explore spectrum sharing with government*, Fierce Wireless, Jan. 31, 2013, http://www.fiercewireless.com/story/att-verizon-t-mobile-forge-pact-explore-spectrum-sharing-government/2013-01-31.

[131] *See* U.S. Department of Commerce, October 4, 2012 CSMAC Meeting Transcript (October 18, 2012), http://www.ntia.doc.gov/other-publication/2012/october-4-2012-csmac-meeting-transcript (Member Roberson, Working Group 1).

[132] U.S. Department of Commerce, October 4, 2012 CSMAC Meeting Transcript (October 18, 2012), http://www.ntia.doc.gov/other-publication/2012/october-4-2012-csmac-meeting-transcript (Member Roberson, Working Group 1).

substantial challenges, particularly the unproven nature of the technology.[133] Because of the technological difficulties, it is not clear today that temporal sharing will supply any more than a small portion of future commercial needs.

*2. Geographic Sharing*. The radio transmissions in the 300 MHz to 3 GHz do not travel across the country or even out of state. The transmissions can be engineered to travel a few miles or even a few yards. This makes **static geographic sharing,** or "fixed" geographic sharing, possible. While geographic sharing with federal users presents some problems because of interference at the boundaries (a geographic place where transmissions from separate users overlap), this problem is not insurmountable and many licensees share spectrum by geography. For instance, PCS and cellular licenses, which are used for mobile phone service, were sold by small geographic blocks—hundreds in total nationwide. Bands can be segmented by geography: the carrier with the 1850–1865 MHz license in Los Angeles may differ from the 1850–1865 MHz licensee in New York City, or even the licensee in Las Vegas. It is even possible to combine geographic sharing with an overlay license scheme. The overlay licensee could transmit over vast swaths of the country but—as a secondary user—would avoid building networks where the incumbent federal user is transmitting signals.

PCAST concluded in mid-2012 that clearing and reallocating federal users in the proposed bands is not feasible.[134] PCAST cited regulatory delay, costs, and disruption to federal

[133] U.S. Department of Commerce, October 4, 2012 CSMAC Meeting Transcript (October 18, 2012), http://www.ntia.doc.gov/other-publication/2012/october-4-2012-csmac-meeting-transcript (Member Sugrue, Working Group 1). ("You could think of a lot of reasons [temporal sharing] wouldn't work. It hasn't been proven.")
[134] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth vi, Report to the President (2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

users as the limiting factors.[135] As a result, PCAST recommends **dynamic spectrum sharing.**[136] Dynamic geographic sharing[137] represents a complete overhaul of traditional spectrum assignment. Instead of exclusive licenses to a specified bandwidth, dynamic sharing depends on cognitive radios that can transmit and receive over huge swaths of spectrum. These cognitive radios sense other users and—when they detect interfering signals from a federal user—search out other vacant bands to avoid harmful interference.

The underlying principles are (a) that devices are free to use any spectrum as long as it doesn't interfere with incumbent uses,[138] and (b) that devices automatically vacate spectrum when they sense attempted use by a licensee.[139] PCAST's primary recommendation is the creation of large-scale unlicensed shared spectrum.[140] PCAST proposes reserving a nearly 1000-MHz-wide band for unlicensed spectrum sharing between federal and nonfederal users, and that device power not be limited as with, say, Wi-Fi routers and baby monitors, which are popular unlicensed devices.[141] With dynamic sharing, government users are the primary users and can continue to use their spectrum, but commercial secondary users with the advanced radios can also use the spectrum provided they don't interfere with the primary users.[142]

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[135] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth vi, Report to the President (2012), http://www.whitehouse.gov/sites/default /files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.
[136] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 11, Report to the President (2012), http://www.whitehouse.gov/sites/default /files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.
[137] Also called opportunistic spectrum access.
[138] Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J. L. & Tech. 25, 79 (2002).
[139] Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J. L. & Tech. 25, 79–80 (2002).
[140] President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 6, Report to the President (2012), http://www.whitehouse.gov/sites/default/files /microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.
[141] "Most promising [for sharing] would be four bands that total 950 contiguous megahertz between 2700 MHz and 3650 MHz." President's Council of Advisors on Science and Technology, Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth 7, Report to the President (2012), http://www.whitehouse .gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf (citation omitted).
[142] Beibei Wang & K. J. Ray Liu, *Advances in Cognitive Radio Networks: A Survey*, 5 IEEE J. Selected Topics Signal Processing 5 (2011).

Technology scholar Eli Noam endorsed the sharing approach in his 1998 article on the subject, describing an elaborate system of dynamic sharing.[143] Yochai Benkler, a scholar at the Berkman Center, says a system of dynamic sharing with sensing radios undermines spectrum management through property-like rights:

> The argument [is] that technology [has] rendered the old dichotomy between government licensing of frequencies and property rights obsolete. It [is] now possible to change our approach, and instead of creating and enforcing a market in property rights in spectrum blocks, we could rely on a market in smart radio equipment that would allow people to communicate without *anyone* having to control the "spectrum."[144]

To mitigate the harms from congestion—a predictable consequence of an open-access commons—Noam proposed congestion pricing and real-time spot markets, but admitted the technology was not capable (in 1998).[145] That may be changing. In 2012, wireless engineer and consultant Steven Crowley told the *New York Times* that the technology required for spectrum sharing is finally maturing to the point where sharing is feasible.[146]

## VI. Recommendations

Policymakers need to address two related issues. The relatively short-term need is for an effective reform of how federal spectrum is reclaimed. In the longer term, the law should be changed to recognize that spectrum is an input and should not be free to federal users. The NTIA and the FCC cannot gauge the amount of zero-cost spectrum federal agencies need any more than they can gauge how much zero-cost steel, personnel, or real property agencies need to operate. Like other operational inputs, federal users should budget for and purchase spectrum.

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[143] Eli Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J. L. & Econ. 765 (1998).
[144] Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J. L. & Tech. 25, 28 (2002).
[145] Eli Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J. L. & Econ. 765, 784 (1998).
[146] Brian X. Chen, *How Spectrum Sharing Would Work*, NY Times Bits Blogs, May 29, 2012, http://bits.blogs .nytimes.com/2012/05/29/how-spectrum-sharing-would-work/.

Prices signal the opportunity costs of inputs and ensure more efficient use of scarce resources—and without prices, substantial market distortions arise.

### *A. Reform the Federal Spectrum Reclamation Process*

CSMAC has studied many of the proposals outlined here and is making recommendations about rationalizing federal spectrum use. However, CSMAC is an advisory committee to the NTIA and lacks enforcement authority. There needs to be an agency with the authority to make and enforce spectrum management recommendations, as well as the ability to revisit its recommendations given the dynamic nature of demands for spectrum. The legislative proposals to create a BRAC-like spectrum authority would accomplish this.

A spectrum reform agency should be established and given various powers to discover what federal systems exist—transparency is needed, even for military systems[147]—and to compel federal and state agencies to vacate the bandwidth. This should be a temporary independent agency.[148] This agency should exist for only a few years to accelerate the identification and reclamation of federal spectrum. Once agencies are paying approximately market value for their spectrum, a longer-term goal described in the next subsection, this agency should be disbanded. When pricing is in place, there should not be a pressing need to reclaim federal spectrum through this agency since federal agencies will pay for spectrum use and the distortions present today will be diminished.

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[147] *See* Kenneth R. Carter & J. Scott Marcus, Improving the Effectiveness and Efficiency of Spectrum Use by the Public Sector: Lessons from Europe 6, TPRC (2009), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1488852.

[148] This agency should be outside of the NTIA and FCC so as to avoid the bureaucratic inertia and political pressures in those agencies. Interviewees were especially concerned with the Department of Defense's influence in NTIA spectrum management decisions. Interviewees viewed the department as unnecessarily change-averse and unconcerned with the social costs of federal use of spectrum. The decades of suboptimal rights allocation by the NTIA and FCC is too much to overcome and—since speedy decisions are the purpose—reclamation is better handled by an unhindered reform agency.

BRAC has many lessons for a similar agency devoted to making difficult choices about reclaiming federal spectrum. Jerry Brito writes that part of BRAC's success in closing military bases is that it had a focused mission (close or realign military bases) and clear criteria (military need) for making decisions.[149] It's hard to imagine an agency with a more defined mandate than to clear a given amount of spectrum by a certain date. The criteria to make such judgments are no more complicated than the criteria involved in military base closures. Congress could mandate that a spectrum committee recommend to the president something like clearing federal systems from 300 MHz of spectrum after avoiding unacceptable risks to national security. Much of BRAC's success in closing military bases is due to the high bar required to stop BRAC recommendations—a congressional joint resolution in opposition.[150] The Kinzinger bill is a good place to start since this bill contains the joint resolution requirement and prevents powerful members from blocking spectrum management decisions. As Brito says, the requirement also gives political cover since members with affected constituencies can oppose the measures with vigor and, if they believe like most that federal spectrum reclamation is an urgent project with overwhelming social benefits, rest comfortably knowing the measure will be enacted.[151]

Such a commission has a few tools for making federal spectrum commercially available. The FCC has used overlay licenses to clear billions of dollars' worth of spectrum held by powerful government and nongovernment institutions. The government's experience with overlays makes this the most promising way of getting federal spectrum "online" fairly quickly. As discussed previously, the FCC took many steps to improve bargaining and relocation in the

[149] Jerry Brito, *BRAC the Federal Budget*, Wash. Times (May 28, 2010), http://www.washingtontimes.com/news/2010/may/28/brac-the-federal-budget/.
[150] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131, 141-42 (2011).
[151] Jerry Brito, *Running for Cover: The BRAC Commission as a Model for Federal Spending Reform*, 9 Geo. J. L. & Pub. Pol'y 131, 142 (2011) ("Members can vote for the popular budget-cutting measure, and then deflect blame to the Commission if a base in their district is ultimately selected for closure.") (citation omitted).

1990s when PCS licensees had to move incumbent systems. The commission could use these past overlay experiences to define swaths of spectrum where overlays are most likely to clear federal agencies. While overlay auctions may not maximize revenue, they work well at clearing incumbents quickly and seem well-suited to the urgent spectrum needs today.

### *B. Use Pricing to Incentivize Efficient Use of Federal Spectrum*

> With practically every other scarce good, the military must justify its needs to the Congress. Radio communication rights, in contrast, are granted free.[152]

Lenard et al. concluded that while "pricing mechanisms for allocating existing government-held spectrum are likely to be ineffective in the short run," the federal government should pursue pricing mechanisms in the long run.[153] Congress should consider the creation of a GSA-like agency that takes possession of federal spectrum and leases it out to federal agencies, thus creating efficiencies in use. Any surplus of spectrum after agencies have leased what they need from the spectrum-holding agency could be sold or leased for commercial use.

Arguments in opposition to charging public organizations are predictable but inadequate. Thomas Hazlett, a former FCC chief economist, recounts the argument between Dallas Smythe, another former FCC chief economist, and Leo Herzel, a brilliant economics student who inspired Ronald Coase's groundbreaking economics work on radio spectrum:

> "Surely it is not seriously intended," wrote Smythe, "that the non-commercial radio users (such as police) . . . should compete with the dollar bids against the broadcast users for channel allocations." Herzel enthusiastically gushed, "It certainly is seriously suggested," and challenged Smythe to explain why, when police departments compete for all sorts of inputs, they should be peculiarly exempted from market participation here. Herzel's

[152] Milton Mueller, Property Rights in Radio Communication: The Key to the Reform of Telecommunications Regulation 10, Cato Policy Analysis No. 21 (1982).
[153] Thomas M. Lenard, Lawrence J. White, & James L. Riso, Increasing Spectrum for Broadband: What Are the Options 26, Technology Policy Institute (2010), http://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

> argument has no serious opposition among contemporary economists, but it has remained a political non-starter.[154]

Getting as much spectrum as possible to licensees with liberal and exclusive rights is the best way to avoid the delay and waste of allocations. Crampton, Kwerel, and Williams described the time-consuming nature of administrative allocation:

> The FCC has been unable to keep up with the pace of change in radio communication since the end of World War II. It took the FCC nearly 10 years to finalize allocation and assignment criteria for television. For four of those years, it had to impose a "freeze" on the licensing of stations. It was almost 30 years before the FCC was able to change those specifications with the LPTV proposal. It took the FCC three years to settle a dispute between FM radio and VHF television over the same frequencies, and it took 10 years to reallocate some frequencies from UHF television to mobile radio. Access to channels is thus constricted by a bureaucracy which frequently needs 10 years to make a major decision, and the result is a backlog of applicants that can only be described as chaotic.[155]

Progress has been slow, but policy has generally favored extending a liberalized regime over federal spectrum. Liberalizing federal allocations and pricing them accordingly gives incentives to economize on spectrum.

### *C. Caution on Dynamic Sharing*

It is not clear that unlicensed devices using dynamic sharing technologies is a viable alternative to traditional licensing. Hazlett outlined the fundamental economic problems with unlicensed devices using shared spectrum in 2001.[156] Much of that criticism still holds true today. Unlicensed devices plant the seeds for their own demise in that once an unlicensed technology

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[154] Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J. L. & Tech. 335, 453 (2001) (citing Dallas Smythe, *Facing Facts about the Broadcast Business*, 20 U. Chi. L. Rev. 96, 100 (1952); Leo Herzel, *Rejoinder*, 20 U. Chi. L. Rev. 106, 106 (1952)).

[155] Milton Mueller, Property Rights in Radio Communication: The Key to the Reform of Telecommunications Regulation 10, Cato Policy Analysis No. 11 (1982).

[156] Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J. L. & Tech. 335, 481–509 (2001).

becomes popular, devices flood the airwaves. Without a spectrum manager responding to price signals, as there are in licensed bands, interference increases and limits the social value of the band.[157] Further, allocating 1000 MHz for an unproven technology, as PCAST proposes, is excessively risky. Dynamic sharing is an ambitious plan and may permit intensive use of spectrum assets in the future, but today there is simply no better way of promoting valuable wireless services than assigning exclusive, liberal licenses to firms responding to price signals.[158]

Dynamic sharing, while feasible and beneficial in small ways, is not yet scalable for today's wireless needs. After over a decade of exploring dynamic sharing with cognitive radios that can search out unused bands, these technologies are still at a theoretical and preliminary stage.[159] The seminal paper on sensing cognitive radios admitted in 2005 that cognitive radios have the potential to transform spectrum management, but "the development of cognitive radio is still at a conceptual stage."[160] While technology has progressed, "the theoretical promise of [dynamic sharing] has yet to be convincingly demonstrated in practice."[161]

To the extent unlicensed and dynamic sharing is utilized, a single "owner" of the spectrum should coordinate devices on the spectrum or arrange relocation. It's the difference between a condominium and an apartment building. If many devices share unlicensed spectrum

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[157] Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J. L. & Tech. 335, 498 (2001) (explaining the overcrowding in the 900 MHz, 2.4 GHz, and 5 GHz unlicensed bands).
[158] *See* Thomas W. Hazlett & Evan T. Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Perspective*, 26 Berk. Tech. L. J. 1037 (2011).
[159] *See* Wassim Jouini et al., *Decision Making for Cognitive Radio equipment: Analysis of the First 10 Years of Exploration*, 26 EURASIP J. Wireless Comm. & Networking 1 (2012) (describing the theoretical future promise of cognitive radio technologies). *See also* Simon Haykin, *Cognitive Radio: Brain-Empowered Wireless Communications*, 23 IEEE J. Selected Topics in Comm. 201, 202 (2005).
[160] Simon Haykin, *Cognitive Radio: Brain-Empowered Wireless Communications*, 23 IEEE J. Selected Topics in Comm. 201, 202 (2005).
[161] Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan,* 64 Fed. Comm. L. J. 87, 110 (2011).

and there is no single party leasing it to the users, a tragedy of the anticommons results.[162] It becomes very difficult to move all users, and by appealing to the FCC the device owners can prevent transactions and relocations because they don't want to buy new devices. In some US unlicensed bands, like 900 MHz, we are already seeing congestion as older, less spectrally efficient unlicensed devices crowd out newer technology devices.[163] One can imagine the public outcry if the FCC tried to reallocate the 900 MHz spectrum for another use, thereby making millions of baby monitors worthless. Further, since it is extremely difficult to locate interfering devices once they are permitted to be sold, as discovered when devices shared spectrum with a federal Doppler radar, the risks of widespread dynamic sharing are large.[164]

Sharing between licensed users, therefore, should been seen as a supplement to exclusive licenses, not as a replacement. Michael Marcus, an electrical engineer who worked at the FCC for 25 years, says that the use of digital packets does make sharing more feasible, relative to the past. However, the very conservative limits the NTIA imposes on commercial users mean that fluctuations in commercial capacity will be an issue.[165] Commercial carriers generally cannot tolerate the periods of service unavailability that sharing with federal users entails in many

[162] *See* Thomas W. Hazlett & Brent Skorup, *Tragedy of the Regulatory Commons: LightSquared and the Missing Spectrum Rights*, DUKE L. & TECH. REV. (forthcoming 2013).
[163] NTIA, Unlicensed Spectrum Subcommittee Report 10 (2010), http://www.ntia.doc.gov/files/ntia/meetings /unlicensedspectrumsubcommitteereport_01102011.pdf. Wireless Internet Service Providers have also complained about congestions in unlicensed bands. *See* Jerry Brito, *The Spectrum Commons in Theory and Practice*, 2007 Stan. Tech. L. Rev. 1 ¶ 68 (2007).
[164] NTIA, Unlicensed Spectrum Subcommittee Report 7-8 (2010), http://www.ntia.doc.gov/files/ntia/meetings /unlicensedspectrumsubcommitteereport_01102011.pdf. Another concern is that federal users have not been very gracious spectrum "co-tenants" in the past. *See* The FCC's UWB Proceeding: An Examination of the Government's Spectrum Management Process 41, Hearing before the Subcommittee on Telecommunications and the Internet of the House Committee on Energy and Commerce, Serial No. 107–114 (June 5, 2002) (testimony of Ralph G. Petroff).
[165] Michael J. Marcus, *Sharing Government Spectrum with Private Users: Opportunities and Challenges,* 16 IEEE Wireless Communications 4, 4–5 (2009).

regions. Exclusive licenses to carriers will need to be in place, he concludes.[166] For now, dynamic sharing of spectrum should remain in testing.[167]

## VII. Conclusion

> The true "public interest" lies in removing obstacles to efficient use of the radio spectrum and allowing it to seek its highest valued use to the public.[168]

There are willing buyers, there is a need, and there are mechanisms in place—auctions and flexible-use licenses—to ensure efficient allocation of spectrum. Unfortunately, the incumbent federal users are reluctant if not outright averse to relinquishing their "free" spectrum. As demand continues to increase rapidly, political pressures are building to make more spectrum available for private and commercial uses. The president has asked for the release of federal spectrum and the NTIA is making some efforts at complying. But with every passing year, tens of billions of dollars of value evaporate. This spectrum shortage is leading to higher prices, less broadband access, slower speeds, and reduced economic growth. Dynamic sharing, while perhaps an easier route in the short term, is fraught with problems we've seen in the past: years and decades of delay, rent-seeking, and untested technology that may leave the shared spectrum unproductive.

Through fees and overlay licenses, it may be possible to reclaim federal spectrum and safely relocate federal wireless systems. The creation of a BRAC-like agency would alleviate some of the political backlash. Still, political pressure will be necessary for the federal users to have accurate recordkeeping of spectrum uses and transparency about how nonclassified systems

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[166] Michael J. Marcus, *Sharing Government Spectrum with Private Users: Opportunities and Challenges,* 16 IEEE Wireless Communications 4, 4–5 (2009).
[167] CSMAC, Final Report, Interference and Dynamic Spectrum Access Subcommittee (Nov. 8, 2010), http://www.ntia.doc.gov/legacy/advisory/spectrum/reports/CSMAC_InterferenceCommitteeReport_01102011.pdf (recommending more testing of dynamic spectrum access).
[168] Glen O. Robinson, *Spectrum Property Law 101*, 41 J. L. & Econ. 609, 609 (1998).

are using spectrum, and to mitigate some of the powerful interests averse to strong reforms. The reclamation of federal spectrum will not be easy, but we know what the best practices are. By educating policymakers and the public on the alternatives, hopefully the necessary reforms will become reality in the near future.