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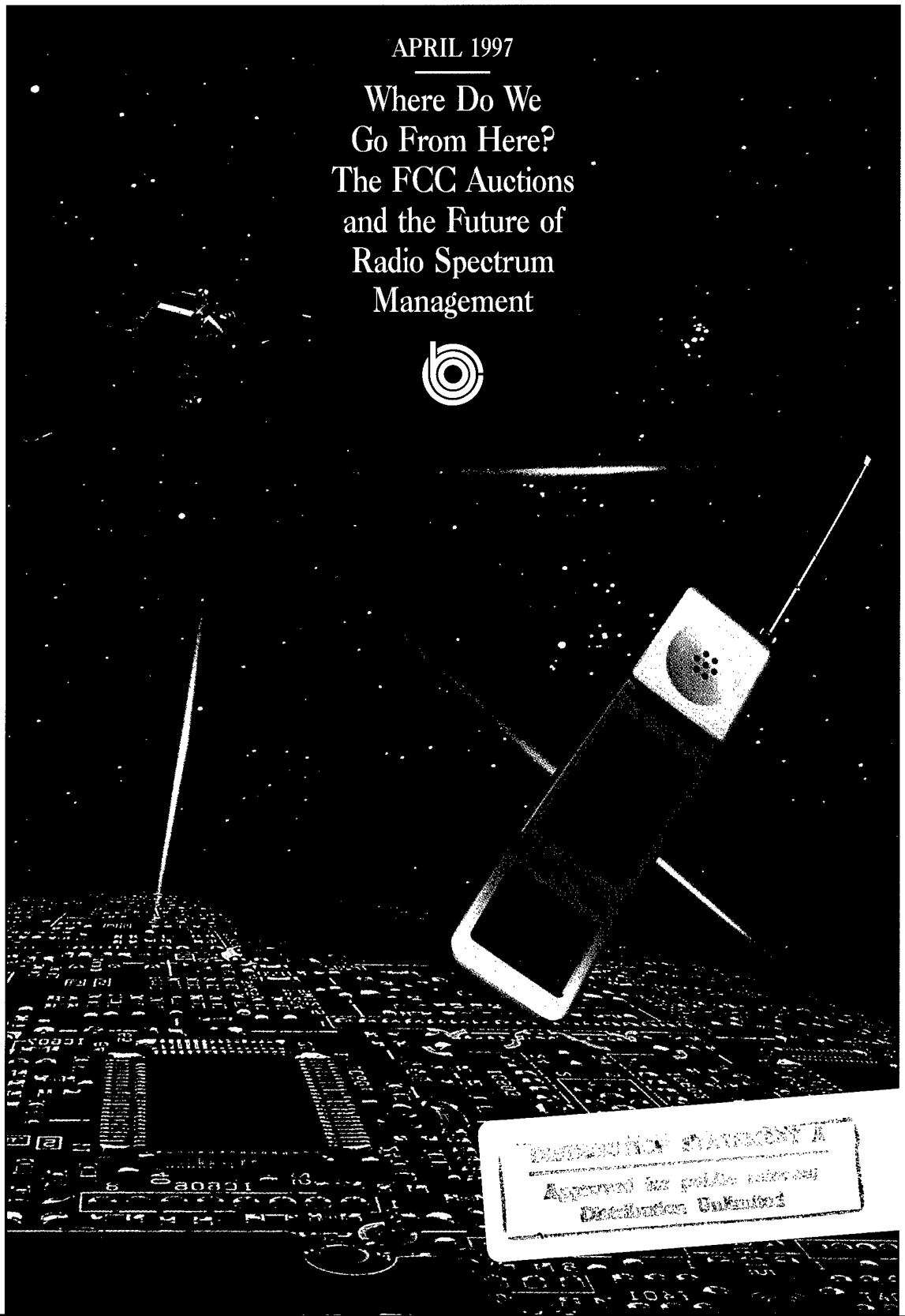
Where Do We Go From Here? The FCC Auctions and the Future of Radio Spectrum Management



WHERE DO WE GO FROM HERE?
THE FCC AUCTIONS AND THE FUTURE OF RADIO SPECTRUM MANAGEMENT

The Congress of the United States
Congressional Budget Office

NOTE

The per-person, per-megahertz prices used throughout this study are based on 1990 populations, the standard used by the Federal Communications Commission to calculate population-based statistics and payment requirements for its auctions.

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Preface

The Congressional Budget Office (CBO) estimates that auctions of licenses to use the radio spectrum conducted by the Federal Communications Commission (FCC) from 1994 through 1998 will yield $27.0 billion in receipts to the federal Treasury. The apparent success of the initial auctions has generated interest in the potential of auctions to raise additional receipts and enhance the value of the spectrum to society. In response to a request from the House Committee on the Budget, this study examines the results of the initial FCC auctions, the general outlook for future auctions, and the applicability of auctions to the introduction of digital broadcast television. The study also considers the prospects for using auctions and other market mechanisms not only in assigning licenses to specific users but also in allocating frequencies to different uses. In keeping with CBO's mandate to provide objective analysis, the study makes no recommendations.

Coleman Bazelon, Perry Beider, and David Moore of CBO's Natural Resources and Commerce Division wrote the study under the supervision of Jan Paul Acton and Elliot Schwartz. Although the three authors contributed to all sections of the study, David Moore, who coordinated the study, wrote Chapters 2 and 3, Perry Beider wrote Chapter 4, and Coleman Bazelon wrote Chapter 5. Mark Booth, Pete Fontaine, and Rachel Forward of CBO provided helpful comments on drafts of the study. For valuable comments and other assistance with their research, the authors also owe thanks to many professional staff members of the FCC and the National Telecommunications and Information Administration, the participants in a February 1996 roundtable discussion held at CBO, and the following individuals: Peter Cramton, Peter Fannon, Dale Hatfield, Tom Hazlett, Chuck Jackson, John Ledyard, Roger Noll, and David Reed.

Sherry Snyder edited the manuscript, and Marlies Dunson provided editorial assistance. Angela McCollough typed the many drafts, with assistance from Rae Wiseman. Kathryn Quattrone prepared the study for publication.

June E. O'Neill
Director

April 1997

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Summary

Within minutes of its beginning on July 25, 1994, the five-year experiment in auctioning licenses to use the radio spectrum produced a surprising result: the first round of bidding for the rights to frequencies that could be used for enhanced paging services generated over $100 million in high bids—far more than was generally expected. Over $20 billion in winning bids later, the $617 million raised in that first Federal Communications Commission (FCC) auction seems a small amount. But even the revenues raised by all of the early auctions may seem less significant several years from now if the commission's authority to auction licenses is extended beyond 1998 and if what some observers see as the broader implications of the FCC auctions lead to a significant overhaul of the national approach to managing the radio spectrum.

The Congressional Budget Office (CBO) estimates that FCC auctions will yield $27.0 billion in receipts from the license sales authorized by the Omnibus Budget Reconciliation Act of 1993 (OBRA-93). That amount includes $8.0 billion in receipts collected between 1994 and 1996 and an estimated $19.0 billion to be collected in 1997 through 2002. Those results far exceed the predictions of CBO and virtually all other forecasters at the time the law was passed. With only modest qualifications, using competitive bidding to assign licenses to use the radio spectrum has proved as successful in other dimensions. Auctions have distributed licenses rapidly, efficiently, and at a low cost compared with the alternatives of assigning licenses by comparative hearings or lotteries. Moreover, the FCC has created special features and rules for its auctions to carry out OBRA-93's mandate to give small businesses and those owned by women or minorities the opportunity to provide new telecommunications services.

On September 30, 1998—only 17 months from now—the FCC's authority to auction licenses to use the radio spectrum will expire. Deciding whether to extend that authority is but one of the issues related to the FCC auctions that are now before the Congress. As this study goes to press, proposals concerning the auctions are a major feature of several plans to balance the budget by 2002. Some of those plans involve future auctions of portions of the spectrum now allocated for television broadcasting and could lead the Congress to codify or revise the plan recently announced by the FCC for introducing a new digital TV technology. The Congress may also wish to consider the merits of extending and applying the lessons of the FCC's initial success beyond the simple assignment of licenses. Just as auctions allow market forces to substitute for government decisions in assigning licenses, giving licensees more flexibility in choosing the services to offer and technologies to employ on their assigned frequencies would give market forces a larger role in allocating spectrum to different uses. Marketlike incentives could also be applied to managing the spectrum frequencies reserved for federal use.

The pursuit of economically efficient use of the radio spectrum is complicated by the problem of current rights holders, who could suffer losses under some policies intended to increase the social value of the spectrum. Because the most valuable frequencies are already allocated to current uses and licensed to current users, many of the opportunities to employ the spec-

trum more efficiently involve displacing those uses and users. In some cases, the costs of such displacements would be widely spread among consumers of popular radio services, who have invested in equipment that could be rendered useless by reallocating frequencies to new uses. Equitable treatment of such rights holders and consumers has been a factor in recent reallocations of parts of the radio spectrum and is likely to be a difficult issue in future reallocations, such as the introduction of digital television broadcasting.

As in the allocation of many other resources, unfettered market forces may, in certain circumstances, fall short of efficiently distributing resources among competing uses. The use of the spectrum to provide public goods, such as national security, and the failure of the market to capture the full social value of some radio services, such as amateur radio, are two factors that limit the efficiency of allocations determined by the market. Consequently, maintaining some elements of the current system of spectrum management that restrict the use of certain frequencies and that limit the property rights of license holders may be consistent with the overarching goal of maximizing the social value of the spectrum.

Background

The radio "spectrum" is a conceptual tool used to organize and map a set of physical phenomena. Electric and magnetic fields produce waves that move through space at different frequencies, and the set of all possible frequencies is called the electromagnetic spectrum. The subset of frequencies from 3,000 cycles per second to 300 billion cycles per second—or 3 kilohertz (kHz) to 300 gigahertz (GHz)—is known as the radio spectrum.

The radio spectrum has value because the right to use it is necessary in the production of wireless communications services, which are increasingly valuable to individual consumers and society at large. The national system of spectrum management, called block allocation, arose in the 1920s and 1930s in response to emerging radio technologies. Under that system, blocks of frequencies are allocated for specific uses and licensed, or assigned, to specific users. The Federal Communications Commission has jurisdiction over the spectrum except for the portion used by the federal government; the National Telecommunications and Information Administration (NTIA), an agency of the Department of Commerce, has managerial responsibility for federal frequencies. Since radio waves do not recognize international boundaries, the United States coordinates its use of the radio spectrum through international planning activities under the direction of the International Telecommunications Union.

In the early days, allocations to specific radio services and license assignments to individuals were made on a first-come, first-served basis. Under the Radio Act of 1927, the comparative hearing became the primary mode of assigning licenses. Contending applicants for a license slot would make their case to the FCC in terms of the public interest standard, an imprecise notion that use of the publicly owned spectrum resource should be granted to the parties that would make the best use of it from society's point of view. In the case of radio and television, the standard might include adherence to programming norms. In the case of mobile communications services, it might measure the financial and technical capacity of an applicant to deploy a service rapidly and offer it to the public.

The shortcoming of comparative hearings in assigning licenses became increasingly evident as more applicants sought the right to use a piece of the radio spectrum. Hearings were time consuming and expensive, and after some point, the public interest standard offered no means for separating claims of equal merit. In 1983, the commission used lotteries to assign some of the first licenses allocated for cellular telephone services. Problems with that approach soon became clear. The commission was swamped with applications for each new licensing opportunity. More important, the value of the right to use the radio spectrum was publicly revealed. Applicants who were lucky enough to have their number come up in the lottery reaped windfall profits in the tens of millions of dollars solely on the basis of chance.

OBRA-93 granted the FCC the right to assign licenses by competitive bidding, in part to remedy the problems with comparative hearings and lotteries and in part to generate receipts to reduce the budget deficit. Despite being hatched in the budgetary venue, the law permitting the FCC to assign licenses by auction made clear that revenues were not to be the sole or most prominent consideration in carrying out the law. The

FCC could use auctions only to assign licenses for nonbroadcast services available on a subscription basis and could not consider revenues in allocating frequencies for one service or another. Moreover, the commission was directed to make special provision in its auctions to ensure that rural telephone companies, small businesses, and businesses owned by women or minorities (referred to collectively as designated entities) were successful in obtaining licenses. Finally, the commission's auction authority was limited to five years, ending on September 30, 1998.

FCC Auctions to Date

Through January 1997, the FCC had concluded 12 auctions of licenses to use the radio spectrum (see Summary Table 1 for an overview of selected auctions). The auctions of licenses permitting new paging services, or narrowband personal communications services (PCS), yielded the highest prices, measured on the basis of average dollars per person, per megahertz (MHz) in the license area. But the sale of licenses for the next generation of mobile telephone services—broadband PCS—involved wider bands of spectrum and accounted for $20.3 billion in winning bids, or just under 90 percent of the total winning bids offered in the auctions to date. Even auctions that did not raise large amounts of money demonstrated that the market could be used to assign licenses.

Designing an auction to assign the PCS licenses was the FCC's major task when it was granted the authority to use competitive bidding. To accomplish that task, the commission had to balance the traditional goal of auction design—awarding licenses to the parties who value them most—with sometimes conflicting legal requirements and goals of telecommunications policy. The law required that designated entities win licenses and participate in providing new wireless telecommunications services. A goal of telecommunications policy —establishing competitive markets for services—required the commission to limit the participation of incumbent providers of mobile telephone services in certain markets, even if those providers might value a license more than other potential bidders.

The FCC allocated the frequencies for PCS into different bandwidths and then subdivided them into service areas of different geographic sizes. Those decisions made it easier to reach some goals but complicated the goal of achieving an efficient distribution of licenses in at least one important respect: some bidders were likely to place a higher value on a specific license if they were assured of winning other specific licenses. Such complementarities among items sold at auction presented more than theoretical problems. Simple and time-tested auction designs—for example, an ascending -bid sale of each license, one after another—were unlikely to meet the goal of distributing licenses efficiently. Ultimately, the commission chose an innovative but untested approach—a simultaneous multiple-round auction. That design kept all of the licenses in a particular sale open for bid until no higher bid was made for any license. Bidders could make offers that took account of the higher value of groups of licenses with some assurance that they could win each one they needed to put together a package of complementary licenses.

The available evidence suggests that the FCC's choice of auction forms for the PCS and other auctions worked out well, for the most part. Assigning licenses by auction has probably cost both the private sector and the government less than comparative hearings or lotteries. The auctions raised substantial receipts for the federal government and arguably distributed licenses to the bidders who most valued them. Designated entities did indeed win licenses, and the competition in the auction reserved for small businesses was so strong that participants bid away the credits offered to them, resulting in higher federal receipts. The simultaneous multiple-round auction form did not collapse from its own complexity, contrary to some pessimistic predictions, and it allowed winning bidders to assemble complementary collections of licenses.

On a less positive note, the FCC's effort to ensure that small businesses have the opportunity to participate in markets for new telecommunications services may have led some of them to bid too much for their licenses. In the C block auction of licenses for providing mobile telephone service, in which only designated entities could participate, the FCC allowed winning bidders to pay off their bids in installments over 10 years, with interest-only payments for six years at low interest rates. Immediately following that auction, two bidders defaulted on their offers. A reauction of those licenses went smoothly, and winning bidders paid

roughly the same amount as the original bidders did. In September 1996, however, two other winners were headed for default. As this study went to press, the second-largest winning bidder in the C block auction, Pocket Communications, was seeking protection under Chapter 11 of the U.S. Bankruptcy Code, and the status of its $1.3 billion debt to the government on the 43 licenses it won at auction is uncertain. Some observers argue that the incentives were too generous. If that is the case, and a large number of winning bidders default on their commitment, the auction cannot be credited either with an economically efficient distribution of licenses or with furthering the objective of ensuring designated entities a role in providing new telecommunications services.

Summary Table 1.
Selected FCC Auctions

Auction	What Was Sold	Total Winning Bids Net of Discounts (Millions of dollars)	Spectrum Value (Dollars per person, per MHz)
	Narrowband Personal Communications Services		
National (July 25-29, 1994)	10 licenses, comprising a total allocation of 0.7875 MHz subdivided into three different-sized bandwidths, that allow the licensee to provide enhanced paging services on a nationwide basis.	617	3.12
Regional (October 26, 1994-November 8, 1994)	30 licenses, covering a total allocation of 0.45 MHz subdivided into six parcels of frequency and five regions, that allow the licensee to provide enhanced paging services.	393	3.46[a]
	Broadband Personal Communications Services		
A&B Blocks (December 1994-March 1994)	99 licenses, covering a total of 60 MHz subdivided into two 30-MHz bandwidths in each of 51 major trading areas (MTAs), that allow the licensee to offer mobile voice and data communications. The FCC's preexisting pioneer's preference policy led to three of the 102 licenses being assigned outside the auction.	7,736	0.51
C Block (December 1994-May 1995, and July 3, 1995)[b]	493 licenses of 30 MHz each, available in each of 493 basic trading areas (BTAs)—subsets of the larger MTAs—that allow the licensee to offer mobile voice and data communications. Participation in the auction was limited to designated entities—small businesses and businesses owned by women or minorities. Defaults by winning bidders in the initial sale required a reauction of 18 licenses. Additional defaults may require other reauctions in the future.	10,248	1.35[a]
D,E&F Blocks (August 1995-January 1997)	1,479 licenses, covering a total of 30 MHz subdivided into 10-MHz bandwidths and 493 BTAs, that allow the licensee to offer mobile voice and data communications. The F block was restricted to designated entities.	2,517	0.33[a]

SOURCE: Congressional Budget Office based on data from the Federal Communications Commission.

NOTE: MHz = megahertz; kHz = kilohertz; n.a. = not applicable.

Future Auctions

CBO projects that under current law, $19.0 billion in FCC auction receipts will flow to the Treasury between 1997 and 2002. The president's budgetary proposal for 1998 includes basic policies that CBO estimates would increase FCC auction receipts by $24.3 billion above the current-law estimate. The comparable estimate by the Administration is $36.1 billion. To close the difference between the two estimates, the Administration has added a fail-safe policy involving a fee imposed on television broadcasters that would be triggered if actual receipts fell short of that amount. CBO estimates that those fees would add $9.4 billion to the receipts generated by the basic policies, bringing its estimate of total

Summary Table 1.
Continued

Auction	What Was Sold	Total Winning Bids Net of Discounts (Millions of dollars)	Spectrum Value (Dollars per person, per MHz)
	Other Services		
Interactive Video and Data Services (July 28-29, 1994)	549 licenses available on a local basis permitting the user to offer a return link to be coordinated with cable or broadcast television for services such as home shopping and banking. Sale provided less than nationwide coverage, because licenses for a number of major markets were already assigned. Postauction defaults will require a reauction in 1997.	249	n.a.
Direct Broadcast Satellite Slots			
At 110 degrees west orbital location (January 24-26, 1996)	A license permitting the use of 28 channels with full coverage of the continental United States.	682	n.a.
At 148 degrees west orbital location (January 24-26, 1996)	A license permitting the use of 24 channels with only partial coverage of the continental United States.	52	n.a.
Multipoint Distribution Service (January 1996-May 1996)	238 local licenses allowing the holder to offer a type of broadcast television in very small areas. The service is called wireless cable because—like its namesake, wired cable television—it can offer a large number of channels (33 currently, more than 100 in the future). Licenses auctioned account for only a fraction of the population/channel coverage provided by all of the spectrum allocated for the service, most of which was already assigned.	216	n.a.
Specialized Mobile Radio (December 1995-April 1996)	1,020 licenses that allow the holder to provide mobile voice and data services. The licenses account for only a fraction of the population/channel coverage provided by all of the spectrum allocated for the service, most of which was already assigned.	204	n.a.

a. Uncorrected for installment payments at subsidized interest rates.

b. Consolidated results of the C block auction and the subsequent reauction of licenses on which winning bidders defaulted.

spectrum-related auction receipts in the 1998 budget plan to $33.7 billion.

The basic policies in the President's plan can be divided into two parts as they pertain to licenses to use the radio spectrum. (A third part, beyond the scope of this study, concerns the auction of toll-free telephone numbers with the prefix 888.)

First, the President's plan would extend the FCC's authority to auction licenses beyond 1998 and broaden that authority to include most types of exclusive-use licenses issued to private businesses. CBO estimates that enacting that part of the President's proposal would increase receipts by $6.0 billion for 1998 through 2002. A second part would direct the FCC and the NTIA to reallocate 234 MHz of spectrum under 3 GHz to new, high-value services and auction the licenses permitting use of those frequencies. CBO estimates that the directed reallocations and auctions in the President's budget would add $17.6 billion to receipts for 1998 through 2002. (The 888 numbers account for the remaining $0.7 billion estimated for the President's plan.)

Two premises underlie those estimates. The first is that finding commercially attractive frequencies to license by auction is difficult. The radio spectrum is already fully allocated to services and users. Some parts of the spectrum are lightly used and could be reallocated at relatively low cost, but very few such bands are available in commercially attractive frequencies and locations. To make significant amounts of spectrum available for auction, therefore, the FCC or the NTIA must reclaim frequencies already in use—a laborious process raising questions of economic efficiency, social benefits, and fairness. Since the agencies are unlikely to initiate such a process on their own, most legislative proposals seeking post-1998 receipts comparable with those obtained in the early auctions have prescribed the amount and type of spectrum—and sometimes the specific frequencies—that must be reallocated.

The second premise is that the prices paid for FCC licenses for even the most sought-after spectrum will fall from the levels paid in the early auctions. CBO foresees a drop in prices for several reasons. One is the diffusion of digital technologies that enable spectrum to be used more intensively, thereby increasing the supply of spectrum and allowing increased competition that can drive down both consumers' prices and providers' profits. Another is the FCC's increased emphasis on both removing regulatory barriers to competition and facilitating competition in allocations for new services. Rapidly growing demand for new wireless services will exert upward pressure on the prices paid for FCC licenses but is unlikely to offset the downward pressure of other factors.

Options for Introducing Digital Television

Digital communications technologies, which are central to many of the radio spectrum's new uses, also create new opportunities and challenges in using the spectrum for television broadcasting. Auctions could be used in different ways to increase the economic productivity of the frequencies currently devoted to local broadcast TV and to let taxpayers share in the value created by private use of the spectrum.

The new digital system for TV broadcasting will have two major advantages over the existing analog system and will therefore allow significant increases in the economic productivity of the TV spectrum. First, it will effectively expand the capacity of the 6-MHz TV channels, allowing each broadcaster to send at any moment a single high-definition signal with enhanced picture and sound quality or to send multiple programs—perhaps as many as six, depending on the nature of the programs—at today's quality levels. Second, the digital signals will be less susceptible to problems with interference, allowing more intensive use of the 402 MHz of spectrum currently allocated for TV broadcasting. One key drawback of the new system, however, is that viewers will not be able to watch the digital broadcasts without new TV sets or adapters for their old sets.

CBO's analysis of options for introducing digital TV considers a baseline plan—so designated because it was the focus of attention during the FCC's rulemaking on digital TV—and five alternatives that were prominently discussed in 1996. The analysis explores their implications for efficiency and equity and, where possible, estimates their likely auction receipts (see Summary Table 2).

Summary Table 2.
Overview of Plans for Introducing Digital TV

Elements and Effects	Baseline	Accelerated Use		Up-Front Auction	Full Overlay	
		Early Return	60-69		Pressler	Right-to-Move
Elements of the Plans						
Who Gets the Licenses for Digital TV?	Current broadcasters	Current broadcasters	Current broadcasters	Highest bidders	Current broadcasters willing to pay deposit	Current broadcasters
When Does Analog TV End?	15 years after plan starts, subject to review	2005	15 years after plan starts, subject to review	Upon decision of individual analog licensee and notification of service area	Upon decision of individual analog licensee and provision of free replacement service	Upon decision of individual overlay licensee and provision of free replacement service
How Is the TV Spectrum (402 MHz) Allocated?	264 MHz for digital TV; 138 MHz reallocated for general use	264 MHz for digital TV; 138 MHz reallocated for general use	264 MHz for digital TV; 138 MHz reallocated for general use	402 MHz for digital and analog TV; licensees may be allowed to offer other services	402 MHz for general use; none reserved for TV	402 MHz for general use, except for frequencies locally occupied by digital TV licensees (average of 80 MHz)
What Gets Auctioned?	Frequencies reclaimed and reallocated for general use	Frequencies reclaimed and reallocated for general use	Overlay licenses on channels 60 to 69; other frequencies reclaimed later	Digital TV channels	Overlay licenses on all TV frequencies	Overlay licenses on all TV frequencies
Effects of the Plans						
Estimated Auction Receipts	Not estimated	$10 billion in 2002, given other provisions of deficit reduction plans that would auction another 120 MHz under 3 GHz	Not estimated	$12.5 billion in 1998 if all channels are auctioned, or $9.5 billion if noncommercial broadcasters are given digital channels for free	Not estimated	Not estimated
Main Determinants of Economic Efficiency	Licenses digital TV; eventually terminates analog TV and clears blocks of spectrum for new uses	Same as baseline plan except transition ends in 2005	Same as baseline plan except some new services start early on channels 60 to 69	Licenses digital TV; does not mandate termination of analog TV or clear spectrum	Licenses all TV spectrum; maximizes flexibility of licensees; does not require digital TV; protects free TV but allows it to move off the spectrum	Similar to Pressler plan but requires digital TV
Efficiency Relative to Baseline Plan	Not applicable	Probably more efficient; net gain estimated at roughly zero to $20 billion in 2002	More efficient	Unknown	Unknown	Probably more efficient

SOURCE: Congressional Budget Office.
NOTE: MHz = megahertz; GHz = gigahertz.

Under the baseline plan, broadcasters would be loaned additional 6-MHz channels to be used for digital TV (and for other services at their discretion) during a transition period in which they would provide both analog and digital TV. Initially, the length of the transition would be 15 years, but the actual length would be subject to later review. At the end of the transition, licensees would cease broadcasting analog TV, and the FCC would reclaim the analog channels, repack the digital channels closer together on the spectrum, and reallocate 138 MHz of cleared spectrum for new uses. Current trends in FCC policy suggest that any portion of the cleared TV spectrum that was designated for commercial uses would be allocated flexibly, allowing licensees to offer a broad range of services.

As this study was going to press, the FCC concluded its rule-making and announced its choice of a policy for introducing digital TV. That policy resembles two of the alternatives to the baseline plan analyzed by CBO—the early-return plan and the 60-69 plan, identified collectively in Summary Table 2 as the accelerated-use plans—and thus tends to share their advantages and disadvantages (discussed below). Like the baseline plan, the FCC's chosen plan and the accelerated-use plans lend each broadcaster a second channel during a transition period and subsequently reclaim the analog channels to clear spectrum for new uses. The early-return plan and the FCC's chosen plan differ most significantly from the baseline plan in that they shorten the transition period, terminating analog TV at the end of 2005 and 2006, respectively.

The 60-69 plan would keep the baseline timetable for shutting off analog TV but would hold an early auction of overlay licenses for the frequencies corresponding to channels 60 to 69, which are relatively lightly used now. Overlay licenses cover spectrum bands that have incumbent licensees; they specify rights for both the incumbents and the newcomers. In this case, the overlay licensees would have immediate use of the portions of the bands not occupied by TV stations. They would also have residual rights to use the occupied portions at the end of the transition period. The plan chosen by the FCC may incorporate elements of the 60-69 plan: in announcing the plan, the commission said that it will consider an earlier reallocation of some of the spectrum in channels 60 to 69 and will give "serious consideration" to recent proposals that four of those channels be reallocated for public safety uses.

Another alternative to the baseline plan, the up-front auction plan, would auction the slots for digital TV directly but allow analog broadcasters to continue their current operations or, in some versions, to convert to digital operation after a certain number of years. Thus, both the identity of the digital TV licensees and the continuation or termination of analog TV would be determined not by government decisions, as in the baseline plan, but by market forces.

A third set of alternatives—the full-overlay plans—would offer second channels to current broadcasters, as in the baseline plan, but would auction overlay licenses covering the entire TV spectrum. Those plans would give market forces the opportunity to shift analog channels to other uses by allowing stations to cease broadcasting if viewers have access to a comparable free replacement service, such as paid-for cable TV. The version proposed by then-Senator Larry Pressler would require broadcasters who want digital channels to pay a refundable deposit for them but would not require them to use the channels to provide digital TV. Under the right-to-move variant of the full-overlay idea, broadcasters would not have to put up deposits for the digital channels, and the overlay licensees would be allowed to move analog TV stations off the spectrum if they provide the broadcasters with carriage on a comparable service that viewers can watch for free. Consistent with the Telecommunications Act of 1996, the right-to-move plan would require the digital channels to be used primarily for TV broadcasting.

CBO has estimated auction receipts for the early-return and up-front auction plans. The other plans, however, involve too much uncertainty (regarding the markets for spectrum services 15 years into the future or the details of the requirements for "free replacement service") to allow for reasonable estimates. The early-return plan would yield an estimated $10 billion in federal receipts, based on 138 MHz being auctioned and assuming, as was true of several 1996 proposals that incorporated the early-return plan, that an additional 120 MHz of non-TV frequencies would be auctioned to help reduce the federal deficit. Using a simple financial model of the potential profits from digital broadcasting and a review of the available indirect evidence, CBO estimates that the up-front auction would yield roughly $12 billion if all the digital channels were included, or $9.5 billion if one-quarter of the channels were excluded and given to public broadcasters for free. The

estimates of receipts under the two plans should be regarded as point estimates surrounded by wide bands of uncertainty and, consequently, as essentially indistinguishable.

Other efficiency and equity implications of the various plans are more useful in distinguishing them from each other. Those implications can be summarized by two findings that illustrate broader themes of this study. First, the sooner the allocation of spectrum can be revised to better reflect current technological opportunities and consumer preferences, without imposing disproportionately higher costs, the greater the gain in efficiency. Second, the pursuit of efficiency can involve difficult trade-offs with the goal of equity to current spectrum users—in this case, broadcasters and viewers.

Uncertainties and incomplete data preclude a complete ranking of the economic efficiency of the baseline plan and the above five alternatives, but CBO's analysis indicates that three of the alternatives are likely to be more efficient than the baseline plan. CBO estimates that the early-return plan is likely to be more efficient because the benefit of its shorter transition period, which allows valuable new services to be introduced sooner, probably outweighs the higher costs to viewers for replacing or adapting their analog TV sets. The 60-69 plan can be expected to be more efficient because it allows vacant portions of that band of channels to be put to productive use perhaps a dozen years earlier. The right-to-move plan carries that idea even further by quickly issuing overlay licenses for all of the TV spectrum, not just for channels 60 to 69. Consequently, it too is likely to be more efficient than the baseline plan, although its reliance on overlay licensees rather than government regulation to clear spectrum blocks of efficient size could be a disadvantage.

The other two plans could be more or less efficient than the baseline plan, depending on the importance of some market imperfections. The up-front auction plan is likely to yield more efficient decisions about how long analog TV continues, but it provides no mechanism to overcome the coordination problems and negotiation costs that the market would encounter in clearing blocks of spectrum. The Pressler plan shares with the right-to-move plan the efficiency advantage of licensing all of the TV spectrum. It does not, however, require that the digital channels be used for TV, and marketplace choices on that score may be inefficient because the prices of broadcast stations are based only on their value to advertisers, neglecting their additional value to viewers.

The various plans would have different implications for the benefits and costs to current broadcasters and viewers. Some critics of the baseline plan have argued that granting the broadcasters the use of a second channel for roughly 15 years would be an unwarranted windfall, especially if subsequent policy changes allowed them to keep both sets of channels indefinitely. The alleged windfall would be equally large under the 60-69 plan, possibly smaller under the right-to-move plan (because it would allow overlay licensees to move broadcasters off the spectrum by paying their relocation costs), and smaller, if not eliminated, under the early-return plan. Conversely, one could argue that the up-front auction and Pressler plans are unfair to broadcasters: the plans would allow broadcasters to keep their analog channels indefinitely but would require them to bid at auction or pay a deposit if they want a second channel. (Under the Pressler plan, a broadcaster could keep both channels but would lose 20 percent of its deposit for each year after 15 that it did so.) Such a shift away from the long-discussed proposal to lend each broadcaster a second channel would diminish the value of current TV licenses.

From the standpoint of the effects on viewers, the baseline and 60-69 plans have the advantage of allowing a relatively long transition period during which analog TV sets could be replaced or adapted. The transition period under the early-return plan would be less than nine years if the analog channels went off the air by the end of 2005, or less than 10 years in the version chosen by the FCC. The continued survival of analog TV would be determined by market forces under the other three plans. The two full-overlay plans would guarantee comparable free replacement service for analog stations that go off the air, but they do not specify the details of such service. Assuming that those details can be worked out, none of the six proposals are likely to threaten the existence of free (that is, advertiser-supported) broadcast TV. Proponents of the baseline plan frequently argue that the up-front auction plan would pose such a threat, but CBO's analysis suggests that free TV would be the most profitable primary use of the digital channels. In any event, the Congress or the FCC could stipulate that some or all of the capacity of the licenses to be auctioned be used for that purpose.

Issues in Spectrum Management

In recent years, the FCC has attempted to increase the efficiency of spectrum use by moving away from its traditional role of allocating and assigning spectrum and, instead, allowing more market-driven processes to perform those tasks. Encouraging market management of spectrum through enhanced property rights allows the spectrum users, who possess the relevant information, to weigh the relative demands on spectrum and make the decisions about how to use it.

Some observers claim that more extensive use of market principles in managing the spectrum can further enhance its efficient use. In particular, reforms could increase the control licensees have over their spectrum, place more spectrum under market management, and introduce marketlike incentives in the management of federal spectrum. Generating those gains through enhanced property rights rests more on the degree of control spectrum licensees have over their spectrum than on formal ownership.

Both economic theory and the available evidence suggest that giving market forces a larger role in managing the spectrum could lead to large gains in economic efficiency. Moreover, those gains would be widely shared by consumers and providers. The presence of various market imperfections and equity concerns, however, may make it desirable to temper the pace or degree with which market forces are allowed to manage the spectrum. For example, consumers could lose some benefits of services that have the attributes of a public good (such as amateur radio) or be forced to buy new equipment they would otherwise not need to purchase. Also, some current providers could face reductions in profits or increased costs of obtaining rights to use spectrum.

The FCC has already started to introduce greater property rights in spectrum. To continue further, without relinquishing its current oversight responsibilities, the FCC could establish a presumption of flexibility that would allow licensees more freedom to modify or augment the services they offer and to select the technologies they use to provide those services. The FCC could also experiment with a fuller set of rights, known as band management rights, that give private entities the right to make the allocation decisions now made by the FCC. The private control of spectrum could be moderated by issuing licenses for a limited time with the expectation that they would be auctioned when they expire. Limiting the terms of licenses may reduce the gains in efficiency that allowing more private management of the spectrum would bring. In some cases, however, such limits could serve as a kind of insurance against unforeseen problems that could undermine efficiency.

For market management to be effective, current or potential users must have control over the spectrum they use. Bands of spectrum devoted to shared, unlicensed, and public safety uses, however, are not licensed to any exclusive entity to which increased control could be given. One possible solution to that problem would be for the FCC to transfer the responsibility for managing shared and unlicensed bands of spectrum to associations of users. The commission could also transfer control over the current public safety bands to the states, which presumably are better placed to assess their own spectrum needs.

Overlay licenses are another tool for assigning control to bands of spectrum containing frequencies for which no rights have been assigned, such as guard bands or unused spectrum around fixed-point to fixed-point uses. Although overlay licenses can put unused spectrum to productive use quickly, the division of rights between new and old licensees can raise questions of equity. In allocating broadband PCS spectrum, the FCC dealt with that issue by giving the new licensees the right to relocate the incumbent licensees but delaying that right three to five years.

Federal users of spectrum operate in a world that is insulated from many of the market forces that private users face, or could face after reforms. Nonetheless, some market-based incentives could be introduced into federal spectrum management, including direct private reimbursement of public relocation costs, private management of bands of public spectrum, purchase of commercial telecommunications services, and the lease or sale of federal spectrum to and from both public and private users. Such reforms are likely to improve the efficiency with which the federal bands are used. Those reforms, however, are untested and could have unintended consequences.

In a climate of increasing urgency, the Congress is examining whether to extend the FCC's auction authority and whether to make greater use of other market mechanisms in managing the radio spectrum. The demand for wireless services is growing rapidly. Digital technologies and the worldwide movement toward deregulation, punctuated in the United States by the passage of the Telecommunications Act of 1996, will alter the most basic conditions of supply and demand in all telecommunications markets. Those factors increase the benefits of allocating spectrum efficiently among uses and users and, conversely, increase the costs of failing to take advantage of the opportunities presented.

Chapter One

Introduction

The Omnibus Budget Reconciliation Act of 1993 (OBRA-93) gave the Federal Communications Commission (FCC) the authority to use competitive bidding, or auctioning, to assign certain types of licenses to use the radio spectrum. The radio spectrum is the part of the electromagnetic spectrum that can be used for communications. The right to use the spectrum airwaves is an indispensable ingredient in producing such commercial products as mobile telephone service and television broadcasting and such government services as law enforcement and national defense. For nonfederal uses of the radio spectrum—that is, use by state and local governments and private entities—the FCC allocates frequencies to specific uses and then assigns licenses to specific parties. The National Telecommunications and Information Administration (NTIA), under the Department of Commerce, is responsible for the same management activities for federal uses.

The Congressional Budget Office (CBO) estimates that FCC auctions conducted between 1994 and 1998 will yield $27.0 billion in receipts to the Treasury. That large sum helps explain why FCC auctions have been prominent in the multiyear budget plans offered by both the Administration and the Congress in recent years. Currently, CBO estimates that provisions concerning the auctions in the President's budget plan for 1998 would increase receipts by $24.3 billion between 1998 and 2002.[1] The possible use of auctions, and the consequences for fairness and efficiency, has also become a high-profile issue in the debate about how to move from the current analog technology for television broadcasting to a new, technically superior digital technology.

A recurring theme in discussions about the FCC auctions has been the relation between the budget and telecommunications policy. Some observers believe that auction receipts can continue to make a significant contribution to efforts to reduce the federal deficit and that pursuing such receipts should be a primary goal of spectrum policy. Adherents of that view argue that auctioning spectrum licenses is typically good spectrum management as well as good budget policy and that the importance of reducing the deficit justifies modest deviations from ideal spectrum management when the two goals do not coincide.

For various reasons, other observers contend that maximizing receipts from FCC auctions is generally inconsistent with sound management of the spectrum. In their view, the importance of telecommunications services to the economy requires that auction receipts take a backseat to managing the spectrum. Some of those skeptics suggest that the auctions have, as they warned, shut the door on small entrepreneurs who would like to provide new telecommunications services. Others emphasize that the quest for easy revenues could lead to bad future choices about how to allocate the spectrum. As evidence that budget issues are coming to dominate spectrum policy, they point to the pro-

1. The Administration's estimate of the receipts from the basic policies included in the budget is $36.1 billion. A fail-safe policy involving a fee imposed on television broadcasters that would be triggered if actual auction receipts fell short of the Administration's estimate would, by CBO's estimate, add $9.4 billion to the receipts generated by the basic policies. Accordingly, CBO's estimate for total spectrum-related receipts in the budget plan is $33.7 billion.

vision in a recent appropriation act requiring the FCC to auction frequencies that it had previously allocated to a new satellite-based radio service.

A third group of observers agree with the skeptics that auction receipts should be secondary to spectrum management but are more sanguine about the results of the auctions to date. In their view, the auctions have demonstrated that market mechanisms can manage the spectrum better than government planning and have thereby strengthened the case for new policies that would give market forces a larger role in allocating the spectrum among different services and choosing the technologies to be used in providing those services. For those observers, the success of the FCC's early auctions is well timed because the current approach to spectrum management could be overmatched by the challenges of improved telecommunications technologies, the impending transition to a new television broadcasting system, and the quickening pace of deregulation in the larger telecommunications markets that is expected to follow the Telecommunications Act of 1996.

In light of the general policy discussion provoked by the FCC auctions, examining auctions as a source of future receipts, as a policy instrument useful in moving to advanced television, and as a point of departure for reforming the system of spectrum management seems in order.

An Overview of Auctions and Spectrum Management

Since the 1920s, in the wake of discoveries and innovations by Maxwell, Hertz, Marconi, and de Forest that made the radio spectrum a valuable resource, the federal government has faced the question of how competing desires to use the spectrum should be resolved. The traditional answer is to allocate specific blocks of frequencies for specific uses. Because radio waves do not recognize international borders, allocations are coordinated internationally through the International Telecommunications Union at periodic gatherings called World Administrative Radio Conferences. After a block of spectrum is allocated for a service (or services) whose users might otherwise interfere with each other, specific parties are assigned licenses that convey rights to use bands of frequencies within the block.

The Spectrum Resource

The radio spectrum does not exist as a physical object; rather, it is a conceptual tool used to organize and map a set of physical phenomena. Electric and magnetic fields produce waves that move through space at different frequencies (defined as the number of times that a wave's peak passes a fixed point in a specific period of time), and the set of all possible frequencies is called the electromagnetic spectrum. The subset of frequencies from 3,000 cycles per second to 300 billion cycles per second—or 3 kilohertz (kHz) to 300 gigahertz (GHz)—is known as the radio spectrum (see Figure 1, which shows the frequencies allocated to some of the most common radio services). Electromagnetic waves above 300 GHz produce infrared radiation, visible light, X-rays, and cosmic rays; those below 3 kHz produce sonic or infrasonic waves.[2]

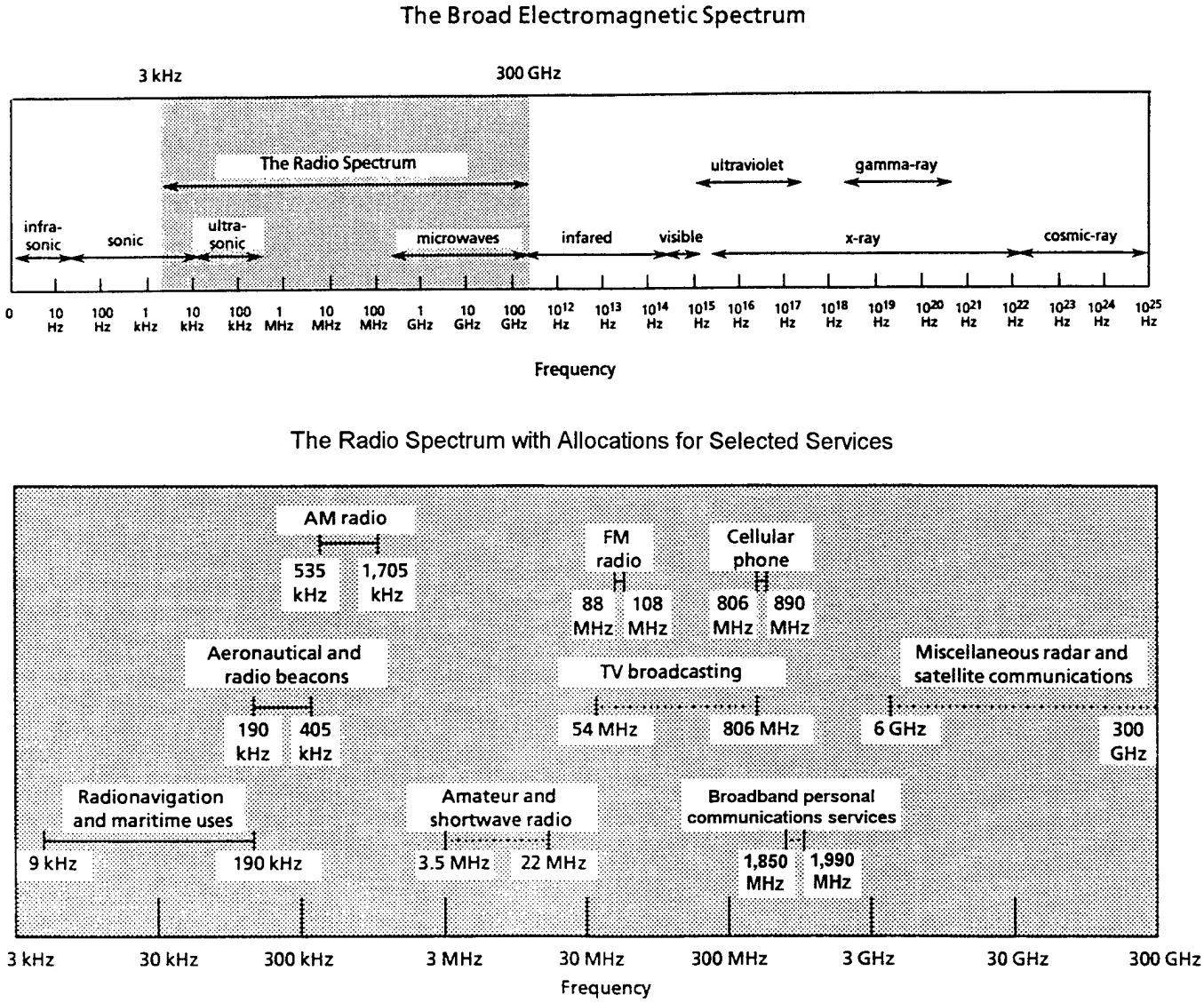
The radio spectrum is a limited but instantly renewable resource. It is subject to congestion, in that signals that overlap in time, location, and frequency may interfere with each other, but turning off the signals restores its original capacity to support telecommunications.[3] As technologies have improved, the amount of information the spectrum can carry has grown. Advances in three types of technologies are responsible for the recent dramatic growth:

- New transmitters and receivers are facilitating the use of frequencies above 3 GHz.
- New modulation techniques, going beyond the familiar amplitude modulation (AM) and frequency modulation (FM) to such methods as quadrature amplitude modulation and spread-spectrum modu-

2. Electromagnetic sonic waves are so named because they have the same frequencies as ordinary sound waves. The latter, however, are produced by vibrations in air (or water, or another material medium), not by electromagnetic fields.

3. Low-level interference from diffuse sources is harder to shut off and can be viewed as a form of pollution. Increases in background spectrum noise, resulting in part from incidental sources such as automotive ignition systems, computers, and fluorescent lights, can raise the power requirements, and hence the costs, of using the spectrum.

Figure 1.
The Electromagnetic Spectrum



SOURCE: Department of Commerce, National Telecommunications and Information Administration, *United States Frequency Allocations: The Radio Spectrum* (March 1996).

NOTES: Frequency scales are logarithmic. Hz = hertz; kHz = kilohertz (1,000 Hz); MHz = megahertz (1 million Hz); GHz = gigahertz (1 billion Hz).

In the radio spectrum, only the largest blocks of use are shown; frequencies not shown are allocated to various other fixed and mobile communications services. Dotted lines indicate that use does not occur on all frequencies within that range.

lation, are increasing the efficiency with which signals can be transmitted over a band of frequencies.

- Advances in digital coding and compression are allowing information to be represented by shorter, more compact signals. Digital representations of information require more spectrum than traditional analog representations, all things being equal. They can, however, be processed to abbreviate, or compress, the less informative parts of a data stream, such as the momentary pauses between words in a telephone conversation or the static images of a news anchor's desk. Moreover, information transmitted digitally also tends to be less susceptible to interference and therefore reduces the need for buffer zones of unused spectrum.

The combined effect of those technological advances may be a new era in wireless communications—and a challenge to policymakers to provide an appropriate legal and regulatory framework.[4]

Historical Background

Like other countries, the United States has treated the spectrum as a public resource. Initially, the government distributed rights for private use on a first-come, first-served basis. In fact, in the very earliest days of commercial use of the spectrum, which began with the broadcast of Pittsburgh station KDKA on November 2, 1920, the Secretary of Commerce issued licenses to all applicants, restricting only the frequency, location, and time of broadcast. A vibrant market for radio licenses developed, and the courts began applying common-law standards in creating a system of property rights for the radio spectrum.[5] In April 1926, however, the courts found in *United States v. Zenith Radio Corp.* that the Secretary of Commerce had no legal basis for restricting radio licenses. In the absence of the previous restrictions to ration and coordinate use of the airwaves, chaos soon resulted.

The Federal Radio Act of 1927 supplied the legal authority the government needed: the act declared the radio spectrum a public resource and created the Federal Radio Commission, which was charged with the responsibility of regulating the spectrum by assigning licenses. The act also introduced the public interest standard—a concept that endures to the present day—requiring that licenses to use the spectrum be assigned on the basis of "public interest, convenience, or necessity." Subsequently, the Federal Communications Act of 1934 gave the regulatory duties of the Federal Radio Commission to the Federal Communications Commission for managing the nonfederal portion of the spectrum and broadened its regulatory purview to include wire-based forms of electronic communications as well.

The 1934 act reserved for the President the task of managing the federal portion of the radio spectrum and left the division of frequencies between federal and nonfederal use to be determined by negotiations between the FCC and the President or his designated manager. By designation of the President and the Secretary of Commerce, the National Telecommunications and Information Administration manages the federal spectrum, allocating and assigning licenses to federal users. In carrying out those functions, the NTIA receives advice from the Interdepartment Radio Advisory Committee, which includes representatives from the most active federal users of the spectrum.

Initially, the FCC granted licenses under its jurisdiction on a first-come, first-served basis except when more than one applicant sought the same license. In those cases, the commission used comparative hearings and the public interest standard to decide among the competing applicants. Comparative hearings give applicants seeking a mutually exclusive license a forum to argue why they should be awarded the license. They also allow other interested parties to present evidence for or against any of the applicants.

Comparative hearings were increasingly criticized for being overly political and time consuming, particularly as a means to assign licenses for nonbroadcast services, for which use of the license to provide content consistent with the public interest was not at issue. Critics argued that selections among applicants that

4. Office of Technology Assessment, *Wireless Technologies and the National Information Infrastructure* (August 1995), Chapters 3-5; and Dale Hatfield, "The Technology Basis for Wireless Communications," in Institute for Information, *The Emerging World of Wireless Communications* (Queenstown, Md.: Institute for Information, 1996), pp. 49-90.

5. Thomas Hazlett, "The Rationality of U.S. Regulation of the Broadcast System," *Journal of Law and Economics*, vol. 33, no. 1 (April 1990), pp. 143-152.

otherwise met the standards for acceptable licensees were often based on insignificant and arbitrary differences, or even pure political favoritism.[6] They also observed that the hearing process frequently took months or even years, delaying the public benefits of the service to be licensed.

Recognizing the problems with comparative hearings, the Congress enacted legislation in 1982 that gave the FCC the authority to assign licenses by lottery. The theory behind the use of lotteries was that they would assign licenses quickly and that it did not matter which applicant, among those meeting certain minimum requirements, was awarded the license. In practice, that mechanism proved unsatisfactory. Many license winners reaped large windfalls by quickly selling the licenses to others, which encouraged a huge number of applications from speculators. The FCC received more than 60,000 applications for licenses to provide data transfer services, and nearly 400,000 for cellular telephone licenses.[7] Such floods of applications eroded the savings expected in time and administrative cost.

Auctions

OBRA-93 included provisions that amended the Federal Communications Act of 1934 and authorized the use of auctions to assign licenses when more than one applicant wanted a license to provide a telecommunications service on a subscription or fee-for-service basis. Auctions were expected to have three advantages. First, the requirement to pay for a license would dissuade thousands of speculators from applying and would thus reduce the time and cost involved in distributing licenses. Second, auctions would capture part of the value of the spectrum for the federal Treasury: windfalls obtained by speculators who participated in a lottery solely in hopes of reselling a license in the secondary market would instead go to the public. Third, auctions would promote efficiency by ensuring that licenses were assigned to the applicants who valued them most.

After the first three years of experience with auctions, using competitive bidding to assign licenses to use the radio spectrum has clearly achieved the limited objectives of distributing licenses promptly and capturing receipts for the federal government. Additional analysis is required, however, to evaluate how well auctions have served the more fundamental goals of spectrum management.

Goals of Spectrum Policy

The radio spectrum is of policy interest primarily because of its role in providing communications services that people value. Accordingly, the success of auctions as a mechanism for assigning licenses must be judged largely on how well they promote society's goals in the markets for those services. Those goals can be summarized as efficiency (the total benefits to society) and equity (the fairness with which the benefits are distributed). At times, the two goals may conflict, forcing policymakers to choose among alternatives that achieve efficiency and equity in varying degrees.

Auction receipts and the public interest are sometimes cited as additional, distinct policy goals. From the economic point of view, however, those objectives are desirable precisely to the extent that they improve efficiency and equity. For example, auction receipts that are used to reduce the federal deficit can improve efficiency if they help to raise a low rate of national saving, or they can promote equity if they reduce unwarranted interest costs to future taxpayers. In practice, potential auction receipts tend to be of secondary importance in comparing the efficiency and equity of alternative policies for managing the spectrum. Because spectrum policy looms much larger as a factor in the markets for telecommunications services than as an influence on the overall federal budget, the effects on those markets typically dominate the comparisons. The issues discussed under the heading of the public interest, such as diversity of ownership of telecommunications companies and the social consequences of television programming, can also be usefully classified as questions of efficiency and equity.

6. Thomas W. Hazlett, *The Political Economy of Radio Spectrum Auctions*, Working Paper 1 (Davis: University of California, Institute of Governmental Affairs, Program on Telecommunications Policy, June 1993), pp. 25-28.

7. John McMillan, "Why Auction the Spectrum," *Telecommunications Policy*, vol. 19, no. 3 (April 1995), p. 192.

Efficiency

The goal of economically efficient use of the spectrum is more easily defined than achieved. Economists say that resources are allocated efficiently if they cannot be redeployed to make some people better off without making anyone worse off. Broadly speaking, then, the efficiency goal of spectrum policy is to put the frequencies and related resources to their highest-valued uses, so that no potential gains go unrealized. Both centrally planned governmental mechanisms (including comparative hearings and the system of allocating spectrum uses on a block-by-block basis) and decentralized free-market approaches (such as auctions) can be employed in pursuit of economic efficiency. Both types of policy tools have their limitations, however, and neither can be expected to yield the ideally efficient solution alone.

Centrally planned (or administrative) mechanisms have two fundamental weaknesses. First, the information needed to identify the spectrum's highest-value uses is widely dispersed, not collected at any central repository. Particularly in an environment of rapid technological change, what the government knows about the preferences of individual consumers and the opportunities available to individual service providers will probably not be sufficient for it to maximize efficiency by administrative fiat. Second, administrative processes can be influenced by lobbying, insider dealing, and other socially wasteful activities motivated by the desire for profitable advantages (rents) resulting from favorable government decisions. Indeed, some observers contend that the regulatory framework growing out of the 1927 and 1934 laws that established the FCC has often been used to restrict competition in markets for telecommunications services and thereby protect the profits of licensees.[8]

Market mechanisms are less centralized than governmental mechanisms: they allow individual households and firms to make different choices in light of their own circumstances. Under ideal conditions, individual decisions would collectively yield the efficient outcome: spectrum rights would be bought and sold at prices that correctly reflect resource values, thereby giving users and potential users the incentive and opportunity to put the frequencies to their most valuable uses. In practice, however, various types of market failures—known by such names as externalities, public goods, and transaction costs—can reduce the efficiency of the pure decentralized approach.

Externalities are effects on third parties that are not reflected in the price of a market transaction and thus break the connection between market price and social value. Congestion of a roadway is a classic example of an externality, and the same analysis applies to a band of spectrum: unless users are charged for their contribution to congestion, the result of individually optimal decisions tends to be inefficient overuse of the resource. Externalities can be both positive and negative, as illustrated by the reputed spillover benefits of televised political debates and educational programs and by the allegedly harmful effects of TV violence. Positive externalities seem to be less common, however, perhaps in part because beneficial effects are generally easier to incorporate in market prices. For example, recognizing that the value consumers place on telephone services increases as the number of other people using those services grows, a telephone company can structure its rates to subsidize newcomers and expand its network.

Public goods are those that any number of people can use or benefit from simultaneously without increasing the total costs of providing the goods or interfering with each other's consumption of them. By that definition, broadcast radio and TV are public goods, as are national security, public safety, flood control, and clean air: in each case, what is provided to one person is available to everyone in the relevant area. The private sector may provide public goods, as the radio and TV cases show, but market signals alone need not lead it to provide them in the efficient quantity. Charging users of a public good a price and excluding nonpayers from sharing in its benefit is often impossible or prohibitively expensive, and if the beneficiaries are not charged—or only some of them are (for example, TV advertisers but not viewers)—then private providers of the good cannot perceive the correct incentive to supply it. Even when charging an exclusionary price is feasible, doing so is inefficient because it needlessly discourages consumption by those for whom the value of the good is positive but less than the price.

8. See, for example, David Colton, *Spectrum Privatization: Removing the Barriers to Telecommunications Competition*, Policy Study No. 208 (Los Angeles: Reason Foundation, July 1996); and statement of Peter Pitsch, Adjunct Fellow, Progress and Freedom Foundation and Hudson Institute, in U.S. Senate, *Spectrum Reform*, hearings before the Senate Committee on Commerce, Science, and Transportation, Senate Hearing 104-346 (July 27, 1995).

Transaction costs are the incidental costs of engaging in a voluntary transaction, including the costs of searching for a desired set of product features, negotiating a price, and monitoring a contract. They can be viewed as a kind of friction impeding market forces, preventing some desirable transactions from taking place. For example, if all rights to use the spectrum had to be purchased in the marketplace, amateur radio users and users of such unlicensed devices as cordless phones and garage-door openers could be at a disadvantage because of the high costs of organizing themselves to purchase the rights collectively. Also, transaction costs could keep potential consumers and producers of a new product—such as videocassette recorders, digital audio tape decks, or digital televisions—from settling on a single standard that would help consumers accept it. If transaction costs are large, market forces alone may be unable to put resources to their optimal uses, and government coordination may yield better results. Again, however, problems with the quantity and quality of available information about consumers' preferences and technological opportunities make it difficult for government decisionmakers to know whether any particular intervention would be efficient in practice.

Equity

Although equity is ultimately a subjective goal, it can be described as the goal of seeing that all parties are treated fairly, in accord with what they deserve. The relevant parties in the context of radio spectrum include service providers (large and small, spectrum-based and wire-based, incumbent and prospective), consumers of various types, and the Treasury. Some equity issues may hinge only on the fairness of the procedures involved; others may rest more on the fairness of the resulting outcomes.

One of the equity objectives mentioned in OBRA-93 is that the FCC recover "a portion" of the spectrum value for the Treasury and avoid "unjust enrichment" of the licensees. A well-run, procedurally fair auction yielding what seems to be a fair market price for the licenses appears to satisfy the Congressional intent behind that language.

OBRA-93 also called on the FCC to ensure that certain categories of firms—rural telephone companies, small businesses, and firms owned by women and members of racial minority groups—would be able to win some of the licenses assigned by auction. That provision reflects a Congressional judgment that the targeted firms, collectively known as designated entities, face such a disadvantage in their access to capital that even neutrally fair auction procedures would not bring about an equitable assignment of licenses.

Similar equity arguments for going beyond procedural neutrality are often made on behalf of groups of consumers that are considered to have too little clout in the marketplace. Such arguments support the universal service program, which ensures affordable telephone service to low-income and remote rural customers. They also underpin concern for the survival of low-power television stations that retransmit signals to distant rural areas or serve foreign-speaking audiences in urban areas.

Remaining Questions About FCC Auctions

In light of the underlying policy goals, a thorough evaluation of the initial FCC auctions and their significance for the future of spectrum management should go beyond the speed of the process and the amount of receipts generated for the Treasury to three additional questions.

- Did the initial auctions promote efficiency and equity in markets for telecommunications services?
- If the experience with the initial auctions was positive, could additional auctions be conducted, and would they produce equally good results?
- Does the experience with auctions provide lessons for spectrum management more generally? In particular, does it suggest that the block allocation system—the context in which licenses become available to be assigned—should be changed?

The Effects of the Initial Auctions on Spectrum Services

An important test for the efficiency of a spectrum auction is the extent to which it assigns licenses to bidders

who value them most, and its ability to do so may depend on its design and circumstances. Thus, for example, because bidders may value specific collections of licenses, such as those for a complete nationwide network, it is relevant to ask whether the auctions allowed optimal groupings of licenses to emerge. One could also look for evidence that uncertainty about the future affected bidders' valuations in such a way as to reduce efficiency. If so, the impact of such uncertainty might be reduced by changing the auction rules to limit the terms of the licenses or include some form of profit sharing or royalty payments as part of the bids.

Another important issue concerning the efficiency of the initial spectrum auctions is whether their greater speed in assigning licenses, relative to comparative hearings and perhaps even to lotteries, will translate into faster rollout of the licensed services. Some observers argue that services will be delayed because of the additional financial burden licensees will face in paying off their bids.

The initial auctions also raise several equity issues. Were the auctions competitive enough to avoid unjust enrichment of the winning bidders? Did the rules give smaller firms, with less access to borrowed capital, a fair chance to win licenses? Did they adequately protect against excessive concentration of ownership in communications services?

Extrapolating to Future Auctions

As noted above, the apparent success of the initial auctions and the difficult budgetary climate have together spurred great interest in the possibility of holding more auctions that could produce additional federal receipts. They have also generated concern that auction receipts could become the tail wagging the dog of telecommunications policy.

Could the FCC continue to produce auction receipts of the magnitude seen in the first five years? That question has two parts: Could comparable amounts of spectrum be made available for auction, and would licenses continue to command prices like those seen to date? The search for spectrum to auction is complicated because frequencies with commercial potential are generally encumbered with current users. Auction prices would be influenced not only by the amount of spectrum made available but also by technological change, which can both stimulate demand for spectrum services and increase the capacity of a given set of frequencies.

Could a narrow focus on maximizing federal receipts lead to decisions that undermine efficiency and equity in telecommunications policy? Recent debates about new digital television services, for example, have focused on the appropriateness of assigning digital TV licenses by auction and on perceived conflicts between generating receipts and achieving other policy goals. More generally, spectrum policymakers could conceivably undercut economic efficiency by withholding spectrum to keep auction prices high or, conversely, by shifting too much spectrum to uses for which licenses could be auctioned and leaving too little for unlicensed and public uses.

License Auctions and the Block Allocation System

The current block allocation system is a centralized, command-and-control mechanism created in the early days of spectrum use to impose structure and minimize problems of signal interference between different users. Does that system adequately serve the goals of efficiency and equity today? Or is it overmatched by the effects of rapid technological and institutional change and explosive consumer demand for new telecommunications services?

License auctions themselves reveal information about the value of spectrum in the uses being auctioned. That information may help spectrum managers make better decisions, thereby possibly maintaining the usefulness of the block allocation system. The same information, however, can also highlight the gaps in value between different uses and increase the pressure for major shifts in the allocation of spectrum. Some observers argue that keeping the spectrum employed in its most valuable uses will require modifying, or even replacing, the current system.

One view is that the license auctions to date have shown that the spectrum is better managed by decentralized market forces than administrative means and that market forces should be given a more direct role in determining not only who uses spectrum but also how it

is used. That role might or might not involve ongoing use of auctions. On the one hand, the government might manage the spectrum with a lighter hand that allows the private sector more discretion than it typically has today, while still reclaiming frequencies, moving incumbent users, and auctioning new licenses as necessary to overcome imperfections in the market. On the other hand, the government could grant all licensees full property rights and complete discretion in how they use the spectrum, eliminating the need for government auctions once all frequencies have been licensed. Some observers go so far as to predict that improved digital technologies embedded in future receivers and transmitters will ensure interference-free wireless communications, solving the problem of insufficient spectrum to meet demand and making licenses to use the spectrum and auctions to distribute the licenses irrelevant.

Aims of This Study

Many of the above questions about the merits of auctioning spectrum licenses and the future of spectrum management are difficult to answer. In some cases, the relevant evidence does not yet exist; in others, the difficulty lies in comparing actual experiences with might-have-beens.

Nonetheless, this study attempts to address these questions by analyzing existing data, identifying needs for additional information, and exploring policy options. In particular, the study examines the results of the initial auctions for spectrum licenses, the general prospects for future auctions within the current system for allocating spectrum, the applicability of auctions to the case of digital television, and the needs and opportunities for broader reform of the system for managing the spectrum.

Chapter Two

Auctions Held by the Federal Communications Commission

Has auctioning licenses to use the radio spectrum been a success? During the many years of debate before the Federal Communications Commission was allowed to assign licenses by auction, opponents leveled a wide range of criticisms and predicted dire consequences if the FCC was given such authority. They feared, for example, that the commission could not design and conduct an auction that did not break down and disintegrate into years of legal wrangling and delays in introducing new services. Critics also expressed more fundamental concerns—for example, that the number of suppliers of wireless telecommunications would dwindle because large firms with deep pockets would outbid other potential entrants and warehouse every available megahertz of spectrum.

Federal receipts alone, even the billions raised in the FCC auctions concluded to date, do not provide sufficient evidence to declare those sales an unqualified success. The Omnibus Budget Reconciliation Act of 1993, which directed the FCC to establish a system of competitive bidding to assign licenses, also included other criteria against which to measure the auctions' success.[1] Too little time has passed, however, to make such an assessment and to examine the choices that policymakers have had to make in reconciling the sometimes conflicting objectives of efficiency and equity. No one can yet determine whether the auctions will help speed the deployment of new telecommunications services, whether those services will be provided in a competitive marketplace, or whether auctions will enable small businesses, rural telephone companies, and businesses owned by members of minority groups and women to provide emerging telecommunications services.

Nevertheless, most observers have concluded, and the initial evidence suggests, that the early FCC auctions have been successful, particularly compared with the alternative methods of assigning licenses—namely, comparative hearings and lotteries (see Table 1 for a description of some of the auctions that the FCC has conducted to date).

At least three questions should be asked in evaluating the early FCC auctions:

- Did the auctions result in an economically efficient distribution of licenses to use the radio spectrum?
- Did the auctions achieve the objective of awarding licenses to small businesses, rural telephone companies, and businesses owned by women and members of minority groups?
- Were the auctions more or less costly than alternative methods of assigning licenses?

1. Federal Communications Commission, *Second Report and Order*, PP Docket No. 93-253, FCC 94-61 (April 20, 1994), p. 4, summarizes the objectives (in addition to those specified in section 1 of the Federal Communications Act of 1934) that the commission must seek in establishing a system of competitive bidding for licenses. Those objectives include developing and rapidly deploying new telecommunications services, promoting economic opportunity in the provision of telecommunications services, recovering for the public a portion of the value of public spectrum made available for commercial use, and using the radio spectrum efficiently and effectively.

Table 1.
Selected FCC Auctions

Auction	What Was Sold	Total Winning Bids Net of Discounts (Millions of dollars)	Spectrum Value (Dollars per person, per MHz)
	Narrowband Personal Communications Services		
National (July 25-29, 1994)	10 licenses, comprising a total allocation of 0.7875 MHz subdivided into three different-sized bandwidths, that allow the licensee to provide enhanced paging services on a nationwide basis.	617	3.12
Regional (October 26, 1994-November 8, 1994)	30 licenses, covering a total allocation of 0.45 MHz subdivided into six parcels of frequency and five regions, that allow the licensee to provide enhanced paging services.	395	3.46[a]
	Broadband Personal Communications Services		
A&B Blocks (December 1994-March 1994)	99 licenses, covering a total of 60 MHz subdivided into two 30-MHz bandwidths in each of 51 major trading areas (MTAs), that allow the licensee to offer mobile voice and data communications. The FCC's preexisting pioneer's preference policy led to three of the 102 licenses being assigned outside the auction.	7,736	0.51
C Block (December 1994-May 1995, and July 3, 1995)[b]	493 licenses of 30 MHz each, available in each of 493 basic trading areas (BTAs)—subsets of the larger MTAs—that allow the licensee to offer mobile voice and data communications. Participation in the auction was limited to designated entities—small businesses and businesses owned by women or minorities. Defaults by winning bidders in the initial sale required a reauction of 18 licenses. Additional defaults may require other reauctions in the future.	10,248	1.35[a]
D,E&F Blocks (August 1995-January 1997)	1,479 licenses, covering a total of 30 MHz subdivided into 10-MHz bandwidths and 493 BTAs, that allow the licensee to offer mobile voice and data communications. The F block was restricted to designated entities.	2,517	0.33[a]

SOURCE: Congressional Budget Office based on data from the Federal Communications Commission.

NOTE: MHz = megahertz; kHz = kilohertz; n.a. = not applicable.

FCC Actions Before the First Auctions

The FCC's most immediate task after being granted the authority to auction licenses was to assign permits for two different types of personal communications services (PCS).[2] The commission allocated a small amount of spectrum to enhanced paging services called

2. Federal Communications Commission, *Second Report and Order*, GEN Docket No. 90-314, FCC 93-451 (September 23, 1993), p. 3. As early as 1989, the commission had begun proceedings that ultimately led to the allocation of spectrum for personal communications services—a variety of new mobile services including voice, data, paging, and facsimile provided to both businesses and individuals.

Table 1.
Continued

Auction	What Was Sold	Total Winning Bids Net of Discounts (Millions of dollars)	Spectrum Value (Dollars per person, per MHz)
	Other Services		
Interactive Video and Data Services (July 28-29, 1994)	549 licenses available on a local basis permitting the user to offer a return link to be coordinated with cable or broadcast television for services such as home shopping and banking. Sale provided less than nationwide coverage, because licenses for a number of major markets were already assigned. Postauction defaults will require a reauction in 1997.	249	n.a.
Direct Broadcast Satellite Slots			
At 110 degrees west orbital location (January 24-26, 1996)	A license permitting the use of 28 channels with full coverage of the continental United States.	682	n.a.
At 148 degrees west orbital location (January 24-26, 1996)	A license permitting the use of 24 channels with only partial coverage of the continental United States.	52	n.a.
Multipoint Distribution Service (January 1996-May 1996)	238 local licenses allowing the holder to offer a type of broadcast television in very small areas. The service is called wireless cable because—like its namesake, wired cable television—it can offer a large number of channels (33 currently, more than 100 in the future). Licenses auctioned account for only a fraction of the population/channel coverage provided by all of the spectrum allocated for the service, most of which was already assigned.	216	n.a.
Specialized Mobile Radio (December 1995-April 1996)	1,020 licenses that allow the holder to provide mobile voice and data services. The licenses account for only a fraction of the population/channel coverage provided by all of the spectrum allocated for the service, most of which was already assigned.	204	n.a.

a. Uncorrected for installment payments at subsidized interest rates.

b. Consolidated results of the C block auction and the subsequent reauction of licenses on which winning bidders defaulted.

narrowband PCS. It designated a very large amount for broadband PCS, which is intended to provide a level of mobile communication that encompasses and goes beyond that offered by the cellular telephone industry.[3]

Assigning licenses for broadband PCS was of paramount importance. Many observers expected that a successful and rapid deployment of those services

3. Carol Weinhaus and others, "Cellular to PCS: A Wireless Primer" (paper presented at National Association of Regulatory Utility Commissioners' Annual Meetings, Washington, D.C., February 1996), discusses the similarity between cellular telephone service that uses frequencies in the 800 and 900 megahertz area and the personal communications services offered in the 1.9 gigahertz area. The paper also notes that both frequency allocations will probably be used to provide the same services to consumers.

would introduce competition into the market for mobile telephone services and generate substantial benefits for consumers and the economy.[4] Many people also viewed auctioning the PCS licenses as a unique opportunity to raise federal receipts in the billions, or even tens of billions, of dollars. Those predictions were based on the spectacular growth of the cellular telephone industry. Service revenues of under $0.5 billion in that market in 1985 increased to almost $11 billion by 1993, and the prices paid for cellular telephone franchises in private-market sales soared to over $200 per person living in the service area in particularly good urban markets.[5]

The commission faced several obstacles in delivering the benefits of PCS to consumers and capturing the receipts expected from the auctions. It had to design an auction system and put it in place. The auction would sell many licenses, and the relationships between those permits were complex. Moreover, the auction approach would have to accommodate goals in addition to (and potentially in conflict with) awarding licenses to the bidders willing to pay the most. The law authorizing auctions was clear that rural phone companies, and businesses that were small or owned by women or minorities, would have to win some of the licenses offered. Also, concerns about competition in the market for mobile telephone services forced the FCC to accept less competitive auctions by imposing restrictions on the participation of businesses already holding licenses to provide cellular telephone services. The rationale was that new players in those markets would lead to better service and lower prices for mobile telecommunications.

Goals and Design of Auctions

A well-designed auction induces bidders to reveal the value they place on the items being sold. When an auction works well, the process of revealing value will end with the items being sold to the bidder who values them most—an economically efficient distribution of the items.[6] The prices paid at auction will clear the market for the items being sold by balancing the demands of bidders with the supply of items.[7]

In the case of the FCC auctions, the idea that awarding the licenses to the bidders who value them most is an economically efficient outcome is intuitively plausible. The bidder who values a license most does so on the basis of a business plan that, compared with the plans of other bidders, projects the highest return—usually synonymous with the plan projecting the quickest, most economical deployment of the service that the license permits. That logic implicitly assumes, however, that the bidder calculates profit within the confines of a competitive market in which the presence of many suppliers limits the power that any one producer has over service prices. When competition is assured in the license auction and is likely to take place in the service market that the license allows the winner to enter, awarding licenses to the bidders who value them most will benefit consumers. Under those conditions, the federal government will raise the amount of receipts necessary to satisfy the broad objectives of the law authorizing auctions—specifically, a level of receipts that precludes winning bidders from undue enrichment and is consistent with the goal of providing consumers with efficiently priced, high-quality telecommunications services.

Most people associate auctions with an aggressive auctioneer barking out prices at lightning speed to an audience of bidders who compete for the item offered by making continuous and progressively higher bids. That type of auction, known as an ascending-bid or English auction, is one of several types of auctions generally recognized by economists.[8] The process of designing an auction is one of fitting the sales process to the nature of the good being sold (is it unique or common?) and the market in which the sale will take place (for example, does the market have many bidders who are certain about the value of the items, or a few bidders who are not very certain about the value?). In

4. Congressional Budget Office, *Auctioning Radio Spectrum Licenses* (March 1992), pp. 22-38, presents revenue estimates for new PCS licenses and evaluates the potential effect of personal communications services on consumers and the economy.

5. Edward M. Greenberg and Catherine M. Lloyd, *Telecommunications Services, Pop Out: The Changing Dynamics of the Cellular Telephone Industry* (New York: Morgan Stanley, April 1991), p. 2.

6. John McMillan, "Why Auction the Spectrum," *Telecommunications Policy*, vol. 19, no. 3 (April 1995), p. 193.

7. Vernon L. Smith, "Auctions," in John Eatwell, Murray Milgate, and Peter Newman, eds., *The New Palgrave Dictionary of Economics* (New York: Stockton Press, 1987), pp. 138-144.

8. Ibid., pp. 138-139.

some cases, an open multiple-round auction will be preferable because bidders are uncertain of the value of the item being sold and seek information and confirmation of their assessment in the auction process. In other cases, concern about collusion among bidders may suggest a single-round, sealed-bid auction.

Much of the FCC's planning for the early auctions involved developing and discussing seemingly arcane issues about specific auction rules—for example, whether bids should be made continuously or discretely, or whether bids could be withdrawn and, if so, at what cost or penalty. The experience of other governments in auctioning licenses to use the radio spectrum illustrates the importance of such rules. Problems with rules led to low receipts and an inefficient distribution of licenses in both Australia and New Zealand.[9]

Designing Auctions for Licenses to Provide Personal Communications Services

The FCC began to consider allocating frequencies for personal communications services in 1989, as part of its ongoing discussion of emerging technologies. By 1993, the rough outlines of allocations for both narrowband and broadband PCS were formed, but the final plans that specified frequencies and block sizes, geographic coverage, and special licensing issues were not completed until the middle of 1994.

The FCC allocated spectrum at 900 megahertz for the new narrowband paging service. Eleven separate licenses permitting the use of three different-sized blocks of frequencies would be available on a national basis, and 10 of those would be sold at auction. Six additional licenses permitting the use of two different-sized blocks of frequencies would be available in each of five regional subdivisions of the nation.[10]

The allocation for broadband PCS—frequencies for additional mobile telephone service—was equally complex. The final plan allocated 120 MHz for that service in the 1.9 GHz area of the spectrum. Licenses allowing the use of two 30-MHz blocks of frequencies, called the A&B blocks, would be auctioned first. Those licenses would be available in each of 51 geographic divisions, or major trading areas (MTAs), of the nation and its possessions. A 30-MHz block of spectrum, the C block, would be auctioned next in each of 493 smaller service areas called basic trading areas (BTAs). Finally, three 10-MHz blocks—the D,E&F blocks, would be made available in each of the 493 BTAs.[11]

Special circumstances applied to the licenses that were sold in each of the three broadband auctions. The FCC's decision to impose a 40-MHz cap on the combined PCS and cellular frequencies of a license holder effectively barred cellular licensees from bidding on the A&B block licenses in the same geographic areas where they held cellular licenses. A policy predating the PCS allocations—the pioneer's preference policy—required the FCC to assign licenses to applicants whose innovative ideas were judged by the commission to have made significant contributions to the development of the PCS concept or its enabling technology. Under that policy, rather than auctioning the A license in the MTAs for New York, Los Angeles, and Washington, D.C., the FCC assigned them to previously selected pioneers, who paid a price based on the value that the B license fetched at auction. The C block and F block licenses were set aside for small businesses and businesses owned by women or minorities, so-called designated entities. Bidders who qualified for those licenses received a variety of incentives including bidder's credits and the option to pay off winning bids in installments.

A bidder might assess the value of an FCC license in one of two ways: as an individual entity or as a part of a group of licenses. Each of the PCS licenses being sold at auction was valuable in and of itself. Accordingly, some bidders would seek the best value by pursuing a strategy of substituting one license for another if the auction allowed bidders to assess current offers and move from license to license as dictated by their valuation of the licenses and the standing high bids for those licenses.

9. Paul Milgrom, *Auction Theory for Privatization* (Cambridge: Cambridge University Press, forthcoming), reviews foreign experiences illustrating the importance of rules in the outcome of auctions.

10. Federal Communications Commission, *Memorandum Opinion and Order*, GEN Docket No. 90-134, FCC 94-30 (March 4, 1994), p. 8.

11. Federal Communications Commission, *Memorandum Opinion and Order*, GEN Docket No. 90-314, FCC 91-144 (June 13,1994), describes the allocation for personal communications services and the commission's rationale for that allocation.

The presence of economies of scale and scope in providing mobile communications services also made it likely that groups of licenses would be more valuable if won by the same bidder than if won by different bidders.[12] For example, a would-be provider of broadband personal communications services might value a group of PCS licenses more than each license individually, because winning the group would allow the producer to provide services at a lower average cost as more customers were covered. Such cost advantages could derive either from spreading the fixed cost of new systems over a larger customer base (for example, expenditures to design marketing programs and billing systems) or from the absence of problems with signal interference at the geographic borders of service areas owned by the same producer.[13]

Simple forms and rules for auctions work best when the value of an item being sold is unrelated to that of any other item, or when a bidder can substitute one item for an identical one. A more complicated problem in matching bidders and licenses is likely to occur, however, when a bidder's valuation for an item is positively influenced by having successfully bid on another item—just the case for many bidders in the PCS auctions.[14] If licenses were offered sequentially, bidders seeking combinations of licenses would probably offer less than full value for licenses sold early in the sequence, fearing that they would not win the licenses offered later that were necessary to justify bidding the full valuation of the early offerings. The likely outcome of using a sequential auction would be an inefficient initial distribution of licenses and low receipts for the federal government.

After an extensive regulatory proceeding, the FCC chose a simultaneous multiple-round design for the PCS auctions.[15] The design required that all of the licenses be offered simultaneously over as many rounds of bidding as necessary to produce no new offers for any of the licenses. The multiple-round feature allowed bidders to gather information about the market value of the licenses, gauge their own valuation against that of the market, and make adjustments as the auction proceeded. It also allowed them to make offers based on winning a combination of licenses by giving them an opportunity to obtain the last license they required to complete their package.

The commission's choice was controversial. The simultaneous multiple-round auction offered the prospect of more efficiently distributing licenses and yielding higher auction receipts than a simpler alternative. But it also demanded that the FCC accept an increased risk that the more complicated set of auction rules and administrative procedures might cause the auction to break down. Some observers faulted the commission for not accepting even greater risks and adopting an even more complex type of auction—the "combinatoric" approach—that was predicted to perform even better than the simultaneous multiple-round auction if the licenses being auctioned were strongly complementary.[16]

Experimental methods played a large and unique role in the FCC's auction design process.[17] Experiments that mimicked real-world conditions helped the FCC in choosing among types of auctions and selecting

12. R. Preston McAfee and John McMillan, "Analyzing the Airwaves Auction," *Journal of Economic Perspectives*, vol. 10, no. 1 (1996), p. 161.

13. The PCS licenses and the cellular licenses owned by a bidder may also complement one another. Those relations did not represent a major problem in designing the auctions after the decision was made to prevent cellular licensees from bidding on large blocks of spectrum allocated for personal communications services in their cellular service area. See Patrick S. Moreton and Pablo T. Spiller, "What's in the Air: Interlicense Synergies and Their Impact on the FCC Broadband PCS License Auctions" (paper presented at the Law and Economics of Property Rights to Radio Spectrum Conference, San Francisco, Calif., July 28, 1995, and revised September 1, 1996), p. 14.

14. Mark M. Bykowsky, Robert J. Cull, and John O. Ledyard, *Mutually Destructive Bidding: The FCC Auction Design Problem*, Social Science Working Paper 916 (Pasadena: California Institute of Technology, Division of Humanities and Social Sciences, 1995), pp. 7-23.

15. Federal Communications Commission, *Second Report and Order*, PP Docket No. 93-253, FCC 94-61 (March 8, 1994), provides an extensive review of the commission's consideration of alternative forms and rules for auctions. McAfee and McMillan, "Analyzing the Airwaves Auction," p. 160, credits Paul Milgrom, Robert Wilson, and R. Preston McAfee as the primary designers of the auction form chosen by the FCC for the PCS sales.

16. Letter from Larry Irving, Assistant Secretary for Communications and Information, Department of Commerce, to Reed Hundt, Chairman, Federal Communications Commission (February 28,1996), *ex parte* submission in PP Docket No. 93-253. Irving advocated a combinatoric auction, in which bids for combinations of licenses could be made contingent on winning the entire package. For the initial auctions, the commission rejected the approach for fear that the potential gains in efficiency and receipts could be captured only by accepting a greater risk that the auction might break down. The commission is considering using a combinatoric approach for future auctions.

17. Charles R. Plott, "Industrial Organization and Experimental Economics," *Journal of Economic Literature*, vol. 20, no.4 (December 1982), pp. 1485-1527, provides background on experimental economics and its applications.

specific rules. They also served as a test bed for software that was later used in actual auctions.[18]

Did the Auctions Result in an Economically Efficient Distribution of Licenses to Use the Radio Spectrum?

By most assessments, the FCC auctions have assigned licenses to use the spectrum in an economically efficient way. Those assessments rely as much on expert opinion and judgment, however, as on unimpeachable analytic results. Positive statements about the efficiency of the auctions' results can most strongly be made by comparing auctions with conjecture about what might have happened had licenses been assigned by lottery or comparative hearing. Ultimately, the volume of postauction resales of licenses will be the best indicator of the economic efficiency of the FCC auctions. But even that indicator will be less than definitive because it does not account for changes in market circumstances that occur between the auction and the future resale of licenses.

Two different approaches have been taken to assess the efficiency of the auctions in assigning licenses. The first approach, used by many economists, looks at the results of the auctions and uses indirect indicators to infer whether the auctions awarded licenses to the bidders who valued them most. Such an analysis must be indirect because bidders characteristically do not disclose their "true" valuation for the licenses they win. The indicators used in this approach are the extent of competition in an auction, the comparability of the prices paid at auction for similar licenses, and the ability of bidders to win groups of licenses that make economic sense.

A second, less extensively used, approach to assessing the allocative efficiency of the FCC auctions relies on experiments conducted in a controlled laboratory environment.[19] That approach seeks to select the best type of auction by repeated tests of different combinations of auction forms and bidders' "true" values for the licenses. Experimenters claim that if they can identify the range of true values and the environments in which bidders will contend, they can select the best type of auction without knowing the values that actual bidders will place on licenses. Contractors to the FCC conducted more than 130 experiments before the commission held the actual auctions. The results of those experiments were often cited by critics of the FCC's choice of the simultaneous multiple-round auction. They argued that such an auction would result in a less efficient distribution of licenses than would alternatives because the simultaneous multiple-round auction would not efficiently assign licenses that were highly complementary. Although useful in making that specific point and raising the possibility that superior forms and rules might be available, the experiments do not provide evidence as to whether the theoretical weaknesses of the chosen auction form were important enough in the initial FCC auctions to reduce the efficiency of the distribution of licenses.

Narrowband PCS

The narrowband PCS auctions were the first and third sales conducted by the FCC. Those sales assigned 40 licenses, 10 of three different bandwidths on a national basis and 30 of three different bandwidths available in five regions. The narrowband auctions raised over $1 billion—$617 million for the national licenses and $393 million for the regional licenses.[20] Available evidence indicates that those auctions yielded the most efficient distribution of licenses.

The FCC requires bidders to declare their interest before an auction and to make down payments based, in the case of the PCS auctions, on the total population of the license areas on which they intend to bid. The ratio of the population that is covered by down payments made by all bidders to the total population covered by

18. Charles R. Plott, "Selling the Electromagnetic Spectrum: The Role of and Uses of Experimental Methods in Economics at Caltech" (paper, California Institute of Technology, April 1995).

19. John O. Ledyard, David Porter, and Antonio Rangel, *The Results of Some Tests of Mechanism Designs for the Allocation and Pricing of Collections of Heterogeneous Items,* Social Science Working Paper 978 (Pasadena: California Institute of Technology, Division of Humanities and Social Sciences, March 1996), pp. 2-3.

20. Peter Cramton, "The FCC Spectrum Auctions: An Early Assessment" (draft, University of Maryland, July 1996), pp. 10-15.

the licenses being sold is called the eligibility ratio. That ratio is a crude measure of the degree of competition in each FCC auction. A higher ratio indicates that more bidders are pursuing the available licenses and thus that the auction is more likely to be competitive and to distribute licenses efficiently among the bidders. At the beginning of the national narrowband auction, the eligibility ratio was 8.8—that is, on average, 8.8 bidders sought each license. The comparable figure for the regional narrowband auction was 6.1. The narrowband auctions registered two of the three highest eligibility ratios of any of the FCC auctions concluded through 1996.[21]

Comparable prices for comparable licenses is a second indicator of an efficient distribution. In a simultaneous multiple-round auction, the movement of bidders from license to license as the auction moves from round to round tends to minimize disparities in prices. When an auction is competitive and licenses are not very complementary, a bidder is less likely to win a license when another bidder values it more. The whole process stops when prices for similar licenses converge, because no bidder has an incentive to move to a different license. The prices of similar licenses sold in the same auction did not differ by more than 5 percent in either of the narrowband auctions. For example, in the narrowband auction of nationwide licenses, each of the five licenses granting the largest amount of frequency sold for $80 million. The differences were greater between the two narrowband auctions, but overall, the average price paid on a per-person, per-megahertz basis was only 6.2 percent higher in the regional sale than in the national sale.[22]

Another indicator of efficiency is the success that bidders have in winning groups of licenses that appear economically rational. Pulling together groups of licenses that may allow a producer to provide services at a lower average cost is economically efficient. In the national narrowband auction, bidders successfully combined adjoining frequency bands, which enabled them to employ spectrum more efficiently by using the band between licensed frequencies that is set aside to guard against interference. In the regional narrowband auction, bidders successfully aggregated licenses for four of the six bands of frequencies available in five regions into the equivalent of national licenses. The 10 remaining licenses—five in each of two frequency bands—were won by five different bidders. That outcome illustrates the situation anticipated by the auction designers in which several bidders with limited objectives might pay more for individual licenses than a single bidder with grander aspirations might pay for the group.

The A&B Block Auction

Most assessments of the A&B block auction credit it with successfully assigning licenses to the parties who valued them most.[23] Some evidence from the auction itself and comparison with the prices paid in the later C block auction, however, suggest that licenses were efficiently distributed but at prices below their full value. The strongest indicator of the auction's success was the ability of three large bidders to win the licenses necessary to provide mobile telephone service nearly nationwide.

In only six of the 48 major trading areas in which both A and B licenses were available did the difference in final prices for the two licenses exceed the minimum bid increment—the amount that a bidder would have to offer above the standing high bid to make a new bid under the auction rules. That outcome provides modest support for the case that the auction efficiently distributed licenses. Nevertheless, price differences between the A and B licenses were large in some markets. For example, in the Tampa/St. Petersburg/Orlando market, the minimum bid increment was 5.0 percent, but at the close of the auction the B license sold for $9 million more than the A license, a difference of about 10 percent.

The story differs if the prices paid across markets are examined. For example, the average per-person,

21. Ibid., Table 8.

22. The difference in average prices is based on adjusting the prices paid for several licenses in the regional auction to account for the installment payment plan granted to the small businesses that won those licences. See Ian Ayers and Peter Cramton, "Deficit Reduction Through Diversity: How Affirmative Action at the FCC Increased Auction Competition," *Stanford Law Review*, vol. 4, no. 401 (April 1996), p. 420.

23. This view represents a consensus that emerged from the conference on Market Design: Spectrum Auctions and Beyond, Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, N.J., November 9-10, 1995. See also Cramton, "The FCC Spectrum Auctions," pp. 37-38; and McAfee and McMillan, "Analyzing the Airwaves Auction," pp. 164-176.

Box 1.
Were C Block Licenses More Valuable Than A&B Block Licenses?

Participants in the C block auction bid considerably more for their licenses than did bidders in the A&B block auction. The average price bid, net of bidding discounts, was about $1.35 per person, per megahertz (MHz) in the C block auction, more than two and a half times the average price of $0.51 paid for the A and B licenses. Several factors account for the higher bids for the C licenses: more favorable rules designed to encourage designated entities to participate; greater competition for the available licenses; and developments during the year following the close of the A&B block auction that may have increased bidders' valuations of the licenses.

The rules adopted to promote participation by small businesses in the C block auction required the winning bidders to pay 10 percent of their net winning bids by the time the licenses were issued, interest only on the remaining 90 percent for six years, and interest and principal for the remaining four years of the license. The interest rate charged on the balance of the license payments was the 10-year Treasury note rate at the time the license was issued; that rate ranged from 6.5 percent to 7 percent, far below typical commercial rates. Analysts believe that the value of the interest subsidy to the small businesses in the C block auction was an effective bidding credit of 20 percent to 40 percent.[1] If that estimate is correct, then a bid of about $1.35 under the C block rules was equivalent to an A&B block bid of $0.80 to $1.10. Thus, installment payments and the lower interest rate explain roughly one-third to two-thirds of the increase in bids in the C block auction.

The easier payment terms helped increase the number of bidders competing for each license in the C block auction. So did the fact that each of the licenses covered a basic trading area (BTA), which is typically a much smaller geographic area than the major trading areas (MTAs) that the A and B licenses covered, because having a license that covers a smaller geographic area reduces the total capital costs to a small business for building out a network. When the C block auction opened, bidders had deposited enough down payments to be eligible to buy 6.7 times the number of licenses available, compared with only 1.9 for the A&B block bidders, making the C block bidders more likely to bid their true valuations for the licenses. How much more A&B block bidders might have been willing to pay for their licenses if that auction had been more competitive is a matter of speculation.

Comparing a market that had relatively strong competition in the A&B block auction with the same market in the C block auction is one way to illustrate the impact of competition on the prices bid. For example, the two licenses for the Chicago MTA (a market in which AT&T, PCS PrimeCo, and WirelessCo actively competed) sold for an average of $1.05 per person, per MHz in the A&B block auction, compared with an average of $1.55 for licenses in the same market (composed of 19 BTAs) in the C block auction. Applying a 20 percent to 40 percent bidding credit to reflect the value of the installment payments reduces the "actual" price paid in the C block auction for licenses in the Chicago market to between $0.93 and $1.24 per person, per MHz. Therefore, the value of the C block licenses for the Chicago market was similar to that of the A&B block licenses.

The licenses in the C block auction may also have become more valuable than those sold in the A&B block auction because of changed market conditions and improvements in technology. During the year between the two auctions, wireless communications markets continued their robust growth. Bidders for C licenses were more optimistic than those for A and B licenses about the size of future markets for those services, anticipating a 60-fold increase in wireless telephone traffic.[2] The intervening year also saw improvements in technologies—especially the code division multiple access (CDMA) technology selected for use by NextWave Personal Communications, Inc., the biggest winner in the C block auction. Qualcomm, a wireless equipment manufacturer, asserts that CDMA technology is less expensive than other digital technologies.[3]

1. Peter Cramton, "The FCC Spectrum Auctions: An Early Assessment" (draft, University of Maryland, July 15, 1996), p. 26; John M. Bensche, *The C-Block Auction* (Boston: CS First Boston, 1996); and a consensus of outside experts at a meeting on spectrum valuation held by the Congressional Budget Office on February 26, 1996.

2. Jeffrey Hines, First Vice President, Research, Paine Webber Incorporated, CBO meeting on spectrum valuation, February 26, 1996.

3. James Madsen, "CDMA vs. GSM: A Comparison of the Seven C's of Wireless Communications" (paper presented at the Telecommunications Policy Research Conference, Solomons Island, Md., October 3, 1994), p. 13.

per-megahertz price paid for the Chicago licenses was $1.05—notably higher than the prices paid for the single competitively auctioned licenses in the New York and Los Angeles markets ($0.56 and $0.86, respectively). Prices could be expected to vary between markets on the basis of consumer demographics—income and time spent commuting in automobiles, for example—but differences as large as those evident in the A&B block auction are too great to be explained by such factors.

Additional questions about the efficiency of the distribution of licenses in the A&B block auction and the two other broadband sales that followed it are raised when the average prices for licenses are compared. The average per-person, per-megahertz price in the A&B block was about $0.50. The C block auction registered a substantially higher price of about $1.35, which drops to about $0.80 after adjusting for the terms of the installment payments available to the small businesses that won C block licenses (see Box 1, which discusses the differences in prices paid for licenses in the A&B and C block auctions). In contrast, the average price in the D,E&F auction was about $0.35, lower than that reported in either of the broadband PCS auctions that preceded it. Prices could be expected to vary among the auctions because the licenses sold granted the right to use different-sized blocks of spectrum that allowed the licensee to operate in different-sized geographic areas. Nevertheless, the ranking of average prices from high to low corresponds to the potential competition in each of the auctions as measured by the eligibility ratio. That ratio was 6.7 for the C block sale, compared with 1.9 for the A&B block sale and 1.7 for the D,E&F sale.

Why wasn't the A&B block auction more competitive? Fewer bidders entered that auction because the FCC restricted participation by the current holders of cellular licenses and permitted would-be competitors to join forces before the auction began. Both decisions should be evaluated as trade-offs between ensuring competition in wireless telecommunications markets and ensuring competition in the auctions for licenses to participate in those markets. Specifically, the commission chose to sacrifice the opportunity to maximize auction receipts to ensure an adequate number of technically capable and financially sound service providers and, ultimately, to sustain the competitive pricing and services that such providers would bring to telecommunications markets.

Table 2.
Total Population in Markets for Personal Communications and Cellular Telephone Services Covered by the Three Largest Winners in the A&B Block Auction (In millions of people)

	Personal Communications Services	Cellular Telephone Services	Total
AT&T	107.0	68.3[a]	175.3
WirelessCo	144.9	28.4[b]	173.3
PCS PrimeCo	57.2	110.4[c]	167.6

SOURCE: Congressional Budget Office based on Peter Cramton, "The FCC Spectrum Auctions: An Early Assessment" (draft, University of Maryland, July 15, 1996), Table 4; and Cellular Telephone Industry Association, *The Wireless Marketbook* (Spring 1996).

a. Estimated as the difference between the total mobile telephone population as reported by the Cellular Telephone Industry Association and the total population in the personal communications services markets as reported by Cramton.

b. Represents the cellular telephone markets of WirelessCo partners Comcast (7.6 million people) and Cox Communications (20.8 million people).

c. Represents the cellular telephone markets of Bell Atlantic/NYNEX (57.7 million people) and AirTouch (55.2 million people) adjusted downward by 2.5 million people for overlapping licenses in Arizona markets.

The result of the A&B block auction that most strongly suggests an efficient distribution of licenses was the success of bidders in aggregating groups of licenses. Each of the three largest winning bidders—AT&T, WirelessCo, and PCS PrimeCo—won licenses that enable them to offer nationwide service.[24] The PCS licenses won by AT&T and PCS PrimeCo, when combined with the cellular telephone licenses that each bidder already owned, provide nearly complete national coverage. WirelessCo, the largest winner in the auction, had the smallest cellular coverage but won 29 PCS

24. WirelessCo is a combination of the long-distance telephone company Sprint and three large cable television companies (TCI, Comcast, and Cox Communications). After the A&B block auction, WirelessCo changed its name to SprintCom. PCS PrimeCo is a combination of three regional Bell operating companies (NYNEX, Bell Atlantic, and USWest) plus AirTouch (a spin-off of another former Bell company, PacTel), which provides cellular telephone service in PacTel's operating area.

licenses permitting it to serve 145 million people (see Table 2). Bidders with more limited objectives, such as PacTel and GTE, were also successful, attesting to the degree of neutrality in the auction between different types of bidders.[25]

The C Block Auction

The PCS allocation offered the C block license as the premier opportunity for certain designated entities—small businesses and businesses owned by women or minorities—to participate in the new broadband service. The licenses permitted the use of 30 MHz of spectrum in each of 493 areas, subdivisions of the 51 areas defining the A&B block licenses. Participation in the auction was restricted to designated entities, who were allowed to pay off their winning bids over 10 years at a low rate of interest with interest-only payments for the first six years, rather than having to pay winning bids at the end of the auction as the A&B block winners were required to do.

One reason to think that the C block auction produced an efficient distribution of licenses is that it was very competitive and generated revenues far above those anticipated by most observers. The eligibility ratio for the C block auction was 6.7, in part because of the smaller coverage areas of the licenses, which pose a lower hurdle in terms of the required investment in capital equipment, and the generous financial incentives designed to encourage participation. The vigorous competition resulted in an auction that took 184 rounds of bidding over almost five months and yielded revenues exceeding $10 billion.

Another factor suggesting that the outcome of the C block auction was efficient is the fact that winning bidders were able to assemble valuable groups of licenses. The largest winning bidder, NextWave Personal Communications, offered $4.6 billion (46 percent of the total receipts generated by the auction) for 63 licenses that granted access to a market of 104 million people.[26] Those licenses were clustered in the mid-Atlantic region, the Midwest, and central Florida, with the notable exception of the Los Angeles market. NextWave subsequently increased its presence in the West by winning licenses in Denver, Portland, and Seattle that became available in a reauction of licenses that slid into default immediately following the original C block auction. The other four members of the top-five bidders' club were also able to assemble geographic clusters of licenses. Those five members accounted for more than 80 percent of the total winning bids in the C block auction.[27]

Not all of the results in the C block sale support the claim that the outcome was efficient, however. Two winning bidders defaulted on their offers immediately after the auction. One was the fourth largest winning bidder, BDPCS, Inc., which offered $874 million for 17 licenses.[28] The prompt reauction of the licenses that were defaulted on raised roughly the same amount as the winning bids committed in the first auction and minimized the cost to society of delays in providing service. In September 1996, several other bidders—who collectively won 31 licenses for which winning bids totaled $130 million—had problems in making their payments. Two of those bidders, who offered $117 million for 17 licenses, may ultimately default on their winning bids.

Some observers fear that more defaults will occur.[29] They contend that the financing terms offered to C block bidders were overly generous and ultimately destructive to the purpose of allowing small businesses to provide emerging telecommunications services. The low interest rates and long deferral of principal payments, according to the critics' view, allowed uninformed bidders to gamble that by the time they had to make their payment, the price of FCC licenses would

25. David J. Salant, "Up in Thin Air: GTE's Experience in the MTA Auctions for PCS Licenses" (paper presented at a conference on Market Design: Spectrum Auctions and Beyond, Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, N.J., November 9, 1995), describes GTE's experience in the MTA auction. For a discussion of the issue of the neutrality of the auction between bidders with national objectives and those with more limited objectives, see Mark Bykowsky and Robert J. Cull, "Broadband PCS (MTA) Auction: An Empirical Examination" (staff paper, Office of Policy Analysis and Development, National Telecommunications and Information Administration, November 1995).

26. Congressional Budget Office estimate of NextWave's bids and licenses from the original C block auction and the C block reauction using data from the Federal Communications Commission.

27. John M. Bensche, *The C-Block Auction* (Boston: CS First Boston, 1996), provides basic data and analysis of the C block auction.

28. A second bidder, National Telecom PCS, defaulted on a license permitting service in American Somoa.

29. Simon Wilkie, "Installment Payments and the FCC Auctions," *Jobs & Capital*, vol. 5 (Summer 1996), pp. 27-29.

rise sufficiently to justify their bids, with relatively little downside risk if that bet was lost. Certainly, if the FCC's installment plan has in fact removed the discipline of capital markets and allowed unjustified risk taking, additional defaults will occur and the distribution of licenses resulting from the C block auction will be shown to be inefficient.[30]

The D,E&F Block Auction

As indicated above, the prices paid for licenses in the D,E&F block sale were the lowest recorded in the three broadband license auctions: on a per-person, per-megahertz basis, the licenses sold for about $0.35, less than the A&B block price of about $0.50 and far less than the C block price, corrected for installment and interest incentives, of about $0.80. Disaggregating the results of the D,E&F auction and comparing them with the results of the previous broadband auctions narrows the gap between the similar D and E licenses (an average price of $0.37) and the A and B licenses, but it widens the gap between the C block and the F block—the blocks set aside for designated entities—with the average price of the F block falling to below $0.25 after taking into consideration the effects of installment and interest incentives.

In the D,E&F block sale, comparable prices were not paid for comparable licenses. For example, the E license for the New York BTA sold for 16 percent more than the D license, and the San Francisco D license sold for 30 percent more than the E license. Differences between prices paid for the D and E licenses and for the F license were even more striking. In some cases, the F license sold for far less than the D and E licenses; for example, the Los Angeles F license sold for $4 million, but both the D and E licenses for that BTA sold for over $30 million. That relation between the licenses set aside for designated entities was different than the comparative results of the A&B block and C block sales, but it was expected by many analysts because the option to pay in installments for the F license was less generous than that for the C license. In other cases, however, the F license sold for a great deal more than the D and E licenses: for example, the F license in Phoenix sold for over $30 million, but the D and E licenses sold for $11.2 million and $9.8 million.

The success of large bidders in aggregating licenses indicates that the distribution resulting from the D,E&F auction was an efficient one. Both AT&T and SprintCom (formerly, WirelessCo), the two largest winners in the auction, won groups of licenses at bargain prices compared with those paid in the previous broadband auctions. SprintCom was an unsuccessful bidder for the A and B licenses in Chicago but won both the D and E licenses for the Chicago BTA. That company also won at least a single D or E license for the BTAs covering the rest of Illinois and, in effect, paid only a fraction of the per-person, per-megahertz price that the winning bidders paid for the A and B licenses covering the same population. A number of other bidders that were successful in earlier PCS auctions, including AT&T and NextWave, were able to obtain complementary licenses in the D,E&F auction.

The indicators that the auction produced an efficient distribution of licenses are weakest for the D,E&F sale. The lack of competition in the auction, as indicated by the low eligibility ratio at the beginning of the sale, is probably the best explanation for the poor showing of the auction in generating comparable prices for comparable licenses. The generally lower prices registered in the auction are explained in part by the relative smallness of the geographic coverage and the amount of spectrum granted by the licenses. Also, capital markets may have been less willing to make additional investments in personal communications services on the heels of the previous broadband auctions.

Other FCC Auctions

The FCC's sales of licenses for services other than personal communications services—interactive video and data services (IVDS), specialized mobile radio (SMR), multipoint distribution services (MDS), and two direct broadcast satellite slots—have not been analyzed as much as the PCS sales. The sum of winning bids in the non-PCS auctions have accounted for only $1.4 billion, or 7 percent of the total winning bids.

Available evidence indicates that those auctions have had mixed success in producing an efficient distribution of licenses. Large-scale defaults on winning

30. As this report went to press, the second largest winner in the C block auction, Pocket Communications, filed for Chapter 11 protection under the U.S. Bankruptcy Code. The fate of its 43 licenses and $1.2 billion debt to the federal government is uncertain.

bids and subsequent missed installment payments indicate that the IVDS auction did not achieve that goal. The other auctions were each marked by spirited bidding. Winning bidders in the auctions for specialized mobile radio and multipoint distribution services aggregated potentially complementary licenses.

Conclusion

Final judgment on whether the FCC auctions distributed licenses to the parties who value them most awaits the passage of time. An active market exists for FCC licenses, including those won at auction. A large volume of license sales over the next several years would be a strong indicator that the auctions did not produce an efficient distribution of licenses; less activity in the secondary market would indicate that the auctions were effective in awarding license to the parties who valued them most. To date, few licenses have been sold in the secondary market.[31]

Even if the economic efficiency of the FCC auctions is less than perfect, as certainly seems the case, auctions are a more efficient means of assigning licenses than are comparative hearings or lotteries. The volume of licenses to be assigned is simply too large for a hearing process to manage. The lottery relies completely on the secondary market for achieving an efficient distribution of licenses, the same mechanism that could make marginal adjustments in the distribution of licenses created by an auction.

In the broader context of spectrum management, decisions made about which frequencies to auction, how to divide them on the radio spectrum and geographically, and which bidders to allow to bid on which frequencies ultimately affect the efficiency of the distribution of rights to use the spectrum more than does the type of auction chosen. Nevertheless, poor choices about the type of auction or more specific rules could lead to outcomes that are less than efficient, even if all of the choices made before the auctions were good ones.

31. Bensche, *The C-Block Auction*, p. 5, reports only three sales of A and B licenses in the secondary market, at prices comparable with those paid at auction.

Did the Auctions Achieve the Objective of Awarding Licenses to Small Businesses and Businesses That Are Owned by Women and Minorities?

Before the FCC was permitted to assign licenses by auction, concerns were expressed that using auctions might preclude certain groups from winning licenses to provide new telecommunications services. Specifically, the concern was that businesses owned by individuals who were historically discriminated against (women and minorities) or who lacked access to capital markets (small businesses and rural telephone companies) would not have the financial resources to compete with larger businesses and would thus be prevented from providing new telecommunications services. The statute granting the FCC the authority to auction licenses addressed that concern by directing the commission to design and test systems of competitive bidding to ensure that some licenses would be won by those applicants, known as designated entities.[32]

To meet those requirements, the FCC set aside specific licenses in the PCS auctions for designated entities and, foremost among other incentives, offered those businesses the opportunity to pay a portion of their winning bids over time at favorable interest rates. Incentives for small businesses, defined in various ways, were available in most of the auctions. Judicial rulings prevented the FCC from including incentives specific to minority- and women-owned businesses in some of the auctions, but the incentives available to small businesses aided those groups as well (see Table 3).

Designated Entities in the PCS Auctions

In the first PCS auction, at which national narrowband licenses were sold, the commission granted designated

32. Federal Communications Commission, *Second Report and Order*, PP Docket No. 93-253, FCC 94-61 (March 8, 1994), pp. 89-116.

Table 3.
Licenses Won by Designated Entities in Selected FCC Auctions

Auction	Small Businesses	Minority-Owned Businesses	Women-Owned Businesses
Personal Communications Services			
Regional Narrowband	11	6	5
Broadband C Block	493	150	95
Broadband D,E&F Blocks	589	70	50
Other			
Specialized Mobile Radio	263	31	35
Multipoint Distribution Service	381	10	19

SOURCE: Congressional Budget Office based on data from the Federal Communications Commission.

NOTE: Licenses may be part of more than one category.

entities a 25 percent bidder's credit on three of the 10 licenses offered.[33] For each dollar bid, the designated entity would pay only $0.75. No designated entity was among the six firms that won licenses in that auction.

For the next auction, the sale of regional narrowband licenses, the FCC made some changes in its auction format that put designated entities in a more competitive position. It effectively set aside two of the six blocks of licenses for designated entities by offering those bidders financial advantages that were so strong that other bidders stood little chance of winning the licenses. The 25 percent bidder's credit was increased to 40 percent for minority- and women-owned businesses. Qualifying as that type of business required 25 percent equity ownership, down from 50.1 percent in the previous PCS auction, with voting control. All designated entities also were permitted to pay off their bids over 10 years, with a six-year period of interest-only payments and financing at the Treasury note rate—an interest rate far lower than winning bidders could have obtained on the open market.

Twenty of the 28 bidders in the regional narrowband auction had some form of preference, and those incentives significantly influenced the outcome of that auction. Designated entities won the set-aside licenses and even one of the licenses open to all bidders. The incentives attracted many bidders to the set-aside licenses, and competition among designated entities was intense. Aided by bidder's credits and installment payments, the bids of designated entities on licenses open to all bidders increased the prices that the ultimate winners of those licenses paid. By the end of the auction, the winning designated entities had bid away their bidder's credit. The effective price they paid, however, was still lower than what regular bidders paid for comparable licenses, because the designated entities were able to pay off their winning bids at a low interest rate over 10 years.[34]

The original plan for assigning broadband PCS licenses featured set-aside licenses and incentives for minority- and women-owned businesses, as well as small businesses. The FCC dropped the special incentives for minority- and women-owned businesses in the C block auction because of the Supreme Court's decision in *Adarand Constructors v. Pena*.[35] That decision made it more difficult in general for the federal government to carry out race- or gender-based programs. In reviewing the Court's decision before finalizing its rules for the F block auction, the commission concluded that a policy of race-based incentives would have difficulty passing the test directed by the Court. The commission also eliminated gender-based incentives but indicated that the case for those incentives might be strong

33. Cramton, "The FCC Spectrum Auctions," pp. 10-15, 25-27, reviews the incentives offered to designated entities and their consequences for the auctions.

34. Ayers and Cramton, "Deficit Reduction Through Diversity," pp. 414-439, provides a detailed review of the results of the regional narrowband auction.

35. Federal Communications Commission, *FCC Seeks Comment on Changes in the C Block Auction Rules for Broadband PCS: Auction Date Set for August 29* (news release, FCC 95-263, June 23, 1995).

enough to clear the somewhat lower hurdle that the lower courts had suggested for those incentives.[36]

The C block auction provided all bidders with what quickly became an across-the-board credit of 25 percent (only one bidder, who dropped out after the first round, did not qualify for the credit) and the opportunity to pay off winning bids on an installment plan. As noted above, the combination of set-asides and installment credit attracted a large number of bidders, making for a very competitive sale that yielded high prices for licenses and large revenues for the federal government. But concern that the credit incentives in the C block auction had been too generous, leading underinformed bidders to pay too much and setting the stage for future defaults on their license payments, prompted the FCC to offer less attractive incentives for the F license.

In the D,E&F block auction, the FCC set aside all of the licenses in the F block for small businesses. The commission established a two-tiered classification for awarding bidding credits to the participants. Bidders with average annual gross revenues of less than $15 million for the three years before the auction received a 25 percent credit, and those with average annual gross revenues of no more than $40 million received a 15 percent credit. The FCC also redesigned the installment payment incentives for the F block auction. Bidders with average annual gross revenues of less than $40 million for the three years before the auction received only two years of interest-only payments, and bidders with average annual gross revenues between $40 million and $75 million received just one year of interest-only payments and had to pay the 10-year Treasury note rate plus 2.5 percentage points. Bidders with revenues between $75 million and $125 million had to pay both principal and interest from the first year on and were charged interest at 3.5 percentage points above the Treasury note rate.[37]

Designated Entities in Other Auctions

The FCC also provided incentives for designated entities in auctions of licenses for interactive video and data services, specialized mobile radio, and multipoint distribution services. In the IVDS auction, over 95 percent of the licenses were won by designated entities, who were granted bidding credits and installment payments. In the SMR auction, bidding credits and the prospect of installment payments helped designated entities to win 26 percent of the licenses auctioned. In the MDS auction, a bidder's credit of 15 percent and attractive financing terms helped designated entities win 77 percent of the licenses.[38] As in the regional narrowband auction, preferences for designated entities increased the overall competitiveness of both the SMR and the MDS auctions and probably drove up total receipts.

In contrast to the PCS auctions in which the success of small businesses in winning licenses was aided by set-asides, designated entities won licenses in the IVDS, SMR, and MDS auctions without that benefit. As a group, the licenses sold in the three auctions were less valuable than those offered in the PCS auctions, because in each case many of the licenses for the best markets had been assigned before the FCC was allowed to auction licenses. The lower value of the licenses auctioned may have leveled the playing field for large and small businesses and enabled small businesses to win licenses in those auctions without the benefit of set-asides.

Outcomes and Issues

Providing set-asides for designated entities has not reduced federal revenues from the FCC auctions. Prices paid in the regional narrowband auction were comparable with, and in some cases higher than, those paid in the national narrowband auction, despite the set-asides offered in the regional sale. The prices paid in the broadband C block auction were significantly above those paid in the A&B block sale, even after accounting for the value of the incentives provided by low interest rates and installment payments. The PCS auctions were made more competitive by incentives that strengthened the position of weaker bidders, who forced prices up.

The law establishing auctions presented the commission with the thorny problem of ensuring the partici-

36. Federal Communications Commission, *Report and Order*, WT Docket No. 96-59, FCC 96-278 (June 21, 1996), pp. 5-11.

37. Ibid., pp. 18-22.

38. Congressional Budget Office estimate based on data provided by the Federal Communications Commission.

pation of weakly capitalized businesses in markets that demanded large-scale and capital-intensive production. Tension on that front has been evident in the ongoing controversy concerning the definition of a small business qualifying as a designated entity. The FCC currently defines a small business as one with gross revenues of less than $125 million in each of the past two years and total assets of less than $500 million. A qualifying business may accept limited equity investments from nonqualifying investors if the entity establishes a control group with at least 25 percent equity in the business of which no less than 15 percent is owned by qualifying investors that have at least 50.1 percent of the voting stock of the designated entity. Consequently, a company participating in an auction as a designated entity can have up to 85 percent of its equity provided by large businesses.

The issue surfaced most dramatically in the C block auction. During the auction, rivals and critics cried foul and accused high bidders of merely "fronting" for larger companies—many foreign owned.[39] For example, NextWave—the largest winner in the C block auction—was backed by large foreign and domestic businesses, among them Qualcomm, a domestic supplier of telecommunications systems with 1995 revenues of almost $400 million; Goldstar, the largest producer of consumer electronics in South Korea; and Sony.[40] Without the liberalized rules that permitted the capital of larger firms to seep into the auctions restricted to designated entities, prices would have been lower, and the winning bidders would have been less able to deploy networks and offer services quickly. Consequently, consumers would be denied the benefits of the increased competition that new entries are likely to create in telecommunications services. Yet the entities bidding in the C block auction seem far removed from the small businesses envisioned by some supporters of the original law.

39. Letter from Kathleen O'Brien Ham, Chief, Auctions Division, Wireless Telecommunications Bureau, Federal Communications Commission, to William F. Maher, Jr., of Halprin, Temple, Goodman and Sugrue, legal counsel for NextWave Telcom, Inc., March 8, 1996; and letter from William F. Maher, Jr., to Reed E. Hundt, Chairman, Federal Communications Commission, March 14, 1996.

40. The issue of foreign participation was particularly prominent in the case of NextWave. In early 1997, the FCC concluded that NextWave was in violation of the rules limiting foreign equity participation but decided that NextWave should be given six months to change its ownership structure and conform to the commission's rules. In making that ruling, the commission indicated, however, that even if NextWave did not conform, its licenses would not be canceled unless doing so proved to be in the public interest. See Debra Wayne, "FCC Puts NextWave's Foreign Ownership Near 40%," *Radio Communications Report,* February 24, 1997, p. 1.

Were the Auctions More or Less Costly Than Alternative Methods of Assigning Licenses to Use the Radio Spectrum?

Broadly defined, the cost of the auctions include the government's cost of conducting the sales, the private resources consumed in seeking licenses, and additional private resources expended to obtain licenses in secondary markets if they were not initially assigned to the parties who valued them most. The cost of assigning licenses by auction is most meaningful when compared with the cost of the alternatives available to the commission—comparative hearings and lotteries.

Government Costs

The FCC spent almost $50 million on its auctions through fiscal year 1996 (see Table 4). The commission estimates that it will spend $22 million annually in 1997 and 1998. A significant amount of spending through 1996, perhaps as much as one-half, was for auction design, facilities, and hardware and software—items that the FCC can use for a number of years if

Table 4.
Spending by the Federal Communications Commission for Auctions (In millions of dollars)

Year	Outlays
1994	7.0
1995	24.0
1996	18.0
Total	49.0

SOURCE: Congressional Budget Office based on data from the Federal Communications Commission.

its authority to hold auctions is extended beyond 1998. The rest has been spent for conducting the auctions concluded through 1996 and planning those scheduled for 1997 and 1998.

It is difficult to compare those expenditures with the costs that the FCC would have incurred in assigning the same licenses by comparative hearing or lottery. It is also difficult to assemble data on the cost of assigning similar licenses by those alternative means in the past. Because the FCC is permitted to cover the cost of auctions from the receipts generated by the sales, those costs are very visible. In the past, however, the cost of assigning licenses was embedded in the overall cost of the FCC's activities and therefore difficult to break out. In fact, no reliable estimate exists of the cost of the resources that the FCC expended in assigning licenses before 1994.

An FCC analysis that compared assigning licenses by auction with the two alternatives, however, suggests that the time necessary to assign licenses and the volume of license applications are indicators of the cost to both the government and the private sector.[41] By those measures, auctions compare favorably with the alternatives. For example, the comparative hearings for assigning licenses to provide cellular telephone services in the 30 largest markets took more than two years, compared with just several months to auction and assign the broadband PCS licenses that provided national coverage.[42] The lotteries that were used to assign the remaining cellular licenses attracted a large volume of applicants. For example, the 30 licenses available in markets 91 through 120 drew more than 5,000 applications, requiring the commission to expend resources reviewing them. In contrast, only 30 applicants sought the first group of broadband PCS licenses that were auctioned.[43]

Private-Sector Costs

The cost to the private sector of assigning FCC licenses is the sum that all potential applicants spend on legal and administrative expenses in preparing applications and participating in the process. A comparative hearing discourages applications, but it inflicts a relatively high cost per application for participating. The tendency of hearing processes to stretch out over many years, particularly when the licenses being awarded are perceived to be of great value, increases the private sector's legal and administrative costs. As hearing processes drag on, the costs of delay mount for producers and consumers alike. Lotteries also impose a substantial social cost for preparing applications when each license opportunity could conceivably attract tens of thousands of applicants.[44] Moreover, since the lottery randomly assigns licenses, additional private resources must be spent after the lottery because the businesses that value the licenses most will buy them in the secondary market. Auctions attract fewer applicants and can be quickly concluded but, like lotteries, may consume substantial private resources in preparing applications and developing bidding strategies.

The auctions the FCC held in 1994 through 1996 certainly were less costly to the private sector than comparative hearings. They were probably also less costly than lotteries because the auctions were generally successful in placing licenses in the hands of the parties who valued them most and, thus, will likely impose a far lower cost of secondary market sales than the random assignment of licenses that a lottery would have produced. Ultimately, the cost of the method of assigning licenses turns on whether the assignment process distributes licenses to the parties who value them most. If not, society bears the cost of additional transactions and likely delays and inefficiencies in providing telecommunications services.

41. Evan Kwerel and Alex D. Felker, *Using Auctions to Select FCC Licensees*, OPP Working Paper Series, No. 16 (Office of Plans and Policy, Federal Communications Commission, May 1995), pp. 3-6.

42. Cramton, "The FCC Spectrum Auctions," p. 35.

43. Under the auction rules, each bidder had to declare for specific licenses. The 30 applicants in the A&B block auction made almost 1,800 declarations of interest for the 99 licenses sold.

44. Thomas W. Hazlett and Robert J. Michaels, "The Cost of Rent-Seeking: Evidence from the Cellular Telephone License Lotteries," *Southern Economic Journal*, vol. 59, no. 3 (1993), reviews the cost of the cellular lotteries.

Conclusion

The FCC auctions have generated substantial federal receipts. Most analysts judge that most of the sales have also resulted in an efficient distribution of licenses among contending parties, particularly in comparison with the alternatives of comparative hearings and lotteries. Consequently, consumers will soon enjoy the benefits of new and improved services that are delivered in a more price-competitive marketplace. Fears that auctions could not be reconciled with other distributional goals—primarily enabling small businesses to provide new telecommunications services—seem unjustified in light of results to date. The prospect of additional defaults by the winners in the C block auction remains a concern. But even if such defaults occurred, the problem lies with the financial incentives offered to auction participants, not with using auctions to assign licenses to use the radio spectrum.

Chapter Three

Proposals and Estimates for Future Auctions

Having licenses to sell and buyers willing to buy them were obvious prerequisites to the Federal Communications Commission's success in its early auctions. Both factors will remain in place until the commission's authority to auction licenses expires in 1998. The Congressional Budget Office estimates that legislation extending the FCC's auction authority beyond 1998 and allowing the commission to auction most types of exclusive-use licenses issued to private businesses would add $6.0 billion in receipts in 1998 through 2002, a level far below the estimated $27.0 billion produced by auctions conducted in the first five years of license sales.

Two factors explain the lower estimate. First, the prices that bidders are willing to pay for the right to use even the most attractive frequencies will probably fall. Second, the current system of spectrum management is unlikely to make available enough high-value spectrum to drive future receipts to the levels seen to date without additional legislative direction. Although new technologies, market opportunities, and the prospect of gains in efficiency are not lacking, the block allocation system has difficulty mediating between the potential gains from a more economically efficient allocation of the spectrum and the rights of current license holders.

Legislative proposals that yield receipts comparable with those captured during the first five years of FCC auctions intervene directly in managing the radio spectrum. The President's budget proposal of 1998 is typical. That proposal requires that substantial blocks of contiguous frequencies from the area of the spectrum under 3 gigahertz be reallocated from current uses to new ones, and that the FCC assign the rights to use those frequencies by auction. CBO estimates that the President's proposals for such directed reallocations, when combined with provisions that extend and broaden the FCC's authority to auction licenses, would increase receipts by $24.3 billion between 1998 and 2002.[1]

The Current Allocation of the Spectrum and Directed Reallocations

In a formal sense, the radio spectrum is all but fully allocated: the frequencies between 3 kilohertz and 300 GHz are divided into blocks that are dedicated to specific services that can be provided only under a defined set of rules that specify exclusive or shared use as well as the technical standards for equipment for transmitting and receiving signals.[2] Frequencies for new services and licenses cannot be made available without

1. For similar proposals offered during the 104th Congress, CBO estimated receipts in the range of $15 billion to over $30 billion, depending on the specifics of the proposal.

2. Department of Commerce, National Telecommunications and Information Administration, *United States Frequency Allocations: The Radio Spectrum* (March 1996), graphically presents the frequencies allocated to 30 categories of radio services. It also indicates whether the service is provided only by the federal government, only by nonfederal entities, or on a shared basis, and whether the service is a primary, secondary, or merely a permitted use of the frequency band. Bennett Z. Kobb, *Spectrum Guide: Radio Frequency Allocations in the United States, 30 MHz-300 GHz* (Falls Church, Va.: New Signals Press, 1996), is a more detailed but also accessible reference that describes the current allocation of the spectrum.

Table 5.
Allocation of the Radio Spectrum to Federal, Nonfederal, and Shared Uses

Frequencies	Federal		Nonfederal[a]		Shared	
	Megahertz	Percent	Megahertz	Percent	Megahertz	Percent
9 kHz to 3.1 GHz	426	13.7	940	30.3	1,734	56.0
3.1 GHz to 30 GHz	1,845	6.9	8,021	29.8	17,034	63.3
30 GHz to 300 GHz	2,000	0.8	7,600	2.8	260,400	96.4
All Frequencies, 9 kHz to 300 GHz	4,271	1.4	16,561	5.5	279,168	93.1

SOURCE: Congressional Budget Office using data from the Department of Commerce, National Telecommunications and Information Administration.

NOTE: kHz = kilohertz; GHz = gigahertz.

a. Includes commercial uses as well as uses for state and local governments.

affecting current services and imposing costs on current license holders. Crowding is most evident in the "good neighborhoods," the frequencies under 3 GHz that by virtue of their technical characteristics are more attractive and valuable than the higher frequencies. Making room in that area of the spectrum requires current users to retune the equipment they are now using or buy new equipment. Clearing large blocks of frequencies usually involves the latter as well as the additional step of moving the incumbent services and users to higher-frequency bands. Although those bands are also allocated for current services, in some cases they can accommodate additional users because they are less intensively used.

The current allocation of spectrum is the product of the historical interaction of technology, economics, and institutions. Taken in its entirety, the radio spectrum is allocated predominantly for shared, nonexclusive use by more than one type of service. Frequencies allocated in that way are usually open to both federal users (under the jurisdiction of the National Telecommunications and Information Administration) and nonfederal users (private entities and state and local governments, under the FCC's jurisdiction). The most intensively used and highly coveted lower-frequency bands are more likely to be allocated for a single type of service that is provided exclusively by a federal or nonfederal user.[3] Both types of users share 93 percent of the spectrum below 300 GHz, but only 63 percent below 30 GHz and 56 percent below 3.1 GHz (see Table 5).[4] Exclusive nonfederal allocations—including those for broadcast television and radio, cellular telephone, paging, and the new personal communications services—account for about 30 percent of the frequencies below 3.1 GHz. Exclusive federal allocations for services such as aeronautical radio navigation, public safety, and national security occupy just under 15 percent of that area of the spectrum.

The most common nonfederal uses of the radio spectrum are well known. Private companies use it to

3. Regarding the relative value of the frequencies above and below 3 GHz, the lower frequencies remain more valuable, advances in technology not withstanding. Two basic technological issues are important. First, at frequencies above 3 GHz, antennas start to lose efficiency, and those frequencies require more power to transmit the same distance. Antennas can be replaced with relatively expensive satellite dish-type receivers, but even that solution may not be practical for mobile technologies. Second, receivers based on silicon chip technology become less effective and in some cases unusable at frequencies above 3 GHz. Gallium arsenide chips may be a workable, but more expensive, technical alternative.

4. The National Telecommunications and Information Administration reports data on users for the area under 3.1 GHz, rather than 3 GHz—the frequency used elsewhere in this report.

provide services such as broadcasting (ground-based television, satellite television, and radio), mobile communications (voice, data, and paging), and fixed-point to fixed-point communications (microwave transmission of telephone signals). State and local governments also hold the right to use parts of the radio spectrum to provide services related to public safety, including police and fire service, forestry and conservation service, highway maintenance, and other local communications needs such as civil defense.[5] Several groups of profit-making entities, including railroads, public utilities, and natural gas companies, also have the right to use the spectrum under a public safety rationale.

Nongovernment use of the spectrum for some profit-making activities is obviously intensive, particularly in densely populated and profitable urban markets. For example, using the technology in place, no excess spectrum is available for commercial television or radio broadcasting in many urban markets. The allocations for cellular telephone service are also intensively used in many markets as evidenced by the inability of customers to make calls at certain times of the day because all available frequencies are in use. Public safety users also claim crowding and seek additional allocations for the future.[6]

The federal government's uses of the spectrum include some that are technically identical to nongovernment uses—for example, mobile telephone service on land, at sea, and in the air—as well as uniquely governmental activities such as monitoring potential military adversaries. The Department of Defense and law enforcement agencies are the largest federal users, accounting for approximately 60 percent of total federal assignments.[7] Federal users, like nonfederal users, complain of crowding and seek larger allocations. Spectrum that is currently allocated to federal users, however, is often suggested as a source of new frequencies for nonfederal uses.[8]

Problems of measurement make it difficult to evaluate the amount of spectrum allocated to the federal government. It is universally accepted that many essential services provided by the government require use of the airwaves. Nevertheless, the absence of a profit motive for the managers of federal spectrum make it likely that the federal frequencies are used less intensively and efficiently than those controlled by private rights holders.

The current allocation constrains the amount of frequency in the most valuable areas of the radio spectrum that can be allocated from current services to new ones. Technical change, however, can free up lower-frequency bands for new allocations by allowing the most crowded parts of the spectrum to be used more intensively; for example, using digital technology for television broadcasting could free up almost 140 MHz of commercially attractive spectrum below 3 GHz and still accommodate perhaps a sixfold increase in the number of viewing alternatives (see Chapter 4). Moving many radio services from analog to digital transmission is currently the most prominent, but not the only, technical force that could make new allocations possible. Freeing up spectrum for new services and having licenses to auction—yielding additional federal receipts—ultimately depend on such changes.

CBO's Baseline for the FCC Auctions, 1998-2007

CBO's baseline is a benchmark for measuring the budgetary effects of proposed changes in federal revenues and spending. Early in each calendar year, CBO establishes a baseline against which to measure, or score, the spending and revenue effects of legislative proposals for the entire year.[9] The baseline for the FCC auctions is a projection of the receipts that will be deposited in

5. Federal Communications Commission, *Notice of Proposed Rule Making*, WT Docket No. 96-86, FCC 96-155 (April 10, 1996), p. 6.

6. Department of Commerce, National Telecommunications and Information Administration, *U.S. National Spectrum Requirements: Projections and Trends* (March 1995), pp. 26-28.

7. Department of Commerce, National Telecommunications and Information Administration, "A Spectrum Information Fact Sheet" (August 16, 1995), Chart 4. This measure reflects the percentage of total assignments made to federal users, not the amount of spectrum actually used or the intensity of use.

8. See, for example, statements of Dale N. Hatfield, a Senior Fellow of the Annenberg Washington Program, and Charles L. Jackson, principal of Strategic Policy Research, before the House Committee on Commerce, September 7, 1995.

9. Baseline projections are updated in a midyear review, but those projections are not used for scoring purposes.

Table 6.
Projected Receipts from FCC Auctions (In millions of dollars)

Auction	Actual 1995	Actual 1996	1997	1998	1999	2000	2001	2002	2007	Total[a]
Broadband Personal Communications Services	7,050	50	8,900	4,000	250	250	150	0	0	20,650
Other	600	300	700	3,100	1,350	300	0	0	0	6,350
Total	7,650	350	9,600	7,100	1,600	550	150	0	0	27,000

SOURCE: Congressional Budget Office.

a. The Federal Communications Commission's (FCC's) authority to auction licenses expires in 1998. Receipts are shown for years after 1998 to account for delays in transferring the payments of auction winners from the FCC to the Treasury and for a small amount of installment payments recorded on a cash, rather than a credit reform, basis. Totals, although summed over the seven-year period from 1995 through 2001, represent the receipts raised by FCC auctions over the first five years of auction authority, 1994 through 1998. Totals through 2007 are the same as through 2002 because no additional receipts are expected under current law after 2001.

the Treasury over 10 years based on laws in existence in the year that the projection is made.

CBO's baseline projections of FCC auction receipts is $27.0 billion for 1994 through 2007 (see Table 6). Of that sum, $8.0 billion was deposited with the Treasury in 1994 through 1996. CBO estimated that under current law, the FCC auctions will yield an additional $19.0 billion in receipts through 2002. Although the receipts covered in the baseline include only those expected from FCC auctions concluded by September 30, 1998 (when the commission's authority to auction licenses expires), some receipts are shown in later years primarily to account for delays in issuing licenses to winning bidders and the subsequent recording of those receipts in the budget. The receipts from the auctions for broadband personal communications services represent about 70 percent of the projected total. Unique aspects of recording the FCC auction receipts in the budget are discussed in Box 2.

The process of building a baseline for FCC auction receipts begins by predicting the auctions that the commission will conduct and how much those auctions will raise net of bidding discounts. Although in many cases those plans are clear, current law gives the FCC substantial discretion about what frequencies will be allocated to what services, under what terms and conditions, and, accordingly, whether auctions will be necessary to assign licenses. Moreover, the FCC does not usually plan its spectrum allocations and license auctions for the next 10 years. Thus, formulating a baseline requires that CBO predict the behavior of a regulatory body whose actual behavior could be influenced by countless and uncertain legal, economic, technical, and political factors.

To estimate the receipts that each FCC auction could generate, CBO analyzes past auction results and the prices paid for FCC licenses in private sales and gathers opinions about the value of the licenses to be sold from experts in the policy, industrial, technical, and financial communities. Further analysis is undertaken when a specific auction (or auctions) appears likely to be a major contributor to receipts.[10] In addition to the sum of receipts anticipated from planned and likely auctions, the baseline includes an "other" category of unspecified auction receipts (currently $2.5 billion spread over the 1998-2000 period) to cover opportunities that are permitted by current law but cannot yet be identified.

Estimating the receipts generated by FCC auctions has proved to be a difficult task. CBO, the Office of Management and Budget, and the budget committees of

10. Congressional Budget Office, *Auctioning Radio Spectrum Licenses* (March 1992), was one such effort that focused on the personal communications services auctions.

the Congress all dramatically underestimated the receipts that the FCC raised under the auction authority granted by the Omnibus Budget Reconciliation Act of 1993. The results of recent auctions provide a good deal more evidence than was previously available about spectrum receipts; nonetheless, the future course of regulation, technology, and investors' perceptions of market opportunities remain highly uncertain.

Estimates of Receipts for Proposals Concerning the FCC Auctions

Legislative proposals that change the commission's behavior in ways that affect auction receipts are evaluated

Box 2.
Issues Concerning the Budgetary Treatment of Receipts from the FCC Auctions

Two features of the budgetary treatment of the receipts from auctions held by the Federal Communications Commission (FCC) deserve special attention. First, in some cases, auction receipts are recorded in the budget many months after the conclusion of an auction. Second, the installment payments that some auction winners are permitted to use are treated as direct loans subject to the requirements of the Federal Credit Reform Act of 1990. Both issues come into play in the budgetary treatment of the receipts generated in the C block auction of licenses to provide broadband personal communications services (PCS).

Although the winners in the FCC auctions concluded in 1994 through 1996 bid over $20 billion for the licenses they sought, the Treasury has recorded only $8.0 billion as offsetting receipts for those same years. The lag occurs because the FCC must review the license application for each winning bidder and resolve any outstanding legal challenges to the licensee before a license is issued and the auction receipts are recorded in the budget. Legal challenges of one sort or another have arisen for most of the FCC auctions. Resolving legal issues for only one auction—the C block sale of PCS licenses—would increase the recorded auction receipts by about $10 billion.

The Office of Management and Budget (OMB) and the Congressional Budget Office (CBO) have determined that the installment payments granted to winning bidders that are small businesses or businesses owned by members of minority groups or women constitute direct loans as defined under the Federal Credit Reform Act of 1990. The budgetary treatment of direct loans requires entries in three different accounts. Total receipts from an auction minus administrative costs (that is, the down payments of winning bidders and the amount of the winning bids that is financed in the year in which the FCC issues the license) are recorded in a *receipts account*. The subsidy cost of the direct loan is also recorded as an outlay from a *program account* in the year the license is issued. Finally, a *financing account*, which has no budgetary standing, records the cash flows from the loan and subsequent installment payments in the years in which they are made.

The subsidy cost of a direct loan is the sum of any interest subsidy and a default allowance, which recognizes the possibility that some winning bidders may fail to make their payments. The C block auction accounts for most of the subsidy costs shown in both CBO's and OMB's budgetary estimates of the FCC's auction receipts. Both estimates assume a subsidy rate of 12 percent and, accordingly, show $1.1 billion in outlays over the 1997-1999 period in the FCC program account. That estimate, however, reflects only a default allowance—the gross amount of the winning bids on licenses that winning bidders subsequently default on minus the receipts generated by reauctioning those licenses. It includes no interest subsidy because the interest rate that licensees pay under the FCC installment plan is equal to or greater than the government's borrowing rate for debt of comparable maturity. Although that accounting treatment captures the budgetary effect of the government's direct loan to winning bidders, it does not capture what most observers would consider an economic subsidy—the value of the difference between the interest rate that winning bidders in the FCC auctions pay and the higher rate they would have to pay if borrowing from private lenders.

Box 3.
A Comparison of the Congressional Budget Office's and the Office of Management and Budget's Estimates of the FCC Auction Receipts in the President's Budget Proposals for 1998

The President's budget for 1998 proposes four basic measures that would increase the receipts from the Federal Communications Commission's (FCC's) auctions over the 1998-2002 period. Those measures would:

- Broaden and extend the FCC's authority to auction licenses to use the radio spectrum, make a directed reallocation of 120 megahertz (MHz) of spectrum below 3 gigahertz (GHz) currently allocated for nonbroadcast use, and auction licenses permitting the use of those frequencies;
- Reallocate 78 additional MHz of spectrum currently allocated to broadcast television and auction licenses to use that spectrum;
- Reallocate 36 MHz of spectrum currently allocated to television channels 60 to 69 and auction licenses to use that spectrum; and
- Auction telephone numbers with the 888 area code for toll-free calls (a subject outside the scope of this study).

By the terms of reference developed in this study, the President's proposals related to the radio spectrum broaden and extend the FCC's auction authority and direct the reallocation and subsequent auction of the right to use 234 MHz of spectrum under 3 GHz.

The Office of Management and Budget (OMB) estimates that the Administration's proposals will raise $36.1 billion during the 1998-2002 period. That amount is in addition to the receipts from auctions authorized under current law. The Congressional Budget Office (CBO) estimates that the same basic policy proposals will raise roughly two-thirds as much, $24.3 billion, over the same period (see the accompanying table). A contingent, or fail-safe, policy devised by the Administration closes $9.4 billion of the $11.8 billion difference between the OMB and the CBO estimates. That policy would impose a one-time fee, to be divided among the current holders of television broadcasting licenses, if receipts fell short of OMB's estimate of $14.8 billion for 78 MHz of spectrum currently allocated to television broadcasting to be auctioned beginning in 2001. The fee would be equal to the shortfall. Including the contingent policy brings CBO's estimate of receipts to $33.7 billion compared with OMB's $36.1 billion.

CBO's estimates are similar to OMB's for broadening and extending the FCC's authority to auction licenses and for the receipts that reallocating and auctioning licenses to use 120 MHz of nonbroadcast spectrum would yield. The two estimates differ significantly, however, for the two television-related components of the budget proposal. The greatest reason for that difference is that CBO assumes that prices for FCC licenses will gradually fall, whereas OMB's estimates assume that prices will remain constant at the levels recorded in recent auctions. Both CBO and OMB adjust the receipts estimated for specific proposals using their assumptions about the basic path of license prices and the quantities of spectrum to be licensed and assigned by auction according to the details of the proposal. For example, OMB adjusts upward its estimate of the receipts from auctioning licenses for the 78 MHz of spectrum currently allocated to broadcast television; it does so to account for its belief that those frequencies are of superior quality to other pieces of the radio spectrum under 3 GHz.

The difference between the CBO and OMB estimates is further illuminated by comparing both with those offered by each agency for proposals affecting the television spectrum in the last budget cycle. CBO's current estimate, on a per-megahertz basis, is close to its

as additions to (or subtractions from) the baseline. The President's budget for 1998 proposes several basic policies that CBO estimates would increase receipts by $24.3 billion for the 1998-2002 period. The Office of Management and Budget estimates that the same proposals would increase receipts by $36.1 billion. (Box 3 compares the CBO and OMB estimates.)

CBO distinguishes between proposals that extend current law and those that direct the reallocation and subsequent auctioning of licenses for frequencies that are currently allocated to specific services and, in many cases, licensed to specific users. The President's budget includes both types of proposals.

projections for last year. OMB, however, has increased its per-megahertz estimate by more than 40 percent. For last year's budget proposal, both CBO and OMB estimated television receipts on the basis of 150 MHz. Currently, the President's combined television proposals would make available only 114 MHz—about 25 percent less than last year's proposal. Thus, when CBO's previous estimate for the television spectrum of $10.8 billion is compared with its current estimate of $7.8 billion, most of the difference is explained by the reduced quantity of spectrum available to license and sell.

Estimating the receipts yielded by the auction of FCC licenses is fraught with uncertainty. Neither OMB nor CBO can forecast with complete confidence the trends in technology, regulatory changes, and other factors that would affect the prices for spectrum licenses assigned by auctions. With the exception of OMB's estimate for the 78 MHz of spectrum proposed to be auctioned in 2001, CBO believes that all of the current estimates by both agencies are reasonable, given the considerable uncertainty involved. CBO expects market prices to decline gradually as more spectrum becomes available—an assumption that makes its estimate for the 78 MHz of reallocated television spectrum logically consistent with its projections for other auctions. It is difficult to discern the rationale for OMB's substantially higher estimate.

Receipt Estimates for the President's 1998 Budget Proposal for Additional FCC Auctions (By fiscal year, in millions of dollars)

	1998	1999	2000	2001	2002	Total, 1998-2002
Nonbroadcast Spectrum						
CBO	0	2,300	4,000	4,500	4,900	15,700[a]
OMB	1,400	1,800	3,800	4,500	5,600	17,100
Analog Broadcast						
CBO	0	0	0	0	5,400	5,400
OMB	0	0	0	0	14,800	14,800
TV Channels 60 to 69						
CBO	0	0	0	1,200	1,300	2,500
OMB	0	0	0	1,800	1,700	3,500
888 Numbers						
CBO	0	700	0	0	0	700
OMB	700	0	0	0	0	700
Total						
CBO	0	3,000	4,000	5,700	11,600	24,300
OMB	2,100	1,800	3,800	6,300	22,100	36,100

SOURCES: Congressional Budget Office; Office of Management and Budget.

a. The estimate includes $6.0 billion in receipts from broadening and extending the FCC's authority to auction licensees.

Extending and Broadening the FCC's Auction Authority

CBO estimates that the President's proposal to extend the FCC's authority to auction licenses beyond 1998 and to broaden the commission's authority to include most licenses sought by a private business would increase receipts by $6.0 billion through 2002.[11] All of the technological, legal, and regulatory factors that

11. The Omnibus Budget Reconciliation Act of 1993 limited the commission's authority to a five-year period ending in 1998. Thus, simply extending that authority will increase receipts above the level included in the current baseline. OBRA-93 also limited the commission's auction authority to licenses that businesses would use to provide services on a subscription-fee basis.

Table 7.
The Federal Communications Commission's Plan for Reallocating the NTIA Spectrum

Frequencies	Megahertz	Availability	Initiation of Rule-Making for Reallocation to Nonfederal Uses
Group 1			2006
1390 MHz to 1400 MHz	10	1999	
1427 MHz to 1432 MHz	5	1999	
1670 MHz to 1675 MHz	5	1999	
1710 MHz to 1755 MHz	45	2004	
	65		
Group 2			1996
2300 MHz to 2310 MHz	10	1996	
2390 MHz to 2400 MHz	10	1995	
2400 MHz to 2402 MHz	2	1996	
2402 MHz to 2417 MHz	15	1995	
2417 MHz to 2450 MHz	33	1996	
	70		
Group 3			1997
3650 MHz to 3700 MHz	50	1999	
Group 4			2006
4635 MHz to 4660 MHz	25	1997	
4660 MHz to 4685 MHz	25	1995	
	50		

SOURCE: Congressional Budget Office based on Federal Communications Commission, *Plan for Reallocated Spectrum*, FCC 96-125 (March 1996), pp. 2-3.

NOTE: NTIA = National Telecommunications and Information Administration; MHz = megahertz.

complicate estimating the current-law baseline become more difficult to predict as the projection period is extended. Two events seem certain, however, if the FCC's basic auction authority is extended.

First, the commission will auction licenses granting the right to use spectrum that was formerly allocated to federal uses. OBRA-93 directed the National Telecommunications and Information Administration to transfer at least 200 MHz of spectrum from the frequencies under 5 GHz from its federal jurisdiction to the FCC's nonfederal jurisdiction. The law directed the FCC to allocate that spectrum to new services, but not necessarily ones that would require exclusive license rights. The law also specified that the frequencies transferred be reallocated over a 10-year period. The NTIA identified 235 MHz of spectrum for transfer. In 1996, the FCC released a schedule that grouped the NTIA spectrum, as it is sometimes called, into four parcels and indicated when each parcel would be available and when the commission would begin to allocate those frequencies for nonfederal services (see Table 7).[12]

CBO estimated that if the FCC's auction authority was extended and broadened, selling the right to use parts of the NTIA spectrum would generate roughly $4 billion in auction receipts between 1998 and 2002. That estimate is subject to considerable uncertainty. Some of the NTIA spectrum is likely to be allocated to services, such as public safety, for which licenses would not be auctioned, and those allocations will therefore

12. Federal Communications Commission, *Plan for Reallocated Spectrum*, FCC 96-125 (March 1996), pp. 2-5.

not generate receipts. For example, in its 1996 plan, the commission indicated that the entire 70 MHz of spectrum included in its "Group 2," as shown in Table 7, would be allocated for either public safety or shared uses that would not require licensing.

Second, the FCC will allocate spectrum from higher-frequency bands—those above 3 GHz—for services for which it could auction exclusive licenses. Improving technologies will enable those frequencies to accommodate a variety of uses and more users. CBO estimates that receipts from those yet-to-be-specified auctions would add $2.0 billion to the FCC's total, if the President's proposal to extend and broaden the commission's authority to assign licenses was enacted. Although more readily available than frequencies under 3 GHz, the value of higher-frequency spectrum, in CBO's assessment, is less than that of blocks of spectrum under 3 GHz. Many of the applications of those higher frequencies have not yet been tested in the market. Moreover, a relatively large supply of higher-frequency spectrum could depress prices. A market test of the value of the higher-frequency spectrum will occur in 1997 or 1998 when the FCC auctions licenses for frequencies at 28 GHz.

Directed Reallocations

By CBO's estimate, the President's budget proposal would generate $17.6 billion from auctioning licenses made available by reallocating frequencies to new uses. The proposal would direct the reallocation and auctioning of license rights to 234 MHz of spectrum below 3 GHz—120 MHz from current nonbroadcast, but unspecified, allocations, and another 114 MHz from spectrum currently allocated to television broadcasting. Identifying 120 MHz of spectrum from nonbroadcast sources under 3 GHz for reallocation will be a difficult task. The NTIA has indicated that 20 MHz could be provided from the federal jurisdiction. The remaining 100 MHz would have to be found in the FCC's jurisdiction.

Spectrum under 3 GHz is crowded with many uses and users. Given the current technologies, only a limited amount of that spectrum can be made available for reallocation without imposing major costs on current license holders. In analyzing legislative proposals made during the 104th Congress, CBO therefore limited the amount of reallocated spectrum that would be credited with raising additional receipts. Those limits were established after consultations with the FCC, NTIA, and outside experts, who suggested that a pool of about 170 MHz of spectrum currently under FCC jurisdiction—but excluding that used for broadcast television—might be tapped for directed reallocations without inflicting unacceptably high costs on society as a whole and uncompensated disruptions on current users.

The pool of frequencies under FCC jurisdiction from which spectrum might be reallocated has decreased from 170 MHz to 120 MHz as a result of legislative actions taken in the 104th Congress. That pool included 50 MHz that the commission was on the verge of allocating to digital audio radio services and an additional 120 MHz allocated to broadcast auxiliary services. In its waning days, the 104th Congress enacted a proposal to reallocate spectrum in provisions of the Omnibus Consolidated Appropriations Act of 1996. Under those provisions, 30 MHz of spectrum drawn mostly from the 50 MHz intended for digital audio radio services—the frequencies 2305 MHz to 2320 MHz and 2345 MHz to 2360 MHz—will be allocated to wireless services, and license rights will be assigned by competitive bidding.[13] The other 20 MHz will remain allocated to digital audio radio services. That leaves the 120 MHz of broadcast auxiliary spectrum as the largest identifiable source of spectrum to reallocate. (In the past, CBO assumed that only part of that spectrum, perhaps 50 MHz, would be available for reallocation.) Because the costs of relocating all current users of the broadcast auxiliary spectrum could be considerable, CBO has lowered its 1998 estimate for auctioning receipts from those frequencies by $1.9 billion.

Turning to the broadcast spectrum, which covers 402 MHz, CBO estimates that if the President's proposal was enacted, an additional 114 MHz of spectrum would be reallocated, and the rights to use those frequencies would be sold at auction. That estimate is lower than the 150 MHz CBO used to estimate a simi-

13. The law further specified that the commission should promote the most efficient use of the spectrum and consider the needs of radio services for public safety in its allocation process. The act included several expedited procedures to ensure that auctions were concluded and receipts to the Treasury recorded by the end of 1997. At the time the law was enacted, CBO estimated that it would increase FCC auction receipts by $2.9 billion in 1997. Subsequently, CBO decreased its estimate to $1.8 billion because of technical constraints on the use of the frequencies, which were unknown at the time the law was enacted.

lar plan in the last budget cycle. The current plan to move from analog to digital television, however, would free up only 138 MHz, and the President's budgetary proposal reserves 24 of the 138 MHz for public safety uses, leaving only 114 MHz that can be allocated to services that are licensed and thus produce auction receipts.

Although legislative proposals can specify the quantity and quality of spectrum that the FCC can license at auction—for example, the President's proposal specifies 234 MHz of high-quality frequencies—they cannot direct buyers to pay a specific price. To estimate the prices that bidders would pay for the licenses under a directed reallocation, CBO uses the prices paid in the FCC auctions for the A&B block licenses for personal communications services and assumes that license prices will fall as more spectrum is brought to the market. Few relevant data are available, however, to indicate how much lower the price will be. Currently, CBO places the per-person, per-megahertz price of an additional 150 MHz of the highest-value spectrum at $0.30, about 60 percent of the price paid in the A&B block sale. (CBO's estimated price is higher if the total amount of spectrum to be brought to the market is smaller and, conversely, lower if more spectrum is to be licensed.) CBO also adjusts anticipated annual auction receipts upward to account for inflation.

Factors Affecting the Prices Paid for FCC Licenses

A basic assumption in CBO's approach to estimating future auction receipts is that large, contiguous (or appropriately paired) blocks of spectrum under 3 GHz will continue to be more valuable than either the same amount of spectrum divided into smaller, noncontiguous blocks or spectrum located above 3 GHz. CBO generally estimates the value of large blocks of spectrum under 3 GHz by first assessing trends in technology and regulation. Those trends are likely to cause the prices paid for licenses to fall from the levels realized in the PCS sales. CBO assumes that the provision of wireless services will be more competitive in the future and that competition will decrease both the profits of service providers and the prices they will be willing to pay for FCC licenses at auction. An alternative perspective is that explosive growth in the demand for wireless services will allow producers to maintain current levels of profit regardless of changes in the regulatory and policy environment and that license prices will increase or remain constant.

The scenario CBO has adopted does not imply that demand for current and new wireless services will be weak. Rather, it holds that such factors as improved technology, a regulatory climate that allows greater flexibility in assigning uses to both current and future spectrum allocations, and a general policy stance that emphasizes competition in new allocations will force providers of telecommunications services to meet that demand in markets in which higher-than-normal profits are dissipated by price competition.

Trends in Technology

Improvements in radio transmission and computer technologies affect the basic conditions underlying both the demand for and supply of radio frequencies and thus also affect the price paid at auction to use those frequencies.[14] The most significant technological developments are digital radio transmission, data compression, and receivers that can operate over a wide bandwidth—all facilitated by more capable and less costly microprocessors. The wireless technologies that are being created from those building blocks can affect the requirements that existing and new services have for spectrum, the cost to consumers of buying the equipment necessary to use a wireless service, and the ability of producers to direct their spectrum holdings to the markets that are most attractive (or, correspondingly, the ability of consumers to "hop" frequencies in search of less costly services).

Technologies That Conserve Spectrum. New technologies are increasing the capacity of a block of spectrum to carry information, be it voice, data, or video. One combination of digital transmission, data compression, and improved receivers, known as time division

14. For an overview of recent developments in wireless technology, see Office of Technology Assessment, *Wireless Technologies and the National Information Infrastructure* (July 1995), Part B; and Dale Hatfield, "The Technology Basis for Wireless Communications," in Institute for Information, *The Emerging World of Wireless Communications* (Queenstown, Md.: Institute for Information, 1996), pp. 49-90.

multiple access (TDMA), increases the capacity of a block of frequencies to carry telephone calls by three to seven times that of the analog technology currently used by providers of cellular telephone services. A second alternative, code division multiple access (CDMA), offers capacity multiples of 10 to 25.[15] Digital technologies for television broadcasting could allow a doubling of the number of TV channels and a fourfold to sixfold increase in the program capacity of each channel.[16]

Technologies that conserve spectrum are likely to depress the price of FCC licenses because they will allow the FCC to permit more competitors to enter the market for telecommunications services. For example, if TDMA allows a provider of mobile telephone services to handle just three times more calls than current analog technology, the 10-MHz licenses being offered in the allocation for personal communications services become the rough equivalent of the 25-MHz allocations that current providers of those services have. From the viewpoint of a spectrum manager whose objective is to increase competition in the mobile telephone market, spectrum-conserving technologies allow a fixed allocation of spectrum to support more competitors. Although the number of participants necessary to make a market behave competitively is not hard and fixed, the greater the number present, the more likely that producers will lose the power to maintain prices and make a larger-than-normal profit.

Spectrum-conserving technologies also increase the ability of current licensees to take advantage of regulatory changes that make service definitions more flexible. Broadened service definitions, such as those allowing the holders of television licenses to transmit data, will introduce more competition into the markets that current licensees choose to enter.

Under some market conditions, however, spectrum-conserving technologies might raise license prices. For example, technologies that increase the capacity of the frequencies used by the cellular telephone providers in markets where only two suppliers operate and are able to maintain high prices might increase the value of spectrum, because reductions in the cost of service would translate into higher profits. In general, if output prices remained constant, spectrum-conserving technologies might prompt a bidder to offer more.[17] But when price effects caused by lower costs are taken into account, and a regulatory will to increase competition prevails, new technologies will probably cause the price of licenses to fall.

Less Costly and Better Telecommunications Equipment. Technical changes that improve and reduce the cost of the telecommunications equipment that consumers use will tend to raise spectrum prices. Improved technology reduces the cost to consumers of entering the market for a new or existing service and, accordingly, increases the demand for the spectrum used to provide the service.

The case of cellular telephones dramatically illustrates the effect of equipment technology on demand for spectrum. The number of people subscribing to cellular telephone services rose from less than 100,000 in 1984 to more than 34 million by the end of 1995. One important reason for that increase was the drop in the price of mobile telephone handsets. In 1984, mobile telephones cost more than $2,000. Today, cellular phones that have better voice quality, batteries that last longer, and a much smaller size can be bought for less than $80 or may be included free as part of a long-term contract for cellular service.[18] Analysts who expect spectrum prices to hold steady or increase argue that less expensive and more capable consumer equipment

15. For the low estimates of the capacity factors of both TDMA and CDMA over current cellular systems, see Office of Technology Assessment, *Wireless Technologies and the National Information Infrastructure*, p. 85. For the high estimates, see Qualcomm, *Economics of PCS: A Tale of Two Networks* (San Diego: Qualcomm, 1994), pp. 1-9.

16. Although digital signal systems will usually perform better than the equivalent analog system, in some circumstance the opposite will be true. For example, in the far reaches of a radio or television broadcast area, a weakened analog signal will provide a transmission of better quality than a weakened digital signal.

17. Qualcomm, *Economics of PCS*, p. 10, presents the assessment of Qualcomm, the leading advocate of CDMA, that the technology will provide more capacity at lower costs than a TDMA option—the global mobile standard (GMS). The analysis specifically argues that choosing CDMA would allow a bidder to offer three and a half times more for a license than a bidder choosing GMS and still generate the same rate of return. A rational bidder will realize, however, that to the extent the new technology is widely available, market output will increase and market prices will fall, as will the value of the spectrum.

18. Herschel Shosteck Associates, *Cellular Market Forecast: Quarterly Survey* (Silver Spring, Md.: Herschel Shosteck Associates, March 1995), p. 3, presents those data and estimates of the monthly cost of equipment to a consumer of 250 minutes of cellular telephone service. In 1984, a phone cost $60 a month and accounted for just over 30 percent of the consumer's total cost. By 1994, phone costs had dropped to $2 a month and accounted for less than 2 percent of total cost.

will fuel similar dramatic growth for new mobile broadband services such as two-way video and wireless access to the Internet. Increased demand for new services will boost the price of FCC licenses for those services.

Less costly consumer equipment that can operate over a wide bandwidth—sometimes referred to as frequency-agile receivers—could also influence license prices, but in a downward direction, by increasing competition. Inexpensive receivers that hop frequencies open the prospect of frequencies moving from service to service as financial returns dictate—in effect, giving consumers and would-be providers a way around the block allocation system and the large profits it sometimes grants incumbent producers. For example, mobile telephones that are technically capable of operating in both the 800 MHz band currently allocated for cellular services and the 1.9 GHz PCS band have recently become available.

Trends in Regulation and Policy

The FCC is reducing its regulation of currently allocated spectrum and has exhibited a marked preference for creating competitive markets when allocating spectrum for new services. Both trends should lead to more competitive telecommunications markets and lower prices for FCC licenses. An additional regulatory policy issue that is likely to influence those prices is the interplay between wireless and wireline telecommunications in the wake of the Telecommunications Act of 1996. The effect of that development on license prices is less clear-cut.

Allowing Flexible Use of Currently Allocated Spectrum. As previously indicated, the rigidity of the block allocation system can lead to misallocation of spectrum, with some services having too much spectrum and others too little. Licenses permitting services for which too little spectrum has been allocated will command relatively high prices. Critics of the block allocation system have long suggested that spectrum allocation should be more flexibly defined as to services, users, and technology. Such flexibility would tend to lower license prices in the areas where spectrum is in the shortest supply, because competition will lower profits.

In recent years, the FCC has recognized that a more permissive stance with regard to restrictions on service, users, and technology is desirable for both current and new allocations of spectrum. Soon after the commission allocated spectrum for cellular telephone service, a stronger-than-expected demand for the new service led to scarcity in some major markets, driving license prices ever higher. Yet rules governing the types of service that could be provided prevented the use of adjacent frequencies for cellular telephone services, even though shifting spectrum to higher-value uses could yield large monetary and social benefits.[19]

The potential for increasing the value of spectrum prompted the commission to view favorably a 1990 proposal that allowed spectrum formerly restricted to dispatch services to be used for mobile telephone service.[20] It probably also influenced the FCC's 1993 decision to adopt a flexible definition of personal communications services. The extent of that flexibility is illustrated by the FCC's recent ruling that allows PCS providers to use their frequencies for fixed as well as mobile communications.

Planning Allocations for Competition. In its recent allocations, the FCC has explicitly sought to create competitive markets for telecommunications services. As indicated above, spectrum-conserving technologies now enable less spectrum to support more competitors. That approach should lead to lower prices for telecommunications services and ultimately for FCC licenses, too.

The broadband and narrowband PCS allocations are the best examples of the FCC's marked preference for establishing competition in new services. The narrowband allocation for nationwide paging services brought to auction 10 licenses of three different bandwidths; six businesses won those licenses. Three successful bidders in the regional narrowband auction of six additional slots won licenses that allowed them to compete nationwide. The broadband PCS auction assigned six more licenses. Consequently, consumers of mobile telephone services will shortly have a choice of five to eight providers rather than the two options generally available before the PCS auction, depending on

19. Evan R. Kwerel and John R. Williams, *Changing Channels: Voluntary Reallocation of UHF Television Spectrum*, OPP Working Paper Series, No. 27 (Office of Plans and Policy, Federal Communications Commission, November 1992), pp. 83-86.

20. Cellular Telephone Industry Association, *Wireless Factbook* (Washington, D.C.: Cellular Telephone Industry Association, 1995), p. 16.

what services the new PCS licensees decide to offer. The PCS allocations stand in sharp contrast to decisions the commission made about cellular telephone services less than a decade earlier, when the debate about competition focused on whether to have two service providers or only one.

The sequence of events that is likely to lead to a competition-induced decrease in license prices may have already begun. In the three markets in which a single new PCS provider was operating as of July 1996—Honolulu, Salt Lake City, and Washington, D.C./Baltimore—personal communications services were priced about 20 percent lower than comparable cellular services.[21] Subsequent new entrants will probably have to at least match those discounts, and cellular operators will eventually have to respond by lowering their service prices. The skeptical response of financial markets to the borrowing plans of PCS auction winners also indicates the impact that competition has had on prices. Although other factors might be involved, several winning PCS bidders have held back or restructured the high-yield bond issues they had planned while financial markets reassess the prospects of PCS after bidders have paid for their licenses at auction.[22]

Deregulating the Larger Telecommunications Market. The Telecommunications Act of 1996 strengthens ongoing trends toward deregulation and convergence in markets and technologies among providers of telephone, cable television, and other producers that transmit information. The effects of those trends on license prices is uncertain, however. A major purpose of the 1996 act is to introduce competition into local telephone service. Currently, the $100 billion annual market for local telephone service is largely supplied on a monopoly basis by the regional Bell operating companies that were created following the 1982 breakup of the Bell monopoly. A system of wireless links from the pole to the home that substitutes for the wired connection—a wireless local loop, as it is sometimes called—may prove to be a cost-effective way for competitors to enter the market for local telephone service. If so, the demand for such links could push license prices higher.

The extent of the upward pressure on license prices remains an open question. First, many different frequency bands, including those above 3 GHz where spectrum is relatively abundant, are technically suitable for providing wireless-local-loop service of one sort or another. Second, as competition emerges in local telephone service, the price charged for local wirelines could fall to such low levels that prices for wireless links would have to be set very low to be competitive. Third, the right to provide a wireless local loop as a substitute for wirelines could be either licensed or unlicensed. If no license was required, emerging demand for a wireless local loop would have a smaller effect on spectrum prices, because entry into the service market would not depend on holding an exclusive right to use the radio spectrum.

Beyond Receipts

Legislative action that directs the FCC to reallocate spectrum and auction licenses to use it could increase federal receipts over the 1998-2002 period. Such action would also have important consequences for efficiency and equity in the markets for telecommunications services, however, because it would involve taking spectrum away from some current licensed users in order to auction it for new services. Some critics claim that few if any opportunities exist to reallocate spectrum without reducing economic efficiency in terms of society's overall benefits from its use of the radio spectrum. Analysis conducted with the benefit of hindsight indicates that some reallocations could have improved efficiency in years gone by.[23] Whether the same is true today is less clear, but some evidence from the market value of licenses to use technically similar spectrum frequencies suggests that it is.

Consider one specific reallocation proposed during the 104th Congress: a proposal offered by Senator Ted Stevens to reallocate 50 MHz of spectrum from broad-

21. Paul Wuh, *Telecommunications/Wireless: So, How Do PCS Rate Plans Compare to Cellular?* (New York: Merrill Lynch, Global Securities Research and Economics Group, June 28, 1996), p. 1, estimates an average discount of approximately 18 percent.

22. Suzanne McGee and Anita Raghavan, "Junk-Bond Market Appears to Be Leery of Debt for Fledgling Wireless Industry," *Wall Street Journal*, August 26, 1996, p. B1.

23. Kwerel and Williams, *Changing Channels*, provides a detailed analysis of one specific reallocation of spectrum between services in the Los Angeles area. It also highlights the complexities of calculating welfare gains and the shortcoming of using only data on market prices.

cast auxiliary to general wireless use. Currently, broadcast auxiliary services—used by television broadcasters to transmit programming from studios to transmitters and from remote locations to studios—are allocated 120 MHz of spectrum adjacent to the 120 MHz allocated for personal communications services. Given that the broadcast auxiliary band accounts for 23 percent of spectrum allocated to television for actual broadcasting and auxiliary services, and that the FCC estimates that the total value of broadcasters' spectrum rights is between $23 billion and $38 billion, a simple proportional valuation suggests that the broadcast auxiliary spectrum might be worth $5 billion to $8 billion in its current use.[24] That range lies below the almost $10 billion that CBO estimates an additional 120 MHz could raise at auction in the next several years, and far below the roughly $20 billion paid for the technically similar PCS spectrum at auction.

Taking the example one more step illustrates the difficulties of trying to estimate efficiency gains or losses. On the one hand, the current value of the broadcast auxiliary band might be less than proportional to its share of total TV broadcasting spectrum, because some studio-to-transmitter links could be replaced by cables and because room might be found in higher-frequency bands to relocate other auxiliary transmissions. On the other hand, the band might fetch less than $10 billion at auction if its value was undermined by the need to accommodate existing secondary uses—namely, communications between satellites and ground stations. International agreements recognize such communications as an important use of those frequencies, notwithstanding their official designation as secondary in the United States.

The specifics of the example aside, the general point is that differences in the market value of licenses to use frequencies with similar technical characteristics suggest opportunities to increase the social value of the spectrum by moving portions of it to the higher-value services. To the extent that such opportunities can be identified, directed reallocations to carry them out approximate, in gross form, the behavior of market forces that promote efficiency by shifting resources from lower-value to higher-value uses in other parts of the economy.

Capturing gains in efficiency, however, is not a simple matter. The general problem is one of equity: the gains of directed reallocations accrue to the economy at large whereas the costs are borne by displaced users. Senator Stevens's proposal recognized the problem by including a provision to relocate the broadcast auxiliary service to a higher-frequency band. The problem of reconciling gains in efficiency and the rights of displaced spectrum users is an even more pressing issue in the transition to advanced television considered in Chapter 4 and in the question of an overall reform of spectrum management considered in the final chapter.

24. Letter from Robert M. Pepper, Chief, Office of Plans and Policy, Federal Communications Commission, to Senator Joseph I. Lieberman, May 5, 1995, p. 5.

Chapter Four

The Case of Digital Television

One of the best-known uses of the radio spectrum is the transmission of television signals. To avoid interference problems, the Federal Communications Commission currently keeps much of the spectrum allocated to TV broadcasting unused, but new digital technologies will allow it to be used more intensively. Federal policies regarding digital TV, and the potential use of auctions and other market mechanisms for managing the TV spectrum, have become controversial issues, with important implications for current broadcasters, their actual and potential competitors, viewers, and taxpayers.

On April 3, 1997, as this study was going to press, the FCC issued its plan for introducing digital TV. Several other kinds of plans have been proposed in FCC, Congressional, and nongovernmental settings, however, and the FCC's decision does not preclude further action by the Congress. Accordingly, the Congressional Budget Office has analyzed six plans, two of which resemble the chosen plan in varying degrees, from the standpoint of their potential auction receipts and their likely implications for economic efficiency and equity.

The proposal that was the primary focus of attention during the initial years of FCC proceedings on digital TV is identified here for convenience as the baseline plan. Under that plan, the FCC would give each current broadcaster the use of a second channel on which to begin digital operations. After a relatively long transition period, estimated at 15 years, the commission would reclaim the analog TV channels and reposition the digital channels, packing them more closely on the spectrum to clear sizable blocks of frequencies for new uses. Licenses to use the cleared frequencies could be assigned by auction, assuming that the spectrum was allocated to services for which mutually exclusive licenses are appropriate and that the FCC retained auction authority at that point. Current trends in FCC policy, noted in Chapter 3, suggest that the new allocation would give licensees the flexibility to offer a relatively broad range of services.[1]

As the FCC proceedings on digital TV continued, rapid developments in telecommunications markets and the apparent success of the initial FCC auctions sparked interest in alternatives to the baseline plan that would speed both the introduction of new spectrum services and the flow of receipts from auctioning the licenses for those services. The five alternative plans discussed most prominently in 1996 can be divided into three groups, as follows.

- *Accelerated Use*. One group of alternatives would follow the basic outline of the baseline plan but make the licenses for new services available sooner. In 1996, the Administration proposed an early-return plan that would shorten the transition period of joint analog/digital broadcasting, terminating analog service in 2005. An alternative put out for comment by the FCC, the 60-69 plan, would maintain the longer transition period but have the FCC issue additional "overlay" licenses covering the residual rights, including all the unused frequencies, in channels 60 to 69.

- *Up-Front Auction*. Under this alternative, current broadcasters would be allowed to keep their analog

1. This chapter designates a baseline plan merely to provide a starting point for the analysis, not to indicate a direct connection to CBO's budget baseline, discussed in Chapter 3. The baseline plan is consistent with the budget baseline, but so is any other plan that yields no federal auction receipts between 1998 and 2002.

channels and, in typical versions, to shift after some period of time to digital broadcasting or other noninterfering services. The digital channels, however, would be auctioned to the highest bidders. Thus, market forces would determine both how long analog TV continued and which parties got the licenses to use the digital channels.

- *Full Overlay.* A third group of proposals would assign the digital channels to current broadcasters but give market forces more opportunity to shift analog or digital channels to other uses. TV licensees would be allowed to cease broadcasting and make other use of their spectrum if viewers were provided with a comparable free replacement service (such as paid-for cable TV). In addition, the FCC would issue licenses for unused frequencies in the entire TV band, not just the lightly used channels 60 to 69. Variants of that idea proposed by then-Senator Larry Pressler and by three spectrum researchers differ as to whether TV would be required on the digital channels and whether broadcasters would have the right to refuse qualified offers from the overlay licensees to buy them out.

The plan chosen by the FCC is a variation on the early-return plan (perhaps with some elements of the 60-69 plan) and generally shares the advantages and disadvantages of that plan, discussed below. Similar to the early-return plan, the chosen plan assigns the licenses for digital TV directly to current broadcasters and requires them to cease analog TV operations by December 31, 2006, although that date is subject to later review by the commission. It differs from the early-return plan in that it does not specify that the frequencies cleared for reuse are to be assigned by auction in 2002; rather, it leaves the questions about how and when to assign the new licenses to be decided later by the FCC or the Congress. The commission did decide, however, to initiate a proceeding to consider the opportunities for early reuse of channels 60 to 69 (perhaps through the use of some overlay licenses, as proposed in the 60-69 plan) and said it would give "serious consideration" to allocating four of those channels for public safety uses.

Notwithstanding the FCC's decision, the Congress could choose not only to specify how or when to assign new licenses to use cleared TV frequencies but also to modify the chosen plan in a variety of small or large ways. For example, it could conceivably expand or contract the range of services that digital licensees may offer, shorten or lengthen the transition period, or even overrule the commission's decision to assign the digital licenses directly to current broadcasters.

In its analysis of the baseline plan and the above five alternatives, CBO estimates that the early-return plan would yield $10 billion in auction receipts in 2002, and that the up-front auction would yield approximately $12 billion in 1998 if all the digital channels were included, or $9.5 billion if noncommercial (public) broadcasters were given digital channels at no charge.[2] Although CBO's charter requires it to provide point estimates of costs and receipts in official scoring of legislative and budgetary proposals, the figures here should be interpreted as having wide confidence bounds around them, making the difference between them negligible relative to the uncertainties involved. Even taking the estimates at face value, the differences in efficiency and equity between the two plans are likely to be dominated by their effects on the markets for TV and communications services, not by their different contributions to federal receipts. CBO cannot reasonably estimate receipts for the other proposals: the baseline and 60-69 plans involve a distant and uncertain auction date for some or all of the affected spectrum, and details of the full-overlay plans (particularly the requirements for replacement service) have not yet been fleshed out.

Uncertainties and incomplete data similarly preclude a complete ranking of the economic efficiency of the various plans. CBO's analysis indicates, however, that the baseline plan is likely to be less efficient than at least three of the five alternatives (the early-return and 60-69 plans, and one of the overlay plans), because it is relatively slow to make spectrum available for valuable new services. The other two plans differ so fundamentally from the baseline plan that their relative efficiency

2. The fact that the receipts would be obtained four years later under the early-return plan modestly decreases their value relative to those from the up-front auction. At a real discount rate of 2 percent per year for government spending and receipts—a standard CBO assumption reflecting the cost of Treasury borrowing—$10 billion in 2002 is equivalent to $9.2 billion in 1998.

   As discussed below, the estimate of $10 billion for the early-return plan assumes that another 120 MHz of frequencies outside the TV bands is also cleared for new uses and licensed by auction. That figure revises CBO's original estimate of $10.8 billion, based on new information from the FCC about how much TV spectrum would be available to auction.

cannot be determined even qualitatively: the up-front auction has the advantage of allowing decentralized market forces to determine how long analog service continues, but it also has the potential disadvantage of not facilitating the clearing of large blocks of spectrum; the Pressler plan licenses all of the TV spectrum but does not require the digital-channel licensees to use them for TV.

The plans raise various equity issues regarding unwarranted windfalls or excessive costs to particular parties. One could argue that the up-front auction plan would be unfair to current broadcasters in that it would undermine the value of current broadcast licenses. The same could be said of the Pressler plan, which would require each broadcaster who wanted a digital channel to pay a deposit for it. Conversely, directly giving broadcasters use of a second channel—as in the baseline, early-return, and 60-69 plans—arguably would give them an unjustified boon. The boon could be particularly large under the baseline plan: its distant and uncertain date for terminating analog TV might allow broadcasters to hold on to both sets of channels indefinitely. The early-return plan would reduce (perhaps even eliminate) the boon by accelerating the return of the analog channels; it would also, however, impose higher costs on viewers to adapt or replace analog TV sets. Assuming that the details of free replacement service in the full-overlay plans can be worked out, none of the proposals pose a threat to the continuation of universal TV service.

The television case is an important and difficult policy problem, with stakes as high as those of any specific issue of spectrum management. On the one hand, use of the technically desirable TV spectrum has been severely constrained because of the sensitivity of analog TV signals to interference, and hence the potential benefits of technological change and corresponding improvements in public policy are particularly high. On the other hand, the investment in the incumbent technology—that is, analog TV sets and broadcasting equipment—is large and unusually diffuse, and hence the efficiency and equity issues involved in any move away from the status quo are particularly difficult. Further complicating the search for the ideal policy is the fact that broadcast services are public goods to viewers—in the technical sense that any number of people within the service area can use the signal without impeding one another—and that the public is sometimes said to have an interest in several aspects of TV broadcasting (including diversity of ownership, local content, the absence of viewer charges, and the quality of children's programs) beyond that expressed by market forces.

Broadcast Television in the Digital Age

Licensed commercial TV broadcasting began in the United States in 1942, following 15 years of experimental development. Broadcasting subsequently became both a major presence in American life and a successful industry, with TV sets in 98 percent of homes—more than have telephones—and 1995 industry revenues of $27.9 billion.[3]

Whether the industry's future will be equally bright is less clear, however. Broadcast TV still accounts for the majority of viewing hours in the United States, but over the past 20 years, viewers have turned increasingly to programs from alternative video-delivery services—cable, microwave "wireless cable" (broadcast from towers to relatively small service areas), and satellite systems—as well as videocassettes, laser discs, and interactive media (including video games, CD-ROMs, and on-line services). The future of broadcast TV will be strongly influenced by new digital technologies that effectively increase the capacity of both spectrum- and wire-based video-delivery systems, thereby allowing increases in picture quality, the number of channels available, or both.

The Current Scene

As of December 1996, the nation had 1,544 broadcast TV stations—1,181 commercial stations (supported by advertising) and 363 public stations (supported primarily by federal, state, and local governments, viewer members, businesses, and foundations). Those figures, like most statistics on TV broadcasting, include only stations licensed to provide full-power service; another 6,597 low-power and translator stations broadcast to

3. "Broadcast Advertising Up 3%," *Broadcasting & Cable*, March 4, 1996, p. 27.

smaller service areas, providing their own signals or retransmitting the signals of full-power stations.[4] The average home receives 13.3 full-power channels, according to a 1993 estimate from Nielsen Media Research, up from 9.1 channels in 1981. The Los Angeles and New York City markets have 24 and 23 stations, respectively, though some are located in outlying areas and are received only in parts of the market.

Each broadcast station is licensed to use a frequency band of 6 MHz. The very high frequency (VHF) stations use three blocks of spectrum: 54 to 72 MHz (channels 2, 3, and 4), 76 to 88 MHz (channels 5 and 6), and 174 to 216 MHz (channels 7 to 13). The ultrahigh frequency (UHF) stations occupy two blocks: 470 to 608 MHz (channels 14 to 36) and 614 to 806 MHz (channels 38 to 69).[5] To avoid interference problems, the FCC enforces minimum spacing requirements between stations using the same frequencies and between stations on adjoining frequency bands.[6] In the UHF spectrum, the commission also spaces certain other combinations of channels whose signals would interfere with each other because of relationships between their frequencies. The allotments resulting from those restrictions leave some room for additional analog TV broadcasting in smaller markets and fringe areas but essentially none in the central areas of the top markets.[7]

Although most commercial TV stations are affiliated with one of four national networks, legal limits on market reach and cross-ownership of media companies keep actual ownership of the stations more diffuse. Until the February 1996 passage of the Telecommunications Act, no network or other entity could own more than one TV station in a market or 12 stations nationwide, or reach more than 25 percent of the nation's TV households.[8] Moreover, an entity generally could not own both a TV station and a newspaper, radio station, or cable system in the same market, although preexisting cases were grandfathered, and the FCC sometimes waived the rule as it applied to radio stations. Ownership is expected to become more concentrated under the Telecommunications Act, which repealed the limits on the number of TV stations that could be owned, raised the national coverage limit from 25 percent to 35 percent, instructed the FCC to consider relaxing the limit of one owned station per market, and liberalized the restrictions on owning both radio and TV stations.

By all indications, TV broadcasting is a healthy and profitable business. A survey of commercial stations by the National Association of Broadcasters shows that 1995 pretax profits were 30 percent of net revenues, on average, for affiliates of ABC, CBS, and NBC; 26 percent for Fox affiliates; and 22 percent for all other stations. Complete industry revenues for 1996 are not yet available, but observers have predicted strong growth, in part because of the Olympics and national elections, on top of 15 percent growth in 1994 and 3 percent in 1995.[9] High revenues, coupled with such factors as the fledgling UPN and WB networks and anticipated deregulation, contributed in 1995 to some dramatically high prices in purchases of individual stations and to two widely publicized megadeals in which Disney bought Capital Cities/ABC and Westinghouse bought CBS.[10]

The darker side of the broadcasting picture, however, is the increasingly successful competition from cable, satellite, and microwave services. By 1995, ca-

4. "By the Numbers," *Broadcasting & Cable*, December 16, 1996, p. 112.

5. Channel 37 is reserved for radio astronomy.

6. Sequentially numbered channels that do not occupy adjoining frequencies are not subject to the spacing requirements. Thus, for example, stations operate on both channels 4 and 5 in Washington, D.C.

7. FCC data show that 228 commercial and 319 noncommercial (public) channels were vacant, with no license applications pending, as of June 30, 1996. Only eight commercial and 15 noncommercial channels were vacant within even 55 miles of the central cities of the largest 25 markets, however, and all of those were UHF channels.

8. For minority broadcasters and others with noncontrolling interests in two or more minority stations, the limits were 14 stations and 30 percent of households. Household coverage is calculated by assuming that each VHF station reaches all of the households in its market and that each UHF station reaches half. See *Broadcasting & Cable Yearbook 1995* (New Providence, N.J.: R.R. Bowker, 1995), p. xxi.

9. "Broadcast Advertising Up 3%," p. 27.

10. ITT and Dow Jones bought WNYC-TV from the New York City government for $207 million, the most ever paid for a UHF station and three times the $65 million estimate of the city's consultant. Also, Tribune Broadcasting, an investor in the WB Network, bought UHF stations in San Diego and Houston for $70.5 million and $95 million. Observers disagree as to whether the San Diego price represents 18 or 29 times the station's existing cash flow, but either figure is well above traditional multiples of 8 to 12. See the following articles in *Broadcasting & Cable*: "The Dawning of Megamedia: Broadcasting's $25 Billion Week," August 7, 1995, p. 4; "ITT, Dow Jones Score WNYC-TV for $207 Million," August 7, 1995, p. 12; "Tribune's $70.5 Million Takes San Diego UHF," September 4, 1995, pp. 7-8; "Tribune Buys Houston U for WB," September 18, 1995, p. 16.

ble coverage had reached 65 percent—62 million of the 96 million households with TVs. (Only about 3 percent had no cable service available; the other 32 percent had not subscribed.) More than 5 million households now subscribe to satellite TV, in part because of the development of direct broadcast satellite (DBS) services—such as DirecTV, USSB, and EchoStar—that operate with higher power and at higher frequencies and can therefore be received by smaller antenna dishes than those used for earlier satellite services. The Wireless Cable Association International estimates that microwave systems, which can be less costly to set up than cable or satellite systems, were reaching 850,000 subscribers by March 1996, an increase of more than 20 percent over the previous year.[11] Moreover, the FCC is planning to make additional frequencies available for microwave services in a higher-frequency band.[12]

The effects of the alternative delivery systems on broadcasters have not been entirely negative, but the main effect has been a loss of viewers. The "must carry" rule, which gives broadcasters the right to have their signals carried on local cable systems, has allowed many UHF stations and some VHF stations to increase their effective range. Indeed, that increased range is a key factor underlying the development of the new UPN and WB networks, which consist primarily of UHF stations. Nonetheless, broadcasters have lost viewers to cable and other competitors. Between the 1984-1985 and 1994-1995 seasons, for example, daily TV viewing by the average household rose 24 minutes (to 7 hours, 31 minutes), but average household viewing of local stations fell 30 minutes (to 5 hours, 16 minutes).[13]

Adding to broadcasters' worries is the possibility that the regional Bell telephone companies and other deep-pocketed firms may join the ranks of providers of video services. Such firms could join forces with existing cable operators, develop or strengthen microwave systems, or upgrade existing phone lines and equipment to enable them to carry video programming. The desire of network and station owners to retain or regain viewers in the face of current and potential competition is another factor behind the recent mergers and acquisitions.[14]

The Digital Future

Broadcasters face not only the uncertainties of a market with increased competition and a changing regulatory landscape but also the uncertainty associated with new technology. Digital TV technology holds great promise: use of digital compression techniques to abbreviate repetitive or redundant video and audio data can effectively increase the capacity and flexibility of a frequency band or cable system, thereby allowing video providers to improve the quality of the picture and sound and to offer more programs and a range of other services. Moreover, because digital broadcast signals are less susceptible than analog signals to interference problems, the new technology could allow the FCC to use the spectrum more intensively—that is, to increase the number of licensed broadcast channels, make more spectrum available for other valuable uses, or both. But no one yet knows how much consumers will be willing to pay for digital TV equipment and what mix of services will attract their attention.

11. "MMDS (Wireless Cable): A Capital Ideal," *Broadcasting & Cable*, May 1, 1995, p. 18; "Cable Continues to Dominate, Competitors Say," *Broadcasting & Cable*, July 29, 1996, p. 22; personal communication to the Congressional Budget Office by Andrew Kreig, Vice President and Communications Director, Wireless Cable Association International, March 29, 1996.

12. New digital technologies are another factor increasing the attractiveness of microwave systems in both the current and the new spectrum bands. Current systems have access to at most 33 6-MHz channels (some of which are available only on part-time leases), but digital compression technologies will expand the capacity of those channels severalfold, allowing the systems to compete more effectively against cable and satellite systems. One disadvantage of microwave systems is that they require direct lines of sight between transmitting and receiving antennas. Moreover, the higher frequencies are susceptible to interference from rain and snow. Some observers suggest, however, that those problems may have been solved. See Mike Mills, "FCC Facing Key Decision on Wireless Auction Rules," *Washington Post*, September 3, 1996, pp. E1-E2.

13. Estimates are based on total viewing data from Nielsen sources (the *1992-93 Report on Television* and a personal communication from Karen Kratz, Manager of Communications) and share data from Cabletelevision Advertising Bureau, *Cable TV Facts* (New York: Cabletelevision Advertising Bureau, 1986 and 1996 editions). The 1994-1995 estimate assumes that local stations account for 9 of the 12 share points attributed to independent stations.

14. The networks are also hedging their bets by diversifying into cable programming and Internet publishing. Such diversification can lead to tension between a network and its affiliated broadcast stations, as shown by the controversy attending NBC's efforts to advertise its new MSNBC cable/on-line news venture on its broadcast programs ("Cable News Prepares for War," *Broadcasting & Cable*, June 24, 1996, pp. 46, 50).

The FCC began investigating the potential of advanced TV technology in 1987, in response to a petition by broadcasters that was in turn prompted by previous research in Japan and by the fear that the commission would accept proposals to reallocate some UHF channels for mobile radio uses.[15] Since then, a consortium of research labs and manufacturers known as the Grand Alliance has developed a digital system for high-definition television. That system is capable of delivering 19 million digital bits of data per second over a 6-MHz broadcast channel, enough for a picture with 1,080 lines and 1,920 pixels (picture elements) per line, compared with 483 lines and 440 pixels per line in today's analog TV.[16] The picture would have a width-to-height ratio of 16 to 19, which is wider than today's TV pictures and closer to the ratios used in movie theaters, and would be accompanied by as many as five channels of CD-quality surround sound.

Those same 19 million bits could be used in other ways, however. In particular, broadcasters could essentially divide their channels into multiple subchannels. Depending on the compressibility of the programs being shown at a given time—prerecorded programs and those with relatively static scenes allow more compression than fast-moving live programs—perhaps as many as six subchannels could be accommodated with picture and sound quality comparable with those of the present analog channels. Alternatively, some of the capacity could be devoted to ancillary services accompanying a TV program (for example, to allow viewers to select alternative camera angles of a sports event or obtain additional product information) or to non-TV services like digital radio or computer data (such as continuous updates of stock and bond prices).

For all its flexibility, however, one thing the Grand Alliance system cannot do is send signals that are intelligible to an unadapted TV set. To watch digital TV, viewers will need at least a set-top box, akin to that currently used by DBS subscribers, to decompress the compressed picture and sound data. Getting the full benefit of high-definition TV programs, however, will require a wide-screen TV receiver capable of displaying the finer resolution. Estimates of the cost of that equipment vary, in part because the specific capabilities of the products are yet to be determined and because prices can be expected to fall as manufacturers gain experience and as electronic chips continue to drop in price. Estimates of the initial price of a set-top box range from $300 to $750.[17] Larry Irving, Administrator of the National Telecommunications and Information Administration, has argued that set-top box prices would decline to $50 or less within a decade, extrapolating from experience with semiconductor chips; others estimate figures as high as $200.[18] As for true high-definition TVs, one manufacturer has stated that they would initially sell at $1,000 to $1,500 above the price of analog sets of comparable picture height, with the difference in prices falling within 10 years to perhaps $250 to $350 for large sets and even less for small sets.[19] The estimates of decreasing prices partly depend, however, on necessarily speculative projections of consumer demand.

Despite the various uncertainties, video providers of all types are moving into the digital age. Direct broadcast satellite services already use digital compression to provide slightly higher resolution than current broadcast TV and to fit more channels into their allotted frequencies. Operators of microwave systems expect to benefit from compression technology and its consequent increase in channel capacity. Video rentals may gain in popularity with the advent of digital video discs. Finally, upgraded digital cable systems (and their potential wire-based competitors, the local telephone companies) will be able to offer not only additional channels and better pictures but also video on demand, in which consumers select programs for imme-

15. Grand Alliance, "The U.S. HDTV Standard," *IEEE Spectrum* (April 1995), p. 37.

16. Current TV broadcasts transmit a total of 525 lines. However, 42 are blacked out in the vertical blanking interval, during which the originating camera and receiving picture tubes reset themselves from bottom to top, leaving 483 active lines.

17. "Hitachi Unveils SDTV Decoder," *Broadcasting & Cable*, September 11, 1995, p. 51; statement of J. Peter Bingham, President, Philips Laboratories, in U.S. House of Representatives, *Federal Management of the Radio Spectrum: Advanced Television Services,* hearings before the Subcommittee on Telecommunications and Finance of the House Committee on Commerce, Serial No. 104-75 (March 21, 1996), p. 172.

18. U.S. House of Representatives, *Federal Management of the Radio Spectrum: Advanced Television Services*, hearings before the Subcommittee on Telecommunications and Finance of the House Committee on Commerce, Serial No. 104-75 (March 21, 1996), pp. 47, 52, 57. Digital video disc players might provide the functions of a set-top box, just as some videocassette recorders made homes "cable-ready," at a marginal cost below that of a stand-alone box.

19. Comments of Bruce M. Allan, Thomson Consumer Electronics, Inc., at the Federal Communications Commission *en banc* hearing on advanced television, December 12, 1995, p. 5.

diate viewing from an available library, as they now do by going to a video-rental store. Some industry analysts expect video on demand to begin providing a significant share of cable systems' revenues early in the next decade. In short, the competition between local broadcasters and other video providers will only sharpen as TV moves into the digital age.

Policy Issues

Recent discussions about the potential of digital TV broadcasting have raised many important policy questions about the introduction of this new technology. Those questions can be grouped under the efficiency and equity headings discussed in Chapter 1.

- *Efficiency.* In light of the new technological possibilities, what public policies would maximize the near- and long-term value of the spectrum to society as a whole?

- *Equity.* What policies would share the benefits of the technology fairly among viewers, broadcasters, and taxpayers?

As always, policymakers may face a trade-off between efficiency and equity: the available policy that produces the most value for society may not be the one that yields the most equitable distribution of the overall benefits.

Efficiency Issues

In the present case, a policy that seeks to maximize efficiency—that is, to put the spectrum and related resources to their highest-value uses—must strive to strike several ideal balances among competing considerations. Both administrative and market-oriented tools for finding the balances have their limitations, and hence, no simple policy can be defined that would be expected to yield the ideally efficient outcome.

The main efficiency issues are as follows. First, in the near term, how can the introduction of digital TV be managed so as to balance the benefits of continued analog broadcasting (given the large investments by consumers and broadcasters in analog equipment) against the benefits of digital TV and other new services that could share the spectrum with it? That issue includes such questions as how the digital TV licenses should be assigned and whether analog TV service should be terminated on some fixed date.[20]

Second, over the longer term, how much bandwidth should be devoted to TV broadcasting, given the competing demands for spectrum for nonbroadcast uses? And what system or rules would allow the amount to adjust appropriately as conditions change?

Third, within the bandwidth used for TV, how many stations should operate at what power levels? Beyond a certain number, the more stations allowed to operate, the smaller the allowable service areas for each and the more spectrum that must be set aside to buffer neighboring signals. Ironically, therefore, the average viewer could actually have more over-the-air choices if the number of stations was reduced, because the need for buffer spectrum would also be reduced, and the remaining stations could operate at higher power levels, covering larger geographic areas. The trade-off would be a reduction in the benefits of localism, such as news and public interest programming tailored to local audiences.[21]

Finally, what should be the form and content of the signals sent out by digital broadcasters? In particular, to what extent should the signals be free (advertiser- or donor-supported TV) as opposed to pay TV or data broadcasting to computers? To what extent should they provide high-definition television (HDTV) as opposed to multiple streams of digital standard-definition television (SDTV) programs? And to what extent should they be devoted to such public interest programming as government meetings, candidate debates, educational shows for children, and cultural events?

20. Another question concerning the introduction of digital TV—whether the licensees should be required to use a single digital broadcasting technology—was recently settled by an interindustry compromise, which the FCC ratified.

21. The FCC chose to emphasize localism over competition in the TV allocation plan it adopted in 1952, rejecting the proposal from the DuMont network that involved regional stations and provided enough coverage for six or seven national networks. Bruce M. Owen, Jack H. Beebe, and William G. Manning, Jr., *Television Economics* (Lexington, Mass.: Lexington Books, 1974), p. 124; Sydney W. Head and Christopher H. Sterling, *Broadcasting in America*, 6th ed. (Boston: Houghton Mifflin, 1990), pp. 65-69.

Each of those issues could be addressed through policies emphasizing centralized regulation or marketplace decisions. On the regulatory side, for example, the federal government could:

- Select the recipients of licenses for digital TV and establish a date—or a set of dates applicable to different sets of stations, or a criterion such as 80 percent household penetration of digital receivers and converters—when analog broadcasting would have to cease;

- Continue to specify the frequencies to be used for TV broadcasting and the location and power limits of individual stations; and

- Within limits set by judicial interpretation of broadcasters' First Amendment rights, require that minimum specified shares of each digital station's capacity be devoted to free TV, to the high-definition format, and to public interest programs.

In some cases, centralized rules may be efficient. A general reliance on such rules is likely to be inefficient, however, given the limited information available to the government and its limited ability, relative to that of the private sector, to respond quickly to new developments and make accommodations for variations in individual circumstances. Those limitations are particularly critical in the current environment of rapid technological changes in both wireless and wireline communications and the evolving consumer preferences for one-way and interactive video, audio, and data services.

Alternatively, policymakers could adopt free-market approaches, letting market forces allocate the spectrum among analog TV, digital TV, and other uses; assign new licenses to the highest bidders; and determine the form and content of digital TV signals. Those alternatives are also unlikely to yield the ideal allocation of resources to competing uses, largely because of various market failures.

- Because broadcast TV is a public good—that is, a good whose cost is independent of the number of people who use it—market prices cannot provide the efficient incentives to broadcasters and viewers. In particular, under the current system of advertiser-supported, free-to-viewers TV, the benefits to viewers are an unpriced side effect (or externality), and hence the market tends to undervalue broadcast spectrum compared with spectrum used for private goods, such as mobile telephone services.[22]

- Because market prices also fail to reflect any external effects of TV viewing on nonviewers (such as the gains to society as a whole from increases in the knowledge of individual voters), an unfettered market could provide less than the efficient amount of public interest programming.

- Finally, if transaction costs made it sufficiently difficult to coordinate individual decisions, a free market could impede the introduction of HDTV or perhaps even digital SDTV and inefficiently delay new spectrum services (especially regional or national services) that would require clearing current users from certain parts of the TV spectrum.

Equity Issues

The main equity issues surrounding the introduction of digital TV concern the possibility of unfair losses or excessive gains to viewers of free analog TV, broadcasters in general, noncommercial and small-market broadcasters, or viewers and owners of low-power TV (LPTV) stations. The issues affecting each group can be summarized as follows:

- *Viewers of free analog TV.* A policy that reduced or eliminated analog TV service at a time when some people wanted to continue receiving such broadcasts would impose losses on those viewers, as would a policy that led broadcasters to shift from ad-supported to subscription-based TV.

- *Broadcasters in general.* A key issue is the level of assistance, if any, that the government should

22. A study published in 1973 estimated that the value of broadcast TV to viewers was roughly seven times the industry's advertising revenues; see Roger G. Noll, Merton J. Peck, and John J. McGowan, *Economic Aspects of Television Regulation* (Washington, D.C.: Brookings Institution, 1973), p. 23. Other market-based funding mechanisms might narrow the gap between the social value and the observed market value of broadcast spectrum, but none could completely solve the fundamental problem that the social value of a public good exceeds its private value. Scrambling broadcast signals and charging viewers, for example, would needlessly dissuade some people from watching, and hence the potential value they could have gained would go unobserved in the spectrum market.

give broadcasters to help them adapt to digital TV. Some observers argue that giving them temporary use of second channels on which to begin digital TV service would be an unjustified windfall, whereas others see it as fair compensation for their contributions to the public interest. A second issue is whether broadcasters' public interest obligations should be expanded, maintained, or reduced for digital TV licensees. Those obligations currently include providing programs for children and limiting advertising time in such programs, producing a quarterly list of significant treatments of community issues, and selling advertising time to political candidates at preferred rates. The fair answer to that question may depend on whether the licenses are awarded by auction or government grant.

- *Noncommercial and small-market broadcasters.* Given their smaller budgets, noncommercial and small-market stations would find it harder to finance a transition to digital TV. The equity argument for special allowances for such stations could be extended to all small-budget stations, including commercial operations in large markets.

- *LPTV broadcasters and viewers.* A policy that reclaimed some low-power TV channels for new full-power digital channels or other new spectrum services would impose losses on the affected station owners and some of their viewers (such as those served by foreign-language and other niche programming in urban areas). The FCC argues that such losses would not be inequitable because LPTV is licensed as a secondary service.

Six Alternative Policies

The number of possible spectrum management policies for the introduction of digital TV is large, and six alternatives received significant attention from the Congress and members of the policy community during 1996. Those alternatives can usefully be grouped into four sets of plans: the baseline plan, two accelerated-use plans, the up-front auction plan, and two full-overlay plans. As noted above, the plan chosen by the FCC as this study was going to press resembles the accelerated-use plans discussed here.

The Baseline Plan

The plan that received primary consideration during the FCC's rule-making process on digital TV would give each current broadcaster a second 6-MHz slot to be used for digital broadcasting, reclaim the original analog channels at some point in the future, and move the digital channels closer together to create sizable blocks of nationally clear spectrum for new uses (see Table 8). The FCC would allocate the cleared spectrum to new services and, where authorized and appropriate, assign licenses to use the cleared spectrum by auction. The version of the baseline plan proposed by FCC staff in July 1996 reclaims 138 MHz as follows: 18 MHz corresponding to current channels 2 to 4, 12 MHz occupied by channels 5 and 6, and 108 MHz used by channels 52 to 69.[23] The total of 138 MHz is consistent with the FCC's previous rough estimate that 150 MHz could be reclaimed.[24] The plan calls for a nominal 15-year transition period but also authorizes the commission to review the 15-year deadline as the transition proceeds, allowing for revisions that seem necessary or appropriate in light of subsequent developments.

Under the baseline plan considered here, broadcasters would have significant freedom to decide how to use the digital channels. In particular, they could use the channels for HDTV, digital standard-definition TV, or any combination of the two. In keeping with the provisions of the Telecommunications Act of 1996, they could also choose to provide ancillary or supplementary services on the digital channels that are "consistent with the public interest, convenience, and necessity," such as audio or data broadcasting, but they would be charged annual fees if they offered such services on a subscription basis.

23. A broadcaster assigned a digital channel outside the core spectrum (channels 7 to 51) would have to shift to one within that range by or at the end of the transition period—to the previous analog channel, if applicable, or some other channel freed up by the cessation of analog service. The table of allotments proposed by FCC staff in 1996 places only 10 percent of the digital assignments outside the core spectrum. An alternative table proposed by the Association for Maximum Service Television that makes greater use of the noncore channels would yield marginally larger average areas of coverage during the transition period but would require more repacking afterward.

24. The plan adopted by the commission in April 1997 also reclaims 138 MHz, including the 108 MHz used by channels 52 to 69, but leaves open for now the question of whether the other 30 MHz will come from channels 2 to 6 or channels 47 to 51.

Table 8.
Summary of Plans for Introducing Digital TV

Plan	Spectrum to be Auctioned	Identity of Digital TV Licensees	Termination of Analog TV Broadcasting	TV Spectrum	
				Reallocated for General Use	Remaining
Baseline	Frequencies reclaimed and reallocated for general use	Current broadcasters	15 years after plan starts, subject to review	138 MHz	264 MHz for digital TV
Accelerated Use					
Early return	Frequencies reclaimed and reallocated for general use	Current broadcasters	2005	138 MHz	264 MHz for digital TV
60-69	Overlay licenses on channels 60 to 69; other frequencies reclaimed later	Current broadcasters	15 years after plan starts, subject to review	138 MHz	264 MHz for digital TV
Up-Front Auction	Digital TV channels	Highest bidders	Upon decision of individual analog licensee and notification of service area	None	402 MHz for digital and analog TV; licensees may be allowed to offer other services
Full Overlay					
Pressler	Overlay licenses on all TV frequencies	Current broadcasters willing to pay deposit	Upon decision of individual analog licensee and provision of free replacement service	402 MHz	None reserved for TV
Right-to-move	Overlay licenses on all TV frequencies	Current broadcasters	Upon decision of individual overlay licensee and provision of free replacement service	402 MHz, except for frequencies locally occupied by digital TV licensees (average of 80 MHz)	No reserved blocks, but digital TV stations occupy an average of 80 MHz

SOURCE: Congressional Budget Office.

NOTE: MHz = megahertz.

The Accelerated-Use Plans

One set of alternative proposals would modify the baseline plan to speed the introduction of new spectrum services that could share the current TV frequencies. One such plan, the early-return plan proposed by the Administration in 1996, would reclaim the analog channels in 2005, thus shortening the transition period. That plan would auction the licenses to use the cleared spectrum by fiscal year 2002, before the frequencies become available for use, to allow the receipts to contribute to the goal of a balanced budget in that year. As noted earlier, the plan adopted by the FCC is similar to the early-return plan, but it continues analog broadcasting through 2006 (subject to later review) and does not specify how or when new licenses will be assigned.[25]

In August 1996, the FCC invited discussion on another alternative to the baseline plan that would also speed the introduction of new spectrum services. That plan would assign, early in the transition period, new licenses for the 60 MHz associated with the lightly used channels 60 to 69. More precisely, given that 97 analog and approximately 15 digital TV stations would remain licensed on those channels through the transition period, the new licenses would be overlays that would give licensees the right to use the unencumbered portions of the spectrum immediately and the encumbered portions after the TV operations ceased or relocated to lower channels. (Overlay licenses and their efficiency implications are discussed in more detail in Chapter 5.) The 60-69 plan would provide overlays covering enough bandwidth and geographic territory to allow licensees to make meaningful use of the spectrum during the transition period without interfering with the TV broadcasters. The analysis below assumes that the licenses would allow a broad range of services and would be assigned by auction.

25. The Administration has revised its original plan. The version included in the President's budget for 1998, like the FCC's chosen plan, also ends analog broadcasting in 2006 rather than 2005. Like the Administration's original plan, however, the revised version would still auction the majority of the new licenses in 2002, thus lengthening the winning bidders' wait to gain access to their licensed frequencies. It would further speed new uses of channels 60 to 69 by using overlay licenses (discussed below), with four of the channels reserved for public safety users and the other six auctioned for general use starting in 2001.

The Up-Front Auction Plan

Another type of alternative, the up-front auction (or second-channel auction), has been articulated in general terms before the Congress and the FCC and discussed widely in the press, but it has not been formally specified. That plan would neither reclaim the analog TV channels nor loan each broadcaster a digital channel; rather, it would assign the digital channels in a direct auction open to current broadcasters and nonbroadcasters alike.[26] Typical versions of the idea would allow incumbent broadcasters not only to continue sending analog TV signals as long as market conditions warrant but also to convert to digital broadcasting after a period of time and after notifying their service areas. Some versions would allow both analog and digital licensees to offer services other than TV, subject to the constraint that they not interfere with other TV signals. Such flexibility would allow the channels to be used for various combinations of video, audio, and data broadcasting and fixed-point to fixed-point services; depending on the specific interference problems, it might also permit mobile communications services in some cases.

The Full-Overlay Plans

The two proposals in the final category share with the 60-69 plan the basic idea of auctioning overlay licenses. They differ from the 60-69 plan in two respects: they would auction overlays for all the TV channels, not just the upper UHF channels; and they would let the marketplace decide the future of over-the-air analog TV. In particular, the plans would allow—or even require—analog TV broadcasters to shift their spectrum to other uses, provided that viewers were given a comparable free replacement for the former TV service. The definition of "comparable free replacement" service has not yet been fleshed out. Its essence, however, is that viewers would be given converter boxes for digital TV or prepaid subscriptions (perhaps for some specified number of years) to cable, satellite, or microwave TV.

26. To allow current broadcasters to participate in the auctions on an equal footing with nonbroadcasters, legislation would have to specify relief from current regulations that allow a firm to own only one station in a market and to reach only 35 percent of households nationwide.

The full-overlay idea has been proposed on the Senate floor by former Senator Pressler and embellished in a conference paper by an academic economist and two FCC staff members.[27] The two versions differ in how they would assign the licenses for the digital channels, the flexibility they would grant digital TV licensees, and their division of rights between the analog TV and digital-channel licensees on the one hand and the overlay licensees on the other. Senator Pressler's version would offer current broadcasters a second channel for each current analog TV license in exchange for a refundable (though not interest-bearing) deposit, payable in installments over 15 years. The amount of the deposit would be based on the prices paid for the overlay licenses. Each TV licensee could return one of its two 6-MHz channels at the end of the 15 years for a full refund of the deposit; alternatively, licensees could choose to keep both channels longer but would lose 20 percent of their deposit for each year after 15 that they do so. Licensees would be allowed full flexibility on the digital channels, meaning that they could use them for any services that do not interfere with the rights of other users, not just for broadcast TV.

An embellishment of the full-overlay idea, identified here as the right-to-move plan, was designed to be consistent with the Telecommunications Act of 1996, so that the FCC could implement it without additional legislation. The plan would directly assign digital channels to current broadcasters but would not require them to pay a deposit; hence, it would not give broadcasters the incentive to surrender one of their two channels in order to recover a deposit. Instead, it would grant overlay licensees the right to move analog broadcasters off the spectrum by making arrangements to have their signals carried on a comparable free replacement service, such as prepaid cable TV. Overlay licensees could also move digital TV licensees to an equivalent spectrum channel if they compensated them for all relocation costs. Consistent with the 1996 act, broadcast television would be required as the primary use of the digital channels.

27. See *Congressional Record*, May 9, 1996, p. S4932; and Peter Cramton, Evan Kwerel, and John Williams, "Efficient Relocation of Spectrum Incumbents" (paper presented at the Telecommunications Policy Research Conference, Solomons Island, Md., September 30, 1996).

Weighing the Alternatives

All of the above proposals would auction some licenses to use frequencies within the current TV block. CBO estimates that two of the plans would yield on the order of $10 billion in auction receipts; receipts from the others have not been estimated but are unlikely to be dramatically larger.

As noted in Chapter 1, however, auction receipts are of interest not as an end in themselves but as a means to the underlying policy goals of efficiency and equity. From the efficiency/equity standpoint, the difference in any two plans' expected receipts is likely to be less important than the differences in their consequences in the markets for telecommunications services. Such consequences are associated with the amount of spectrum a plan licenses, the flexibility of spectrum use it allows, its mechanisms for assigning new licenses, and its treatment of existing licenses for analog TV, among other factors.

All of the proposals for introducing digital television would improve economic efficiency by increasing the productive use of the spectrum, and those that allow valuable new uses to begin sooner, without imposing disproportionately higher costs, will probably be more efficient than the others. A central finding of CBO's analysis is that the baseline plan is likely to be less efficient than the early-return, 60-69, and right-to-move plans, and perhaps the others as well, because it is relatively slow to introduce new spectrum services. The analysis is generally limited to qualitative conclusions, because of uncertainties and insufficient data, but it does provide one quantitative estimate: the gain in efficiency from the early-return plan relative to the baseline plan is estimated to range from roughly zero to approximately $20 billion, measured in dollars discounted to 2002.[28]

28. Discounted dollars measure the present value of a multiyear stream of payments and receipts, recognizing that one dollar today can be invested to return more than one dollar in the future and that individuals generally prefer not to delay gratification, all other things being equal.

Effects of the Baseline Plan

The baseline plan would generate federal receipts if the licenses to use the frequencies reclaimed at the end of the transition period were assigned by auction. However, CBO has not estimated those receipts. Because of the rapid pace of change in spectrum and wireline uses and technologies, CBO judged it impractical to estimate receipts 15 years or more into the future.

Qualitatively, the plan would clearly improve economic efficiency by putting more of the current TV frequencies to productive use—first by providing licenses for digital TV services, and later by reclaiming the analog channels and repacking the digital channels to clear sizable blocks of spectrum nationwide for new uses (see Table 9). The creation of significant blocks of cleared spectrum is a major goal and selling point of the plan (and also of the accelerated-use alternatives). The greater the value of services, such as satellite broadcasting and possibly mobile telephone services, that could not economically use the fragmented vacancies in the present TV spectrum, the larger the gain in efficiency from clearing the spectrum blocks. Conversely, the gain could be zero if the highest-valued use for the returned spectrum proved to be additional local TV broadcasting or some other service that does not require contiguous blocks of nationwide spectrum.

Of course, no gain from clearing the spectrum can actually occur until the analog channels are turned off and the digital channels are repacked. As noted above, the plan calls for a 15-year transition period, subject to review as events proceed. Critics argue that the plan's tentative and relatively late date for cutting off analog TV makes it likely that broadcasters would manage to keep the channels indefinitely.[29]

From the point of view of current broadcasters, one notable and desirable feature of the baseline plan is that it directly assigns them the digital TV licenses. As discussed below, CBO estimates that the licenses would yield $12.5 billion if auctioned directly. The net gain to broadcasters under the baseline plan would be less because they would eventually have to return the analog channels and repack the digital channels, but those costs would be small compared with the licenses' estimated value. To the extent that the loan of second TV channels seems to be excessive compensation for the social benefits that broadcasters provide by smoothing the transition to digital TV, one concept of equity would call for splitting the excess 50/50 between broadcasters and the government. Serious measurement problems would make that notion of equity difficult to carry out, however. Some kind of rough allocation of the excess—for example, through enhanced public interest commitments—may be the most that could be done in practice.

Viewers would have a relatively long time—15 years or so—to adapt to digital TV under the baseline plan. Even at that point, however, some households might still be relying exclusively on over-the-air analog broadcasts for their TV viewing, and others might still use analog TVs as secondary receivers. The benefits to viewers would depend on the exact mix of video, audio, and data services—with and without subscription charges—offered on the channels, but the plan gives broadcasters wide discretion to choose that mix individually, provided that they continually use at least part of each channel for nonsubscription TV.

To make room for the required number of digital channels, the plan reclaims frequencies used by some low-power stations in crowded markets. Moreover, LPTV stations that are not displaced initially may be forced out at the end of the transition period if the FCC decides to use their frequencies for the repacked digital channels or for the new licenses to be auctioned. The percentage of LPTV stations that digital TV stations and other new users would displace is not known, nor is the percentage of displaced stations that would be able to move to suitable vacant frequencies.

Effects of the Accelerated-Use Plans

The early-return plan and the 60-69 plan have many points in common with the baseline plan, but they would speed the introduction of new services that would share the TV spectrum. The 60-69 plan differs from the baseline plan only in that it calls for the FCC to issue overlay licenses covering the upper UHF channels, thereby allowing productive use of unused portions of that spectrum early in the transition period.

29. See, for example, the statements of Faye M. Anderson, President, Douglass Policy Institute (pp. 5-6), and Gigi B. Sohn, Deputy Director, Media Access Project (pp. 7, 15), at the Federal Communications Commission *en banc* hearing on advanced television, December 12, 1995.

The effect would be a gain in economic efficiency relative to the baseline plan; estimating the size of the gain, however, would require additional detailed analysis.

The early-return plan differs more significantly from the baseline plan. It would reclaim the analog channels and repack the digital channels in 2005, allowing new services to begin on the cleared 138 MHz in just eight years (assuming that the plan begins in 1997) but making more analog TV equipment obsolete and thereby forcing more viewers and broadcasters to purchase new equipment sooner than they would prefer. The net impact of those effects on economic welfare is an empirical question. CBO's analysis suggests that the result would probably be a gain in efficiency relative to the baseline plan.

Table 9.
Summary Evaluation of Plans for Introducing Digital TV

	Auction Receipts		Economic Efficiency		Equity Issues		
Plan	Estimate	Source	Main Implications	Relative to Baseline Plan	Broadcasters	Viewers	Low-Power Stations
Baseline	Not estimated	Licensees for new services using cleared spectrum in about 2012	Licenses digital TV; eventually terminates analog TV and clears blocks of spectrum for new uses	Not applicable	Offered use of second 6-MHz channel during transition period (15 years, subject to review); must then surrender analog channel	New digital channels available; unadapted analog sets go dark after 15 years (subject to review)	Many displaced by digital channel assignments and spectrum clearing
Acclerated Use							
Early return	$10 billion in 2002, given other provisions of deficit reduction plans that would auction another 120 MHz under 3 GHz	Same as baseline plan except receipts come in 2002	Same as baseline plan except transition ends in 2005	Probably more efficient; net gain estimated at roughly zero to $20 billion in 2002	Same as baseline plan except transition ends in 2005	New digital channels available; unadapted analog sets go dark in 2005; viewers of rural "translators" and other small-budget stations may lose choices	Same as baseline plan except spectrum is cleared in 2005
60-69	Not estimated	Same as baseline plan except overlay licenses for channels 60 to 69 are auctioned early	Same as baseline plan except some new services start early on channels 60 to 69	More efficient	Same as baseline plan	Same as baseline plan except some viewers of low-power stations on channels 60 to 69 may lose choices sooner	Same as baseline plan except some stations on channels 60 to 69 could be displaced sooner

SOURCE: Congressional Budget Office.

Auction Receipts. CBO estimates that the early-return plan would yield $10 billion in auction receipts in 2002. That estimate was derived using the approach discussed in Chapter 3 for commercially attractive blocks of spectrum under 3 GHz that are licensed for general telecommunications services. It reflects CBO's view that as more spectrum becomes available for similar services, growing competition will decrease service prices, profits, and ultimately auction bids. The estimate was prepared as part of an analysis of legislative proposals that sought to reallocate and auction large amounts of spectrum, in part to maximize the near-term contribution to deficit reduction. In particular, those proposals included another 120 MHz in large blocks under 3 GHz in addition to the cleared TV spectrum, which was estimated at 150 MHz then but is now estimated at 138

Table 9. Continued

Plan	Auction Receipts		Economic Efficiency		Equity Issues		
	Estimate	Source	Main Implications	Relative to Baseline Plan	Broadcasters	Viewers	Low-Power Stations
Up-Front Auction	$12.5 billion in 1998 if all channels are auctioned, or $9.5 billion if noncommercial broadcasters are given digital channels for free	Digital TV licensees	Licenses digital TV; does not mandate termination of analog TV or clear spectrum	Unknown	Face more competition if outbid for digital channels; not obligated to cease analog service	New digital channels available; analog TV continues while sufficient market exists	Many displaced by digital channel assignments
Full Overlay							
Pressler	Not estimated	Overlay licensees, plus interest on deposits and surrendered deposits from digital TV licensees	Licenses all TV spectrum; maximizes flexibility of licensees; does not require digital TV; protects free TV but allows it to move off the spectrum	Unknown	Must pay deposit for digital channels; may surrender deposit and keep two channels; need not use the digital channels for TV; may continue analog TV service and must arrange comparable free replacement service to end or reduce it	Digital TV may or may not be available on local broadcast channels; continued free TV on analog sets is guaranteed (but length of guarantee is not specified)	All are subject to displacement by overlay licensees
Right-to-move	Not estimated	Overlay licensees	Similar to Pressler plan but requires digital TV	Probably more efficient	Offered use of second channel; must surrender analog channel or move digital channel if compensated by overlay licensee	New digital channels available; continued free TV on analog sets is guaranteed (but length of guarantee is not specified)	All are subject to displacement by overlay licensees, possibly with compensation required

NOTE: MHz = megahertz; GHz = gigahertz.

MHz. The estimate of receipts would exceed $15 billion if the 138 MHz were the only frequencies to be reallocated and directed for auction; a larger supply of 258 MHz to be auctioned, however, yields a lower price per MHz and hence the lower estimate of $10 billion for additions to total receipts.[30]

CBO has not estimated the likely receipts from the 60-69 plan. The majority of the frequencies (78 of the 138 MHz) would not be auctioned until the end of the transition period; again, that date is too distant and uncertain to allow for reasonable estimates. The receipts the federal government is likely to glean from auctioning overlay licenses for the remaining 60 MHz (channels 60 to 69) could be estimated. Doing so, however, would require detailed data on the location and range of the analog and digital TV broadcasters that overlay licensees would have to work around during the transition.

Economic Efficiency. By speeding the introduction of new telecommunications services, both plans would benefit producers and consumers of those services. In terms of efficiency, consumers would benefit if the value they placed on the services (that is, the maximum they would be willing to pay for the services) exceeded the price they actually paid in the market. Producers' benefits would be measured similarly by their profits—the difference between the dollar sales of the services and the costs of providing them.

Comparing the early-return plan with the baseline plan, the benefits that producers and consumers of the new services would gain from reclaiming the channels sooner would be at least partly offset by costs to viewers and broadcasters in lost TV services or equipment made obsolete. As detailed in Box 4, CBO estimates that the net effect would probably be a gain in efficiency, roughly between zero and $20 billion in 2002, although the analysis does not entirely rule out a net loss.

The 60-69 plan more clearly represents a gain in efficiency over the baseline plan: it would impose losses on viewers and owners of low-power TV stations operating on those channels, but given the stations' modest spectrum coverage and relatively small audiences, the losses would be small compared with the gains from more comprehensive use of the channels.[31] As with the potential auction receipts, however, a quantitative estimate of the efficiency gain would require information on the portion of the spectrum block that would be occupied by full-power TV broadcasters during the transition.

Equity and Compensation Issues. The costs offsetting some of the benefits of the accelerated-use plans represent issues of equity as well as efficiency. For example, a major equity issue associated with the shorter transition in the early-return plan is the costs to viewers of adapting or losing service on analog TV sets that would still otherwise be usable at the end of 2005. Such costs would be of particular concern if they fell on low-income households, which are more likely to rely on over-the-air TV.[32] To reduce the losses to viewers, NTIA Administrator Larry Irving has suggested that the federal government could establish a fund to subsidize the purchase of one set-top box by each household that would otherwise lose all TV service; a fund of $1 billion, for example, could provide a $50 subsidy to each of 20 million households. Such a subsidy would be difficult to implement, however, because it would require verifying each claimant's purchase and eligibility, and the administrative costs of doing so could be prohibitive.[33]

30. The additional 120 MHz is not a factor, however, in CBO's estimate of receipts from the up-front auction plan, noted in Table 9 and discussed later in this chapter. The difference lies in the extent to which the frequencies would expand the supply of similar services. The 120 MHz and the spectrum cleared under the early-return plan would both be licensed for a general, wide range of uses and would be expected to find their highest value in similar types of mobile communications (see Box 6). In contrast, CBO's estimate assumes that the need to avoid interference with analog TV signals would limit the possible uses of the channels awarded in the up-front auction, leaving TV broadcasting as their most profitable primary use.

31. The FCC has suggested that the 60-69 plan could be modified to reserve some of that spectrum for low-power stations. If the stations' value to their viewers, which is not directly reflected in market prices, was sufficiently large, then the modification could conceivably improve the plan's efficiency.

32. Data from MediaMark Research, Inc., show that 54 percent of households with annual income under $20,000 subscribe to cable, compared with 67 percent of all households. See Cabletelevision Advertising Bureau, *1996 Cable TV Facts* (New York: Cabletelevision Advertising Bureau, 1996), p. 41.

33. Administrative feasibility aside, one could also argue that the proposed fund would not go far enough, in that it would not benefit households that had purchased digital sets or boxes on their own but faced the loss of service on second or third sets. Such households presumably present less of an equity issue, however, in that most could afford to adapt their secondary sets if the value of doing so exceeded the price of a box, and many of the households that placed a lower value on the sets would be compensated enough by the value of the new digital TV services received on their primary sets.

Another issue the early-return plan raises is the ability of stations with smaller budgets, such as noncommercial stations and those in smaller markets, to meet the tighter deadlines for conversion to digital service. Analysis suggests that the cost of start-up digital capacity—giving stations the ability to pass through a high-definition network signal and convert local analog programming to standard-definition digital—would be manageable for the majority of commercial stations in even the smallest markets, although it would certainly be a greater burden on them than on stations in large markets.

According to recent estimates, start-up capacity will cost perhaps $700,000 to $1.6 million per station, depending on the power of the station's transmitter and the performance of new lightweight silicon-carbide transistors.[34] Many stations would finance the investments by borrowing; assuming for illustration 10-year financing at 10 percent interest, costs of $700,000 to $1.6 million imply annual principal and interest payments of roughly $110,000 to $250,000. For comparison, data from a survey of commercial stations conducted by the National Association of Broadcasters found that average 1995 net revenues and operating expenses were $3.5 million and $2.4 million in the smallest 36 of the nation's 211 TV markets, $4.5 million and $3.1 million in the next largest 25 markets, but much higher—$62.6 million and $35.1 million—in the top 10 markets.[35] Total costs would be higher for certain stations, such as those with networks of low-power or full-power stations that rebroadcast the signals of the primary station, and those that would have to modify existing broadcast towers or construct new ones. Accordingly, some of those stations could face special difficulties in making a full transition by 2005.[36]

If the burden on small-market, noncommercial, or other low-budget stations was deemed to be unfairly high, the plan could be modified to give them more time to convert to digital operations. A full analysis of the issue should also consider whether broadcasters in small markets might receive relatively greater benefits from their investments in digital technology: the ability to divide a channel into multiple subchannels could be particularly valuable as a competitive tool in smaller markets, which now offer only a few over-the-air channels against the many available on cable and DBS systems. It should also consider possible efficiency costs: lengthening the transition period for certain broadcasters could undermine the use of the returned spectrum for services requiring nationally clear frequencies, such as those delivered by satellites.

For owners of low-power TV stations and their viewers, both plans would impose higher costs than the baseline plan by reclaiming some or all of the spectrum sooner. The FCC notes that about 17 percent of all LPTV and translator stations occupy the upper UHF channels that could be auctioned in the next few years under the 60-69 plan.[37] That figure might overstate the relevant impact: some of those low-power stations would be displaced by digital TV channel assignments in any case, and some stations on the affected channels might be able to relocate to lower channels during the rest of the transition period. The early-return plan, of course, would affect LPTV stations on all the cleared frequencies by completing the transition in 2005.

Effects of the Up-Front Auction Plan

In many ways, the effects of a direct auction of the digital channels would be very different from those of the previous proposals. An up-front auction would not free up large blocks of spectrum for other uses, but it would allow more of a market test between analog and digital TV and give individual broadcasters more flexibility to choose a strategy that reflects their specific circumstances. Large uncertainties about future technologies and consumer preferences preclude CBO from determining whether the balance of those effects would

34. J.A. Flaherty, "Digital ATV/HDTV: On Your Mark, Get Set, Transition" (paper presented at the CBS Affiliates Chief Engineers Breakfast, annual convention of the National Association of Broadcasters, Las Vegas, Nev., April 15, 1996); personal communication to the Congressional Budget Office by Rupert Stow, Rupert Stow Associates, East Moriches, N.Y., April 30, 1996.

35. The comparisons are somewhat inapt because principal and interest payments are not included in operating expenses. Total cash flows, including those from investing and financing activities, would be the most complete basis on which to judge a station's capacity to absorb the additional costs, but those figures are not available in the National Association of Broadcasters' data.

36. Conversely, the costs of start-up capacity might be only half those cited here for stations that can wait for used equipment to come on the market. See Federal Communications Commission, *Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rule Making*, FCC 92-438 (October 16,1992), p. 40.

37. Federal Communications Commission, *Sixth Further Notice of Proposed Rule Making*, FCC 96-317 (August 14, 1996), p. 28.

Box 4.
Estimates of the Relative Economic Efficiency of the Baseline Plan and the Early-Return Plan for the TV Spectrum

The Congressional Budget Office's (CBO's) analysis suggests that the net effect on the economy of the early-return plan to reduce the phaseout period for analog TV would probably be positive, although a small loss cannot be ruled out. Using the estimate that the plan would yield $10 billion in auction receipts as a starting point, the overall economic effect could range from a loss of $1 billion to a gain of $22 billion. The effect includes benefits to consumers and producers of new spectrum services of almost $9 billion to $28 billion, and offsetting costs to viewers and broadcasters totaling roughly $6 billion to $9 billion. All figures are in dollars discounted to 2002.

The ranges reflect important uncertainties, discussed below and shown in the accompanying table. They do not, however, reflect uncertainty about the estimate of $10 billion in auction receipts, which could widen the ranges of benefits and net effects. The net effect could range from a loss of roughly $4 billion to a gain of $42 billion (based on benefits between $5 billion and $48 billion and the same costs as above) if receipts were as little as $6 billion (an earlier CBO estimate, made before the C block auction of licenses to provide personal communications services) or as much as $17 billion (the Administration's 1996 estimate for an auction of 150 megahertz of reclaimed spectrum).

Benefits. The economic benefits associated with shortening the transition can be estimated from the auction receipts for the early-return plan because both derive from the anticipated stream of future payoffs resulting from the new uses of spectrum. Three differences between them need to be taken into account, however.

First, the receipts reflect only the expected payoffs to the new licensees, whereas the total economic benefits to society also include the gains to consumers. CBO's estimate assumes that consumers would gain between 100 percent and 300 percent as much as the licensees—that is, that total social gains would be two to four times those to the licensees alone. The range was chosen partly on the basis of a previous study by two analysts at the Federal Communications Commission. The study estimated that reallocating one ultrahigh frequency (UHF) television channel in the Los Angeles area to cellular telephone service would have increased total economic welfare by $922 million, roughly 3.6 times the potential gain of $253 million to the new cellular operator.[1] The details of their study are necessarily specific to the particular case, and the ratio could be significantly higher or lower under other circumstances. Erring on the side of caution, CBO merely rounded 3.6 up to 4 in choosing the upper bound. The lower bound of 2 was chosen on the assumption that continuing competition among service providers and rapid technological change would ensure that consumers garnered at least half of the total gains.

Second, the auction receipts reflect a private discount rate above the appropriate social discount rate and hence tend to understate the benefits to the economy as a whole. The rate that auction bidders use in calculating the present value of their expected future payoffs is influenced not only by their willingness to trade present for future gratification but also by the taxes they face on income from capital and the financial risks to their individual firms (such as the risk of losing market share to competitors). From the standpoint of the whole economy, however, the taxes and individual risks that represent actual or potential losses to a particular firm are merely transfers to another party and are thus irrelevant to the discount rate. The impact of the difference between private and social discount rates depends on the timing of the future economic payoffs: because the effect of a difference in rates compounds over time, the more distant the payoffs, the wider the gap between the present values calculated using the different rates.

CBO's estimate assumed that the $10 billion in auction receipts would reflect the bidders' use of a real discount rate between 7 percent and 12 percent a year, chosen to represent plausibly low and high scenarios for the level of risk that bidders would associate with the licenses. The estimate used a real discount rate of 2 percent in calculating the benefit to the economy as a whole—CBO's standard rate for analyzing public investments, where taxes and financial risk are similarly irrelevant. Ideally, the analysis would apply the lower discount rate to a detailed path of payoffs over time, with small or even negative initial payoffs followed by larger gains later. For simplicity and caution, however, CBO assumed that payoffs would be constant over time, thereby giving greater weight to the early years and tending to minimize the impact of the gap in discount rates. The result of the assumptions is that the present value of the future payoffs is between 3.34 and 5.46 times as large using the social discount rate as it is using the private discount rate, with the range corresponding to the assumed range of private discount rates.

Finally, the receipts reflect the winning bidders' expectations of all their future profits, whereas the benefits of the shorter transition represent just the portion of the economic gains attributable to starting sooner than under the baseline plan. CBO's estimate assumed that the licenses would be available in 2012 under the baseline plan, rather than 2005, and would be equally valuable in inflation-adjusted dollars at that point. Given those assumptions and the 2 percent real discount rate, the head start accounts for almost 13 percent of the total present value of the benefits associated with the licenses in 2005.

The above three adjustments can be combined to convert estimated auction receipts under the early-return plan into estimates of the economic benefits of the shorter transition (see

1. Evan R. Kwerel and John R. Williams, *Changing Channels: Voluntary Reallocation of UHF Television Spectrum*, OPP Working Paper Series, No. 27 (Office of Plans and Policy, Federal Communications Commission, November 1992), p. 83.

Estimated Benefits and Costs of a Shorter Transition to Digital TV

	Low-Case Estimate	High-Case Estimate
Benefits		
Estimated auction receipts (Billions of dollars)	10	10
Ratio of total social gains to licensee payoffs	2	4
Ratio of present values using social and private discount rates	3.34 (Based on 7 percent private discount rate)	5.46 (Based on 12 percent private discount rate)
Share of present value attributable to seven-year head start	0.129	0.129
Estimated Economic Benefits (Product of above terms, in billions of dollars)	8.6	28.2
Costs (Billions of dollars)		
Value of lost service from analog TV sets	5	2
Value of lost service from rural translator stations	4	4
Depreciated value of analog transmitters	0.2	0.2
Estimated Total Costs	9.2	6.2
Estimated Net Benefits to the Economy (Benefits minus costs, in billions of dollars)	-0.6	22

the accompanying table). CBO's estimate of $10 billion in auction receipts implies economic benefits ranging from a low end of roughly $9 billion (if consumers and licensees benefit equally and the bidders' discount rate is 7 percent) to a high end of $28 billion (if consumers' gain is three times that of licensees and the bidders use a 12 percent discount rate). Other estimates of receipts would imply proportionately higher or lower benefits.

Costs. Offsetting the above gains would be three main types of losses to viewers and broadcasters. First, viewers would lose the value of continued use from analog TV sets they were not ready to replace or adapt at the end of the shorter transition. Although two-thirds of U.S. households already subscribe to cable or satellite TV, and some nonsubscribers would have already purchased digital TVs or set-top boxes by 2005, the early cutoff could affect 40 million or 50 million receivers (roughly one-sixth to one-fifth of the nation's total) that would otherwise remain usable for years. If the average loss per receiver was $50 to $100, the total efficiency cost would be between $2 billion and $5 billion.[2]

Second, accelerating the transition could cause a loss of service to some viewers, mostly in rural areas, who receive broadcast signals via low-power translator stations or their full-power counterparts, called "satellite" stations. Some broadcasters operating translator or satellite networks might have trouble borrowing enough money to replace all the necessary equipment within the shorter period. An estimated 6 million households depend on translator stations, either directly or through cable systems that carry their signals.[3] Erring on the pessimistic side, if all such households were to lose their current service and valued TV relatively highly—that is, highly enough to choose to replace their lost service with satellite TV—the cost could exceed $4 billion.[4]

Third, broadcasters would bear costs corresponding to lost years of service from analog transmitters that would have to be turned off. Those costs would probably be smaller than the above costs to viewers. The cost of purchasing and installing analog transmitters and related equipment is roughly $1 million per station, but the economic loss would be reduced by depreciation occurring before the cutoff and the decreased value of analog equipment associated with the migration of viewers to digital TV (even without a mandatory cutoff). Those factors might imply an average loss per transmitter of perhaps $150,000; multiplying by the 1,544 broadcast stations yields a total loss of roughly $230 million.

2. The average loss per receiver could not exceed the price of a set-top box, because households could purchase boxes for receivers they wanted to keep using. Of course, the number of unadapted sets and their associated costs could be significantly higher if the introduction of digital broadcasting was unexpectedly delayed. Arguably, one advantage of the baseline plan is that it allows more time for correcting unanticipated technical problems. The Grand Alliance system has undergone extensive testing under the auspices of the Federal Communications Commission, however, and four experimental stations were on the air as of February 1997 ("HDTV Heats Up In Seattle," *Broadcasting & Cable*, February 3, 1997, p. 76).

3. Personal communication to the Congressional Budget Office by Darwin Hilberry, Chairman, National Translator Association, Riverton, Wyo., July 3, 1996.

4. The estimate assumes that the discounted cost per household of subscribing to satellite TV for seven years is roughly $700, based on $300 in equipment costs (reflecting an assumption that technology and competition will drive prices down) and $5 per month for a low-cost package of channels (on the assumption that viewers would regard such a package as at least as valuable as the broadcast service they lost).

make the plan more or less efficient than the baseline and accelerated-use plans.

Auction Receipts. Auction receipts from the up-front auction would be comparable with the $10 billion anticipated under the early-return plan. In particular, CBO estimates that an up-front auction would yield $12.5 billion if it included a full complement of digital channels (one for each current analog station), or $9.5 billion if roughly one-quarter of the channels were removed from the auction and given to noncommercial broadcasters at no cost.[38]

The estimates derive from a simple financial model, created by CBO, of the future digital broadcasting industry and are consistent with CBO's review of estimates produced by others. The model calculates the present value of a stream of profits resulting from using the digital channels primarily to provide four subchannels of standard-definition TV programming supported by advertisers, plus some software and data broadcasting, pay-per-view events, advertising enhancements (additional product and dealer information, discount coupons to be printed on a home computer, and so on), and perhaps occasional HDTV programming. The model assumes that the digital channels do not have "must carry" rights on cable systems.

The model emphasizes ad-supported SDTV not because CBO assumed that the licenses would require it but because it appeared to be the most profitable of the feasible alternatives. Ad-supported SDTV could help broadcasters regain market share from cable networks by giving many viewers access to 40, 50, or 60 channels of programming for the one-time price of a digital TV set or converter box. Moreover, the enhanced advertising capabilities could induce advertisers to shift more of their spending to TV, away from other media such as newspapers and direct mail.

Other potential uses did not appear promising. The constraint of noninterference with existing analog TV broadcasters seemed to limit the channels' usefulness for cellular telephone services and other mobile uses. HDTV appeared to be unprofitable as a primary use because the high cost of HDTV receivers would probably limit the size of audiences for many years. Subscription-based SDTV was ruled out as unrealistic, on the grounds that aggregating each channel's handful of program streams into a subscription service able to compete with cable and satellite systems would require both close cooperation among local broadcasters and implicit or explicit approval from spectrum and antitrust regulators.

The financial model required CBO to make specific assumptions about the rate at which households would acquire digital sets or converter boxes, the costs of the digital equipment and of providing four program streams, revenues from the ancillary services, the premium that advertisers would pay for the enhancements of their ads, and the discount rates that broadcasters would use in comparing digital and analog channels. Those assumptions were necessarily subjective, given the absence of data, but FCC staff and private-sector analysts with whom CBO consulted considered them reasonable. Moreover, the estimate resulting from the set of assumptions is broadly consistent with the available evidence from related markets (see Box 5) and CBO's estimate of receipts under the early-return plan (see Box 6).

Economic Efficiency. Because a full up-front auction would yield higher receipts than the early-return plan, in CBO's estimates, and because higher receipts are generally associated with higher-value uses, it is tempting to conclude that the up-front auction would be more efficient than the early-return plan and hence even more efficient than the baseline plan. Two factors undermine the inference, however. First, little weight can be attached to the difference between the estimates of $12.5 billion and $10.0 billion, given the uncertainties surrounding both figures. Second, even taking the estimates at face value, the relative receipts tell only a part of the efficiency story because each plan auctions only part of the current TV spectrum. The up-front auction could be both less efficient and a better source of auction receipts if it yielded a smaller overall economic pie—measured by the combined value of the services provided by the new licensees and remaining incumbents—but gave taxpayers a sufficiently larger slice. Accordingly, analysis of the efficiency of the up-front auction must go beyond the auction receipts to consider the likely pattern of spectrum use.

38. The net effect on the federal Treasury could be between those two figures if noncommercial broadcasters have to pay for digital channels but receive bidder's credits or an appropriation to pay for part of the cost.

Box 5.
Other Estimates of Receipts from Auctioning the Digital Channels

Analysts from the Federal Communications Commission (FCC) and elsewhere have also estimated the receipts that could be raised by auctioning licenses to use the digital TV channels. Their methods, like those of the Congressional Budget Office (CBO), rely on indirect data, and the resulting estimates are both higher and lower than the CBO estimate of $12.5 billion.

One widely cited estimate of $70 billion is the upper end of a range from $11 billion to $70 billion calculated by the FCC. The commission derived that range by assuming that an average of 80 megahertz (MHz) would be auctioned (reflecting the national average of 13.3 channels available over the air) and extrapolating from the per-person, per-MHz prices paid in the first four spectrum auctions.[1] As discussed in earlier chapters, however, there can be no presumption under the block allocation system that the market value of spectrum is similar in different uses. Hence, no reasonable basis exists for extrapolating from the auctions of licenses for personal communications services (PCS) to the price that bidders would pay for spectrum to be used for digital TV.

The FCC calculated a second set of estimates by looking at the value of spectrum allocated to the current analog channels. Using data on stations' advertising revenues and depreciation costs, the commission found that the value of spectrum used by current commercial stations may be between $23 billion and $38 billion. Extrapolating from the recent sale of New York City's WNYC led to a similar figure of $33 billion. Those data, though more germane than the PCS auction prices, are still difficult to relate to the value of the digital channels, which may ultimately be more profitable than today's analog channels but will have to build their audience up from zero.

Professor Jerry Hausman of the Massachusetts Institute of Technology has also analyzed data on existing stations. In particular, he examined sale prices of stations sold between 1990 and 1995 and estimated that the value of all commercial ultrahigh frequency (UHF) stations in the country is approximately $3.5 billion to $4.5 billion.[2] Hausman argues that the value of a current UHF station is a good proxy for the value of a digital channel. Extrapolating his figures to include the auctionable digital channels corresponding to current noncommercial and very high frequency (VHF) stations yields a range of $8.7 billion to $11.2 billion. That range is relatively close to, albeit lower than, CBO's estimate of $12.5 billion, and arguably errs on the low side by failing to account for the value that bidders would place on being able to create instantaneous networks.

The recent auction of a satellite slot for direct broadcast satellite (DBS) services provides another relevant comparison point for auctioning a second, digital channel. That comparison yields dramatically lower estimates of potential receipts. Because the capacity of the DBS slot won by MCI is equivalent to 40 6-MHz ground-based digital TV channels reaching the continental United States, or roughly three times the number proposed for local digital TV broadcasting, the winning bid of $682.5 million suggests that receipts from a second-channel auction might be on the order of a few hundred million dollars. Several factors could make the second-channel licenses more valuable to bidders than the DBS slot was, including the desires of viewers for local programming, the interest of advertisers in reaching local audiences, and the fact that DBS services require special receiving antennas. Moreover, auctions for the second channels could be more competitive than the DBS auction, which had only three bidders. Nonetheless, the DBS result is certainly grounds for caution in estimating receipts from a second-channel auction in the billions or tens of billions of dollars.

Other observers have suggested that the digital channels could be worth much more, with columnist William Safire mentioning a figure of $500 billion.[3] The FCC has argued that "it is highly unlikely that the capital markets can or will put forth a half-trillion dollars on what are now speculative services with equally speculative demand."[4] CBO agrees with that assessment.

1. Letter from Robert M. Pepper, Chief, Office of Plans and Policy, Federal Communications Commission, to Senator Joseph I. Lieberman and others, May 5, 1995, pp. 1-7.

2. Statement of Jerry Hausman, MacDonald Professor of Economics, Massachusetts Institute of Technology, in U.S. Senate, *Concurrent Resolution on the Budget for Fiscal Year 1997*, hearings before the Senate Committee on the Budget, Senate Hearing 104-487, March 14, 1996, p. 224.

3. William Safire, "The Greatest Auction Ever," *New York Times*, March 16, 1995, p. A25.

4. Letter from Robert M. Pepper to Senator Joseph I. Lieberman, p. 9.

One factor suggests that the up-front auction plan could be more efficient than the baseline plan and perhaps the accelerated-use plans—namely, its reliance on decentralized market forces to determine how long analog broadcasting continues. Market forces take more account of individual variations in preferences and opportunities than do centralized, governmental mandates and therefore yield more efficient outcomes, at least in the absence of significant market failures. A decentralized approach would allow broadcasters and viewers in large urban areas, for example, to move quickly to digital service while those in more rural areas stayed longer with the analog system. It could also allow different analog and digital broadcasters to coexist in the same city, in different market niches.

Important market failures may exist in this case, however, and may be enough to reverse the presumptive benefit of decentralizing the decisions regarding analog TV. In particular, transaction costs might prevent or delay private parties from clearing large blocks of spectrum through decentralized negotiations—a result that the above plans would bring about via government fiat—even if such blocks allowed the spectrum to be used more productively. The importance of such transaction costs, relative to the benefits of decentralization, would depend on two factors: the difficulty of private negotiations to clear blocks of spectrum, which is likely to be great given the large number of parties that could hold out for a bigger share of the benefits; and the extent to which clearing blocks of frequencies

Box 6.
Are CBO's Estimates Internally Consistent?

Some observers have questioned the consistency of the Congressional Budget Office's (CBO's) estimates that the early-return plan and the up-front auction plan would lead to auction receipts of $10.0 billion and $12.5 billion, respectively. The argument is that the former would auction a larger quantity of spectrum and, because the licenses would allow digital TV broadcasting as well as nonbroadcast uses, would yield an equal or higher price per megahertz (MHz). CBO believes that the argument involves two incorrect premises and that an analysis consistent with CBO's approach to the up-front auction plan shows that using the spectrum reclaimed in the early-return plan for digital broadcasting instead of mobile communications services would justify bids totaling much less than $10 billion, not more.

Most critically, the early-return plan would not auction a larger quantity of usable spectrum. The 138 MHz of spectrum reclaimed for auction under that plan cannot be appropriately compared with the estimated national average of 80 MHz of broadcast licenses available in the up-front auction (based on 13.3 channels available over the air to the average viewer and 6 MHz per channel). The reason is that the latter figure does not include the buffer spectrum required around the broadcast signals to avoid problems with interference. The FCC expects to clear for reuse only 138 MHz (originally, 150 MHz) of the 402 MHz currently allocated to TV, because the remaining 264 MHz would be needed to accommodate the digital channels and the associated buffer spectrum. Hence, the appropriate comparison is not between 138 MHz and 80 MHz but between 138 MHz and 264 MHz. Conversely, applying the same ratio of total spectrum to usable channels suggests that devoting the 138 MHz to additional TV broadcasting might yield only 42 MHz of digital channels.

Moreover, CBO believes that winners of licenses under the early-return plan would find it much harder to make money by starting digital broadcasting in 2005, given that existing broadcasters would already be operating in digital, than would winners in the up-front auction, who would be the first to provide local digital television broadcasting in service areas comparable with those of today's analog stations.[1] That assessment is consistent with CBO's general view that increases in the supply of a given service imply greater competition and lower profits. Consequently, the opportunity under the early-return plan for winning bidders to use their frequencies for digital TV does not ensure that the average price per usable MHz would be at least as high as in the up-front auction.

1. Some wireless cable systems are likely to introduce digital technology before second-channel licensees could, but smaller coverage areas and the need for a direct, unobstructed line of sight between transmitting and receiving antennas limit the reach of such systems, at least at present. Moreover, such systems involve higher costs for receiving equipment.

would in fact increase the productivity of the spectrum by facilitating services that were more valuable than those that do not need large blocks.

Uncertainties surrounding future technologies and consumers' desires make the importance of clearing large blocks of spectrum, and hence the relative efficiency of the up-front auction plan, difficult to evaluate. For some spectrum services, such as continued analog TV broadcasting and conversion of analog stations to digital TV, spectrum clearing would be irrelevant. For satellite-based broadcasting, however, it would be essential. For local mobile telephone service, it might be irrelevant, helpful (that is, cost-reducing), or essential, depending on local circumstances and the abilities of future communications equipment. Thus, the lack of spectrum clearing in the up-front auction plan may or may not be a major disadvantage from the point of view of economic efficiency. Indeed, it could even be an advantage: because market forces undervalue TV stations by neglecting their value to viewers, the reduced flexibility associated with smaller blocks of frequencies could increase efficiency by forestalling a skewed choice between TV and nonbroadcast uses of the spectrum.[39]

Other alleged market failures that would make the up-front auction less efficient than the plans discussed above lack empirical support. In principle, the plan might be undermined by coordination problems—a type of externality—because it does not include a uniform deadline for analog TV. Such a deadline might be needed to spur enough purchases of digital equipment to allow manufacturers to reach critical scale economies and broadcasters to reach sufficiently large audiences. The available evidence most relevant to the issue is the rapid penetration of digital satellite services (requiring both set-top boxes and dish antennas), which suggests that the externality would not be a major problem. A related argument that a decentralized transition would make it more difficult for HDTV to succeed against standard-definition digital TV is more plausible. Still, no data show that a critical manufacturing threshold exists for HDTV sets, or that viewers and advertisers would prefer HDTV to SDTV even if scale economies reduced HDTV prices.[40] Indeed, the FCC dropped the proposed requirements for a minimum number of hours of HDTV programming from the transition plan it issued recently, partly in response to requests from broadcasters.

A final factor that could affect the relative efficiency of the up-front auction is the speed with which it would introduce digital TV. Current broadcasters who were given the licenses directly under one of the above plans would have more resources already in place than nonbroadcasters who won licenses in a direct auction. In all cases, however, licensees would have a strong incentive to roll out attractive services quickly so that they could compete with video providers using cable, satellite, and microwave technology.

Equity Issues. Auctioning the digital channels to the highest bidders eliminates any possibility of an unwarranted windfall to current broadcasters. Conversely, however, one could argue that it would be inequitable to broadcasters who have recently bought or invested in analog stations, in part on the assumption that the FCC would carry out its proposal to give each analog licensee a second, digital channel. From that view, an up-front auction would unfairly undermine the value of current TV licenses by changing the rules in the middle of the game.

A frequent but unpersuasive criticism of the up-front auction plan is that it would deprive the public of free nonsubscription TV. Critics argue that the licenses would be so expensive that winning bidders would be forced to seek higher revenues by charging viewers or

39. Any loss of efficiency resulting from a skewed choice by the market under the plans involving spectrum clearing would probably be much smaller—but not zero—if the FCC allowed winning auction bidders to assemble enough licenses to make subscription-based TV services a viable alternative. In that case, market forces would perceive the relative value of broadcast and nonbroadcast uses more accurately. Some efficiency would still be lost, however, since the subscription fees would inefficiently deter some viewers who would have benefited from the digital channels.

    The tendency of the market to undervalue TV relative to nonbroadcast spectrum services, and hence to supply too few viewing options, does not undermine the above finding that the early-return plan is likely to be more efficient than the baseline plan, even though the former clears spectrum and puts it up for auction sooner. The viewing options at stake between those two plans are additional years of analog broadcasts, which are likely to be of low value to viewers able to receive the digital channels. The main value of the additional viewing options would lie in allowing viewers to defer the costs of adapting or replacing analog TV sets, and CBO's analysis took those costs into account.

40. Viewers in Japan can receive nine hours a day of HDTV (broadcast using a hybrid digital/analog technology that predates the Grand Alliance's all-digital system), but only some 30,000 high-definition receivers (roughly one for every 4,000 people) were sold in the first five years those broadcasts were available. See Yuichi Ninomiya, "The Japanese Scene," *IEEE Spectrum* (April 1995), p. 54.

shifting to non-TV services and that the existing analog stations would lose viewers and be driven out of business or, at best, hang on as marginal services providing poor-quality programming. Analog broadcasters today, however, are legally allowed to scramble their signals and offer subscription service but choose not to do so. That fact suggests, as does CBO's analysis, that the highest-profit use of the digital channels would emphasize nonsubscription TV. Moreover, if the potential loss of nonsubscription TV was of sufficient concern, the Congress (or the FCC, if delegated the authority) could specify that the channels must be used partially or primarily for that purpose.[41]

Critics of the up-front auction similarly argue that it threatens small-market broadcasters because their audiences are not large enough to justify the millions of dollars needed to win the licenses at auction. That argument ignores the economic logic that the bids required to win the licenses in markets with smaller revenue potential would be smaller as well.[42] In any event, broadcasters who chose not to bid or did not win licenses in an up-front auction could continue to operate their analog stations during the early, lean years of digital TV and convert to digital later when market conditions warranted—an option not available under the baseline and accelerated-use plans.

Both advocates and opponents of an up-front auction have argued that digital broadcasters who paid for their licenses would have a strong legal and philosophical case for exemption from the public interest regulations under which analog broadcasters now operate. Again, however, if the efficiency or equity benefits were judged to be sufficiently large, continued (or strengthened) public interest requirements could be explicitly imposed on the licenses to be auctioned.

Like the previous plans, the up-front auction would displace some low-power stations to make room for the digital channels, with the resulting equity implications for owners of those stations and their viewers. The up-front auction differs in that it would not displace any additional LPTV stations in order to repack the digital channels and clear spectrum for new uses. Moreover, it could be modified more easily than the other plans to protect those stations by reducing the number of digital channels. Of course, the low-power stations would not reach as many viewers as the full-power digital stations they would preclude, so the potential equity gain would come at a cost in the average number of viewing choices.

Effects of the Full-Overlay Plans

The full-overlay plans attempt to combine the best features of the various plans discussed above. By issuing overlay licenses covering the entire TV spectrum, they allow decentralized market decisions to determine the fate of over-the-air analog TV (as does the up-front auction), promote increased use of the spectrum (like the 60-69 plan), and seek to facilitate spectrum clearing (prominent in the baseline, early-return, and 60-69 plans). Because some details of the plans have not yet been specified, CBO is unable to quantify their auction receipts or economic efficiency. One qualitative conclusion that can be drawn is that the right-to-move version of the full-overlay idea would probably be more efficient than the baseline plan.

Auction Receipts. Both plans would auction overlay licenses that would collectively cover the entire country and all TV channels. The auction receipts cannot be estimated at the plans' current level of detail, however, because the bids would depend in part on how easily licensees could relocate or remove incumbent TV broadcasters to clear blocks of spectrum for higher-value uses. Both plans would require that viewers affected by any reduction or elimination of analog TV service be given comparable free replacement service, including the necessary receiving equipment. However, neither plan specifies key details such as whether the

41. If potential bidders did indeed value the spectrum more highly for other uses, a minimum broadcasting requirement would result in lower auction receipts. The reduction in receipts would represent the federal cost of supporting the public interest in the continuation of free TV.

42. The auction-price argument could be more plausible if some bidders sought the licenses for reasons that depended less on the size of the local population—for example, to fill out a regional or national PCS network. Whether the geographically isolated 6-MHz licenses would be useful for any such purposes and whether mobile uses such as PCS could overcome the potential interference problems with TV signals on nearby channels are questionable. Technical issues aside, the problem could again be avoided by specifying that only broadcast services are allowed under the licenses to be auctioned.

replacement service must be free in perpetuity or for a fixed number of years.[43]

The most that can be predicted is that auction prices should be lower under the Pressler plan, which grandfathers analog TV licensees indefinitely and hence gives them veto power over proposals to relocate them, than under the right-to-move plan, which gives overlay licensees the final word. Total federal receipts need not be lower under the Pressler plan, however, since they would include both the interest earned on the deposits that broadcasters would pay for digital channels and the deposits partly or wholly surrendered by any broadcasters who kept both the analog and digital channels longer than 15 years.

Economic Efficiency. Of all the plans for introducing digital TV, the full-overlay plans go the farthest in shifting to the private sector the responsibility for allocating spectrum to different uses. Indeed, under the Pressler plan, licensees of the digital TV channels would not have to use them for television at all. As discussed more in Chapter 5, privatizing spectrum management can improve efficiency to the extent that market failures—from externalities, public goods, transaction costs, and other causes—are less critical than governmental limitations of rigidity, limited information, and susceptibility to political influence. CBO's analysis of the balance of effects resulting from the right-to-move plan suggests that it would be more efficient than the baseline plan. The relative efficiency of the Pressler plan is harder to evaluate because it does not require digital TV.

The right-to-move plan is likely to be more efficient than the baseline plan because of two main advantages. First, it would license all of the TV frequencies, maximizing the opportunities to put previously unused spectrum into productive service. Second, it would let market forces determine when analog TV stations would stop broadcasting, allowing more sensitivity to local conditions than would the centralized plans and, in particular, avoiding the inefficiently long transition period of the baseline plan. In principle, if the right-to-move plan defined the costs of the free replacement service appropriately—that is, including the true costs of replacing over-the-air analog TV with another TV service of comparable quality but excluding any above-normal profits broadcasters now receive because of the limited number of over-the-air stations and the costs of service enhancements—then it could give overlay licensees the incentive to move each station at the efficient time.

The key threat to the potential gains in efficiency in practice is likely to come from transaction costs. Such costs might delay the termination of analog TV and reduce efficiency by making it difficult for the overlay licensees in a given geographic area to agree on how to divide the costs of providing viewers with the required replacement service, or for licensees overlaying the same frequencies in different areas to coordinate their efforts to clear specific blocks of spectrum. With careful judgment, however, the FCC could probably define overlay licenses that were sufficiently large (or that could be aggregated) to keep the inefficiencies from transaction costs to a modest level, but not so large as to facilitate abuses of market power.[44]

The Pressler version of the full-overlay idea shares with the right-to-move plan the advantage of licensing all of the TV spectrum. From the perspective of efficiency, the key difference between the two plans is the flexibility that the Pressler plan gives to digital-channel licensees not to use those frequencies for broadcast TV. As noted above, the presumption that market choices are efficient does not hold here because the benefit viewers receive from ad-supported TV is essentially an externality that the market does not recognize. Consequently, an allocation by the market of little or no spectrum for digital TV, with more going to nonbroadcast uses such as mobile telephone services, may or may not be more efficient than the allocation provided in the baseline plan. A second notable difference between the Pressler plan and the right-to-move plan is that the former would give analog TV licensees the right to continue operations indefinitely, putting them in a better bargaining position in their negotiations with overlay licensees. As discussed in Chapter 5, some academic

43. Formally, the right-to-move plan requires that an overlay licensee that wants to relocate a broadcaster arrange to have the broadcaster's signal carried on a comparable free replacement service—that is, one that its viewers can receive for free.

44. The plan could also be inefficient in cases in which the value of the analog TV station was lower than the cost of moving it off-spectrum. In such cases, if the value of the best new service that could use the TV channel was intermediate—that is, enough to justify shutting the station down but not enough to move it—the plan's requirement for free replacement service might inefficiently deter the new service. See the more general discussion of relocation rules in Chapter 5.

research suggests that the resulting negotiations would be more costly and less likely to reach the efficient outcome.

Equity Issues. In terms of their effects on current broadcasters, both full-overlay plans fall between the up-front auction plan on the one hand and the baseline and 60-69 plans on the other. Like the up-front auction plan, the Pressler plan allows broadcasters to keep two channels indefinitely if they pay for the second one; the difference is that the Pressler plan does not require broadcasters to compete in an auction for the channels and spreads the cost over 15 years. Broadcasters who do not want to keep both channels can surrender one at the end of the 15 years, as in the baseline and 60-69 plans, but they implicitly pay a rental fee equal to the forgone interest on their deposits. In contrast, the right-to-move plan simply offers broadcasters a digital channel for each of their current analog channels, with no deposit required, but allows overlay licensees to evict the analog stations from the spectrum by arranging for replacement service.

Both plans appear to ensure that TV viewers who now watch local broadcast stations over the air will see no reduction in the number of options available to them. Again, the language the plans use to describe the "free replacement service" leave some details open to question, such as whether the service remains free indefinitely and whether it covers new households or new TV sets that enter the area after it replaces the analog station. Digital broadcast TV would definitely be available to viewers who were willing to buy the necessary receivers or converters under the right-to-move plan, as under the four previous plans. As noted above, however, the Pressler plan differs by not specifically licensing any spectrum for digital TV.

One equity consequence of the exhaustive licensing in the full-overlay plans is that it would presumably allow the overlay licensees to evict all low-power TV broadcasters. The Pressler plan does not refer to LPTV directly but explicitly uses the phrase "full power" in the clause grandfathering existing analog stations. The authors of the right-to-move plan raise the possibility of requiring overlay licensees to compensate the owners of LPTV stations for evicting them from the spectrum, perhaps with an upper bound on the compensation set by a formula determined by the FCC.

Lessons from the TV Case

The analysis in this chapter focuses on the relative merits of policy options for introducing digital TV. On another level, however, it illustrates three main themes regarding spectrum management in general. First, the existing allocation of blocks of frequencies to different uses does not reflect current technological opportunities and consumer preferences, and the potential gains to the economy from improving the allocation are large. Second, however, any shift away from the current allocation raises difficult questions of efficiency and equity as to which incumbent users should move and when. Third, the use of auctions to assign specific licenses does not exhaust the possibilities of market-based mechanisms for managing the spectrum. In particular, combining overlay licenses with broadly flexible rights to use spectrum can effectively transfer decisions about allocations from the government to the private sector.

Indeed, overlay licenses are just one of several tools—some mutually compatible, others competing alternatives—that have been proposed as elements of an improved system of spectrum management. The next chapter goes beyond the TV case and considers the general advantages and disadvantages of the various elements in more detail.

Chapter Five

Improving Spectrum Management: The Next Steps

In an effort to better manage the radio spectrum and increase its value to society, the Federal Communications Commission has recently begun to move away from its historical role as allocator and assigner of spectrum by allowing more decentralized and market-driven forces to perform those tasks. Some observers claim that even greater gains are possible if the decisionmaking process is further decentralized. This chapter explores the efficiency and equity implications of several widely discussed reforms that—like many of the proposals for the transition to digital TV, but on an even grander scale—would increase the role of market forces and incentives in managing the radio spectrum.

The advantages and disadvantages of the current system of spectrum management, called block allocation, are well known.[1] Under that system, the FCC dedicates bands of contiguous frequencies to specific services provided under uniform technical standards by nonfederal users. The National Telecommunications and Information Administration performs the same function for the frequencies used by the federal government. On the plus side, block allocation limits interference between contending signals, offers producers and consumers the benefits of a stable environment in which to develop and purchase equipment, makes room for socially beneficial uses of the radio spectrum that the private market might not provide, and is an internationally recognized approach to managing the radio spectrum. Advocates generally claim that the ability to reserve spectrum in anticipation of new technological developments is also a positive feature of the system.

Block allocation also has an obvious drawback. In large areas of the radio spectrum—particularly those where the technology is most developed and the services provided are most valuable—frequencies are not permitted to flow freely between services, federal and nonfederal users, or different technologies. Even if an initial allocation of spectrum is the "right" size with the "right" service rules and technical standards, changes in technologies and tastes are likely to outpace the ability of the block allocation system to adjust. Thus, that system tends to create a crazy quilt of submarkets for various services that are allocated either too little or too much spectrum.

Proposals to change the system of managing the spectrum are not new, but they have achieved new prominence. As discussed above, the President's budgetary proposals for 1998 would reallocate some federal and nonfederal spectrum in commercially attractive bands, broaden and extend the FCC's authority to auction portions of spectrum, and allow private entities to reimburse federal users directly for the costs of clearing a band of spectrum. For advocates of more dramatic change, those initiatives address some of the consequences of an outmoded approach to managing the spectrum but fall short of addressing the basic problem. More to their liking is an initiative introduced late in the 104th Congress by then Senator Pressler, in his role as

1. Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future*, NTIA Special Publication 91-23 (February 1991), pp. 55-56.

Box 7.
An Alternative Path of Reform

Some analysts, most notably George Gilder, believe that spectrum is scarce because it is not used as efficiently as technology allows.[1] Several proposals, under the name of open access, are based on advances in technology that allow the spectrum to be used with greater technical efficiency. Those technologies include digital transmission, data compression, and broadband radios. A key component of the open-access proposals is "spread spectrum" communications, such as code division multiple access (CDMA) systems for voice and data transmission, that use those new technologies.

The success of open-access proposals hinges on developing new technologies and improving and refining existing ones. Whether the proposals are technologically feasible is at best unsettled and is beyond the Congressional Budget Office's ability to judge. Even if an open-access regime is technically feasible, however, serious doubts remain about whether it would deliver the economic benefits touted by its proponents.

Open Access Without an Allocation System

Theoretically, an open-access system would turn the spectrum into a great commons. With the artificial barriers of the block allocation system gone, users would be free to use the entire spectrum. The potential for interference that is currently controlled by partition and licensing would be avoided by new, smart radios with built-in technology "etiquettes" that govern the performance of the radio. Spectrum users would have to use robust receivers that are tolerant to interference and can "hear" through other signals. They would also have the responsibility to use radios that are not too "noisy"—that is, radios with etiquettes that limit the power level of transmissions.

A key issue in evaluating open-access proposals is whether technology would make spectrum abundant and eliminate the need for an allocation system. If new technologies make such efficient use of spectrum that scarcity is no longer an issue, then the price of spectrum (its opportunity cost) will fall to zero, thus eliminating the need for an allocation system. However, if spectrum stays scarce but is nonetheless treated as if it was free, it will probably not be used in an economically efficient manner.[2] A classic tragedy of the commons could result, with the spectrum being inefficiently overused.

The ability of the new technologies to deliver on the promises of open-access advocates remains to be seen. Some analysts do not believe that those technologies will live up to the claims that they avoid problems with interference, especially in the near future.[3] For example, commercial applications of CDMA technology have not developed as rapidly as some analysts anticipated.[4]

1. For a full explanation of his ideas, see George Gilder, "Auctioning the Airwaves," *Forbes ASAP*, April 1994 (available at http://www.forbes.com/asap/gilder/telecosm7.html). Supporting arguments on the artificial scarcity of spectrum and the potential of new digital technologies can be found in David Colton, *Spectrum Privatization: Removing the Barriers to Telecommunications Competition*, Policy Study No. 208 (Los Angeles: Reason Foundation, July 1996), pp. 6-8.

2. Eli M. Noam, "Taking the Next Step Beyond Spectrum Auctions: Open Spectrum Access," *IEEE Communications Magazine* (December 1995), p. 69.

3. Terrence P. McGarty and Muriel Medard, "Wireless Architectural Alternatives: Current Economic Valuations versus Broadband Options. The Gilder Conjectures" (paper presented at the 22nd Annual Telecommunications Policy Research Conference, Solomons Island, Md., October 2, 1994), p. 24; Noam, "Taking the Next Step Beyond Spectrum Auctions," pp. 71-72; and Department of Commerce, National Telecommunications and Information Administration, *U.S. National Spectrum Requirements: Projections and Trends* (March 1995), p. 191.

4. Quentin Hardy, "An Inventor's Promise Has Companies Taking a Big Cellular Gamble," *Wall Street Journal*, September 6, 1996, pp. A1-A7.

Chairman of the Senate Committee on Commerce, Science, and Transportation.[2] That plan, commonly referred to as the Spectrum Reform Discussion Draft, included provisions that allowed licensees more latitude in deciding how to use their portions of spectrum, reallocated one-quarter of the federal spectrum bands to the private sector, and granted blocks of spectrum for public safety uses to the states. Other analysts and policy-

2. That initiative included the proposal, discussed in Chapter 4, to auction overlay licenses covering the current TV spectrum.

Without those new technologies, open access is not feasible. Also, the spectrum etiquettes required for an open-access regime risk locking in certain technologies and preventing some future innovations.[5] Given the uncertainty surrounding the development of new technologies, basing spectrum management policy on them would be risky.

Open Access with an Allocation System

If technology does not do away with spectrum scarcity, an allocation system will be needed. One open-access variant—the "bit tax"—would charge users a fee tied to the amount and type of spectrum used.[6] Advocates of a bit tax agree with proponents of "pure" open-access proposals that the present system of allocating spectrum through exclusive-use licenses is inefficient, but they do not agree that technology alone will obviate spectrum scarcity. Accordingly, they propose to supplement the basic open-access concept with an economic allocation system that would control excess demand by charging users for their access to the spectrum.

The proposed fee system would require additional new technologies. All users of bands of spectrum covered by a bit tax would pay an access fee that would be continuously and automatically determined by the existing congestion in the various frequency bands.[7] If the technology worked correctly, the fee would charge users the incremental cost of their spectrum use, changing continuously to keep spectrum supply and demand balanced across frequency bands and geographical areas. In some versions of the proposal, the fee could also be collected through the use of electronic currency that could ride the airwaves along with the data packets.[8]

Even if the new technology worked as promised, however, it would create large efficiency losses in other ways. An open-access system is essentially a massive disaggregation of spectrum blocks, and the bit-tax approach to allocating those small blocks creates new transaction costs when a large or reliable block of spectrum is needed. The costs of collecting the fees could further dilute the benefits of a bit tax. In addition, as with any open-access proposal, the etiquettes built into the as yet undeveloped technology could lock in a given level of technology and thus block the development of some new innovations.

If workable and efficient technology for monitoring and pricing spectrum access was developed, it could be used outside an open-access context. In particular, bit-tax technology could be combined with the spectrum management reforms discussed in this chapter, which emphasize more extensive and flexible private licensing. Given sufficient flexibility in services and technology, licensees could use the technology to institute private pricing systems for renting out some or all of their spectrum. Leaving individual licensees to determine the technological and financial merits of the pricing technology might delay its introduction but would be less risky than a government decision to adopt it as part of a large-scale shift to an open-access system.

5. Thomas Hazlett, "Spectrum Flash Dance: Eli Noam's Proposal for 'Open Access' to Radio Waves" (comments at the Conference on the Law and Economics of Property Rights to Radio Spectrum, Marconi Conference Center, Tomales Bay, Calif., July 27-29, 1996, revised October 21, 1996), pp. 10-11; Noam, "Taking the Next Step Beyond Spectrum Auctions," pp. 66-73.

6. Noam, "Taking the Next Step Beyond Spectrum Auctions," pp. 66-73.

7. Ibid., p. 69.

8. Eli Noam, "Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism" (draft, Columbia University, Graduate School of Business, September 30, 1996), p. 35.

makers have also recommended numerous reforms, all of which emphasize greater flexibility in spectrum use.[3]

This chapter discusses the concept of allowing market forces to manage the radio spectrum and then ex-

3. Evan R. Kwerel and John R. Williams, "Moving Toward a Market for Spectrum," *Regulation*, no. 2 (1993), pp. 53-62; Reed E. Hundt and Gregory L. Rosston, "Spectrum Flexibility Will Promote Competition and the Public Interest," *IEEE Communications Magazine* (December 1995), pp. 40-43; and Jon M. Peha, "A Proposed New Spectrum Management Policy" (working paper, Department of Engineering and Public Policy, Carnegie Mellon University, October 18, 1996).

plores the advantages and disadvantages of three broad, complementary types of reform. Each of the reforms examined here takes the market-based principles and the lessons learned from auctioning licenses for spectrum and applies them to spectrum management in general. Those reforms would:

- Expand property rights in spectrum currently licensed to private users so that decentralized market forces could play a more active role in allocating spectrum—that is, in deciding what services to provide on which frequencies and by which technologies;
- Increase the amount of spectrum managed by the market; and
- Inject some market-based incentives into managing spectrum used by federal agencies.

Another, quite different approach that reform could take would be to increase the efficiency of spectrum use through technological advances. That type of reform, commonly referred to as "open access," is discussed in Box 7 (see page 70).

Managing by Market Mechanisms

The idea of managing the radio spectrum by using market mechanisms is not new. For at least 45 years, scholars have argued that a decentralized decision-making process for allocating and assigning spectrum would yield great gains in efficiency.[4] Under such an approach, private markets would make more of the decisions about allocating spectrum that the FCC now makes. Sometimes referred to as privatizing the spectrum, such reforms would give licensees more property rights but would not necessarily take the spectrum fully out of the public domain.[5]

Proponents of allowing the market to manage the spectrum argue that spectrum is a scarce resource and should be managed as other scarce resources are—through the market. Under the block allocation system, the FCC and the NTIA have the daunting task of trying to balance all competing needs for spectrum. They argue that in an uncertain and changing world, maintaining that balance is an impossible task for any central administrator. If, instead, the spectrum managers relied more heavily on decentralized market mechanisms, the spectrum users themselves would weigh the relative demands on spectrum and make decisions about how to use it.

Opponents of an expanded role for the market in managing the spectrum argue that market failures would limit efficiency gains in practice and that continued government steering at roughly the current level is desirable from a societal perspective. They contend, for example, that schemes that would increase the degree of private control over the spectrum—in particular, using auctions to allocate spectrum—would fail to provide enough of the airwaves for public safety and unlicensed uses. In addition, opponents point out that choices made by the market would be likely to conflict with international agreements governing the use of the spectrum.

Even if proponents of reform were correct in their prediction that increasing the role of markets in managing the radio spectrum would increase economic efficiency, not all producers and consumers would have net gains. Indeed, some could suffer significant losses. Thus, opponents also challenge the reforms on grounds that the distribution of such gains and losses would be inequitable.

Consumers of private goods would almost certainly gain as a group because allowing the market to manage the flow of spectrum between services would probably

4. Leo Herzel, "Public Interest and the Market in Color Television Regulation," *University of Chicago Law Review*, vol. 18, no. 4 (Summer 1951), pp. 802-816; R. H. Coase, "The Federal Communications Commission," *Journal of Law and Economics*, vol. 2 (October 1959), p. 18; Progress & Freedom Foundation, "The Telecom Revolution—An American Opportunity" (Washington, D.C.: Progress and Freedom Foundation, May 1995); Adam D. Thierer and Alex C. Walker, *A Policy Maker's Guide to Deregulating Telecommunications, Part 6: A Free-Market Future for Spectrum*, Heritage Talking Points No. 11 (Washington, D.C.: Heritage Foundation, March 19, 1996).

5. Like grazing and mining rights on public lands and water rights in the western United States, spectrum is a publicly owned good that private entities have some degree of claim on or rights to. Although many proposals advocate introducing market forces into western water management, for example, none hinge on taking final legal ownership out of the public domain and fully privatizing water. See Coleman Bazelon, "The Political Economy of California Water" (Ph.D. dissertation, University of California, Berkeley, 1995).

lead to more competition in providing telecommunications services. Some consumers, however, would suffer losses if the market failed to allocate sufficient spectrum for services with the attributes of public goods—such as public safety, broadcast TV, and amateur radio—or to unlicensed services whose transaction costs could induce a market to allocate too little spectrum. Also, the changes in technology that would probably accompany a greater degree of management by the market could reduce the useful life of current equipment or force some consumers to buy new equipment they would not otherwise have had to purchase.

As for service providers, current licensees would be confronted with both opportunities and challenges: opportunities to use their spectrum to provide new, higher-profit services, and challenges from new competitors entering markets that were formerly restricted to current licensees. Consequently, opponents of reform argue that increased competition could erode some of the value of spectrum recently purchased at auction or in secondary markets and that such a result would be unfair.

Expanding Property Rights in Spectrum

To establish a more market-based approach to managing the radio spectrum, the FCC would need to increase the property rights of spectrum users to give them more control over their frequencies. Whether those rights are full legal rights (such as a title or deed to a band of spectrum) or simply rights in practice (for example, the ability to change what a band of spectrum is used for) is not the key issue. As a practical matter, even though private users of spectrum have not legally owned their frequencies, most of them have always had the right to dispose of or sell their spectrum licenses.[6] In addition, the terms of licenses have increased in recent years, and almost all are routinely renewed when they expire. The key to achieving the enhanced efficiency that reformers seek is to give license holders more control over the types of services they can provide with their spectrum—the allocation decision—and the technologies they can use to provide them.

Several options are available to increase the control of license holders over their spectrum. The FCC could establish a *presumption* of flexibility, without relinquishing its current oversight responsibilities, by allowing licensees to modify or augment the services they provide and how they do so. In essence, any licensee that demonstrates that a proposed new use of its spectrum will not interfere technically with another licensee or violate an international treaty could expect to have its request for a change of service approved. The FCC could also experiment with giving *absolute* flexibility—that is, a fuller set of property rights, known as band management rights, to the users of certain bands of spectrum. While increasing property rights in general, the commission could set a time limit on some or all of those rights by substituting the certainty of reauctioning the right to use the radio spectrum for the current high expectation of perpetual renewal.

Current Trends

The FCC is already taking steps to allow license holders more control within the block allocation system. The allocation of spectrum for personal communications services, for example, entailed a broader definition of a service category and more flexible technical standards than did the earlier allocation for cellular services. The commission has allowed even greater flexibility in two recent allocations—for general wireless communications service and wireless communications service—that would allow licensees to do almost anything with their new frequencies and would make interference with other services the factor that limits the services that a licensee can provide.[7] Those broader definitions of a service category, which FCC Chairman Reed Hundt argues should be the model for all new allocations, give far more flexibility to the users of spectrum than any current service category.[8]

6. One exception is that the designated entities that received preferential treatment in recent auctions (see Chapter 3) face some restrictions on selling their licenses for a number of years. Also, several restrictions govern to whom spectrum can be sold.

7. Bennett Z. Kobb, *Spectrum Guide: Radio Frequency Allocations in the United States, 30 MHz-300 GHz* (Falls Church, Va.: New Signals Press, 1996), pp. 196-197; and Federal Communications Commission, "FCC Proposes New Wireless Communications Service in 2.3 GHz Band Implementing Provision of 1997 Appropriations Act," NEWSReport No. DC 96-101, GN Docket No. 96-228 (November 12, 1996).

8. Hundt and Rosston, "Spectrum Flexibility," p. 43.

The commission has also moved to establish a broader range of rights for already licensed spectrum users as shown by the example of commercial mobile radio services (CMRS). CMRS is the new umbrella service category that encompasses for-profit mobile telephone, radio, and paging services that were previously under separate categories.[9] CMRS licensees can now also provide fixed services, such as wireless local loop, along with mobile services.[10]

Loosening Restrictions on Use: Presumptive Flexibility

One approach to enhancing property rights in spectrum is to give FCC license holders a presumptive expectation that requests to introduce new services or employ new technologies will be granted. Currently, the commission evaluates requests for changes in service or technical rules using a vague public interest standard. Under a regime of presumptive flexibility, that standard would be replaced with the assumption that the licensees know best how to use their spectrum. The licensees would be responsible for not interfering with others, or negotiating settlements if interference occurred, but could presume that the commission would approve their request.[11]

Presumptive flexibility would shift the current bias that favors the status quo toward a bias for change. Providers could assume that the FCC would approve any proposed change in service so long as it would not harm other users. (Any negative effects from increased competition should not be considered "harm.") Inevitably, with the relaxation of service definitions and technical rules, some licensees would experience more interference and would be responsible for seeking redress. For this option to pass a cost-benefit test, those costs to licensees would have to be outweighed by gains. Under presumptive flexibility, the FCC would retain much of the management and coordination role it now has, but with a new standard for accepting or rejecting petitions to alter uses of spectrum.

What type of changes might occur if the commission signaled a presumption of flexibility? The FCC allows data transmissions in the vertical blanking interval (VBI) of television signals.[12] Under a regime of presumptive flexibility, the FCC would not declare using the VBI permissible; instead, a license holder would already implicitly have the right to use it and would only need to demonstrate that using the VBI would not interfere with other licensees. Furthermore, a licensee would be able to modify use of the spectrum, such as using the entire channel to broadcast customized newspapers to personal computers in the early morning instead of broadcasting a TV signal.

Band Management Rights: Absolute Flexibility

A second approach to enhancing property rights in spectrum would grant band management rights on portions of the spectrum, restricted only by the requirements that licensees do not violate the rights of other licensees to freedom from interference and that they respect international treaty obligations.[13] Band managers would have the right to allocate the frequencies that their licenses cover to any service they choose, use any suitable technology, and subdivide their rights either by frequency or within a geographic area. The band manager would in essence exert the control over the designated band that the FCC currently exercises over all nonfederal spectrum.

How band management rights might work is illustrated by applying it to a current allocation. For exam-

9. Kobb, *Spectrum Guide*, p. 102.

10. Federal Communications Commission, "FCC Votes to Permit Flexible Service Offerings in the Commercial Mobile Radio Services," NEWSReport No. DC 96-61, WT Docket No. 96-6 (June 27, 1996).

11. Department of Commerce, *U.S. Spectrum Management Policy*, pp. 57-62.

12. Kobb, *Spectrum Guide*, p. 97.

13. The New Zealand government embraced band management rights in the Radiocommunications Act of 1989. The management rights can be retained by the Crown or sold to private entities. "A key characteristic of management rights is that they carry with them no requirement that limits use to any specific telecommunication or broadcasting application. Spectrum rights are also freely tradeable, and can be reconfigured to suit the particular needs of band managers where necessary." Band mangers must still comply with any international obligations that the New Zealand government has entered into. See New Zealand Ministry of Commerce, "Summary of Public Submissions on the Future Management of the Radio Spectrum Between 68 MHz and 174 MHz," July 1995 (available at http://www.govt.nz/ps/min/com/rsp/dp2a.html), p. 3.

ple, under a current FCC license, a multipoint distribution service (MDS) provider is authorized to offer wireless cable television services only. Turning that MDS license into a band management right would eliminate that restriction, allowing the MDS provider—now effectively the spectrum owner—to decide to stop providing wireless cable services and instead provide a wireless local loop for telephone service, for example, or any other suitable business that does not violate the rights of other licensees or international treaty obligations. The licensee would also be free to sell or lease spectrum without first obtaining the FCC's approval.

Band management rights can be particularly effective in portions of the spectrum that are unencumbered with current users—typically, the higher-frequency portions of the spectrum where technology is less developed and potential uses are more limited, at least in the near term. Establishing band management rights could encourage licensing of those upper bands and thereby promote the type of research and development needed to be able to put the bands to productive use. One argument for caution about which bands should be licensed, and when, however, is the possibility that speculators could warehouse those upper bands until the time the frequencies could be productively used. Such warehousing is less likely if the band management rights are assigned by auction, however, because few speculators would choose to tie up funds in assets that will generate revenue only at some uncertain point in the future.

Limited-Term Licenses

Because presumptive flexibility and band management rights would represent a large and relatively untested increase in private control over the radio spectrum, the FCC could temper those reforms by auctioning spectrum licenses for a limited term with the expectation that a license would be reauctioned when it expired. The owners of limited-term licenses could still use their spectrum as other licensees do, but they would be limited in how long they had control over their bands of spectrum.[14]

Creating a right to use spectrum that is limited in time would probably have a negative effect on the efficiency of spectrum use: firms would probably not have the incentives to make the optimal amount of fixed investment in developing the spectrum if they cannot capture the fruits of their investments. Disincentives would be strongest as the license expiration date approached and in cases involving large up-front investments that could not easily be transferred to another licensee. Offsetting the effect of those disincentives would be the opportunity the FCC would have to reconfigure the spectrum blocks when the license expired. Alternatively, the FCC could retain the authority to reconfigure spectrum blocks in cases in which transaction costs would prevent the market from doing so.

Extending the Scope of the Market

A second major area of reform would increase the amount of spectrum managed by the market.[15] Whatever the degree of property rights, market mechanisms can work only where rights have been established. Consequently, the extent to which control is established over previously "unowned" spectrum will determine the scope of the market in allocating spectrum. Some spectrum is currently considered unowned because it is allocated to various shared or nonfederal public uses. Other spectrum is unowned simply because rights to it were never assigned.

Specifying who has control over each bit of nonfederal spectrum could increase its social value. Newly defined "owners" would have incentives to put the frequencies they control to their highest-value uses. As with other reforms that grant more control, however, a drawback could be increased interference with other licensees and the costs they would incur in identifying, proving, and remedying harm. Moreover, market failures could yield too little spectrum for some uses if the scope of the market extended to the entire spectrum. The framework of block allocation may arguably miss opportunities to increase the private value of the spectrum, but it may provide the best structure to protect the

14. In the United Kingdom, TV Channel 3 licenses were auctioned for a 10-year term with the expectation that they would be reauctioned when they expire, but it is too early to glean much from that case study. See Congressional Budget Office, *Auctioning Radio Spectrum Licenses* (March 1992), pp. 13-15.

15. Support for exhaustive licensing can be found in Progress & Freedom Foundation, "The Telecom Revolution," pp. 65-67.

social value of spectrum in uses undervalued by the market.

Introducing Market Mechanisms to Manage Shared-Band, Unlicensed, and Public Safety Spectrum

The case for having the government allocate spectrum for shared, unlicensed, and public safety uses holds that the market fails to recognize the value of those services to society and that, accordingly, a market-based system of spectrum allocation would fail to provide enough spectrum for those purposes. Even if society is better off letting the government decide how much spectrum to allocate for those uses, however, gains in efficiency may still be realized by extending marketlike incentives to the management of that spectrum.

The difficulty of allocating efficient amounts of spectrum for shared, unlicensed, and public safety uses arises from several market failures. Some shared uses may produce positive social outcomes that are not priced in the market; for example, amateur radio operators have provided vital communications links with areas struck by natural or man-made disasters. In other cases—for example, the spectrum set aside for such unlicensed uses as garage-door openers or local computer networks—the cost of users banding together to buy spectrum in the market may be prohibitive, even though its collective value to those users would be high enough to justify the purchase. In the presence of such market failures, allocations made by a centralized allocator may more nearly maximize the social value of the resource.

Some proposals to reform spectrum management seek to overcome, or at least lessen, the market failures in new ways that would maintain the flexibility of market mechanisms. The Spectrum Reform Discussion Draft, for example, suggests that private organizations be created to manage the spectrum allocated for some shared and unlicensed uses. Those organizations, which could be modeled on the private frequency coordination that is used to allocate frequencies at construction sites or among factories using wireless communications, would be vested with rights similar to those of an individual license holder.[16] For the bands allocated to amateur radio, an existing or new association of amateur radio users could be endowed with the spectrum now allocated for that use and manage the bands for the benefit of its members. The association could qualify licensees, set technical standards, and represent its members in any market transactions to buy, sell, or trade spectrum. Likewise, a group of manufacturers of radio equipment could manage spectrum currently allocated for unlicensed uses.[17] Those groups could also eventually become the "owners" of the spectrum they manage.

The property rights approach to spectrum management need not be confined to private uses. Another new management tool, which is also included in the Spectrum Reform Discussion Draft, would grant the states bands of spectrum allocated to public safety services.[18] Doing so would shift the burden of weighing the needs of public safety users against other spectrum users from the federal level to the state level, allowing each state to respond more flexibly to its particular needs. A densely populated state could choose to purchase extra spectrum or additional capacity from a commercial provider, and a sparsely populated state could choose to sell off unneeded bands of spectrum.[19]

In effect, providers of public safety services would no longer be given a free license. Instead, states would be endowed with a one-time transfer of the spectrum that is now allocated to public safety providers. If the needs of those providers for spectrum increased in the future, they would not petition the FCC but would instead purchase spectrum or additional capacity from commercial providers.[20] The FCC might still have a role to coordinate interstate uses, settle interference disputes between the states, and manage bands shared with nonpublic safety users, at least in the near term,

16. *Congressional Record*, May 9, 1996, p. S4930; Nathan Associates Inc., *Methods for Assigning Licenses of Newly Allocated Spectrum for Private Wireless Communications* (report prepared for the Private Wireless Communications Coalition, July 1995), p. 3.

17. For one of two unlicensed PCS bands, the FCC designated an unlicensed equipment manufacturers' association as the frequency coordinator.

18. *Congressional Record*, May 9, 1996, p. S4930.

19. The FCC tentatively endorsed the purchase of commercial services by public safety users. See Federal Communications Commission, *Notice of Proposed Rule Making*, NT Docket No. 96-86, FCC 69-155 (adopted April 5, 1996), p. 32, paragraphs 89 and 90.

20. The costs of such additional capacity might be lower than seen in today's wireless markets, to the extent that reforms reduce the artificial scarcity that drives prices up in certain bands.

but the overall allocation of public safety spectrum nationwide would no longer be driven by the needs of the most densely populated states.

The current users of the shared, unlicensed, and public safety bands of spectrum have raised objections to that approach. For example, many users of shared bands do not think they can compete in an open market for additional spectrum. (Some, however, do not object to paying for additional spectrum through user fees.[21]) Some public safety users feel their chances of acquiring additional spectrum are better with the FCC than with their state legislature.

The reforms mentioned above attempt to minimize the market failures associated with shared-band, unlicensed, and public safety spectrum but are unlikely to eliminate them. For example, even an association of amateur radio users would face some transaction costs in ascertaining the desires of its members for access to additional frequencies. Consequently, whether the above reforms would lead to an increase in efficiency is not certain. The extent to which the reforms can deliver on their theoretical promise will remain unknown unless they are put into practice, perhaps on a partial or trial basis.

Assigning Rights with Overlay Licenses

Overlay licenses can be an effective tool for expanding the reach of the market by assigning rights to currently unused spectrum. Proposals for such licenses recognize that although the spectrum is fully allocated, much of it that could be used at a given moment now lies fallow. For example, much spectrum is left idle in "guard bands" to prevent interference between licensees or allocations. Other frequencies are held in reserve for future licensing. Also, users of fixed-point to fixed-point spectrum, such as microwave links, typically use their allocation in only a small geographic portion of their service area.

As discussed in Chapter 4, an overlay license authorizes the use of any unused portions (sometimes called white space) of a band of spectrum and also provides some residual rights to the frequencies already assigned to incumbent users.[22] Some bands may include enough white space to let a new licensee work around the incumbents and start providing a partial service quickly, especially if the overlay license gives the holder increased flexibility in selecting the type of service to provide and the technology with which to deliver the service. New technologies, such as code division multiple access, greatly enhance the possibility that an entrant and incumbent can coexist in a given band of spectrum, thus allowing new services to be provided quickly. In other cases, launching a significant new service or otherwise making use of currently unused spectrum would require displacing some or all of the incumbent users.

The main policy issue associated with overlay licensing is the appropriate division of rights between overlay licensees and incumbent licensees under various circumstances. The residual rights to encumbered spectrum may give the overlay licensee the right to move some or all incumbents from their existing frequencies either immediately or after some period of time, with or without a requirement to pay some level of compensation; or they may protect all incumbent licensees indefinitely, giving the overlay holder only the opportunity to negotiate voluntary relocations with the incumbents.

To achieve the most economically efficient outcome when an overlay license is granted—that is, create the highest surplus of benefits over costs—one of three things should happen: the entrant accommodates the incumbent user, the incumbent user relocates (on or off the spectrum), or the incumbent user ceases operation. For example, if the incumbent user's service is more valuable than the entrant's proposed service, then the incumbent should continue using the spectrum, and the new overlay licensee should accommodate that use. If the incumbent's spectrum is more valuable to the entrant, then efficiency requires the incumbent to stop using that particular band and relocate to another band of spectrum, relocate to a nonspectrum replacement (such as fiber-optic cables), or terminate operations, depending on the relocation costs and the value of the operations.[23]

21. See Nathan Associates Inc., *Methods for Assigning Licenses.*

22. Overlay licenses may be impractible in many shared bands. When the incumbent users share a band of spectrum—for example, for amateur radio or unlicensed use—there is currently no entity to which the incumbents' rights can be assigned.

23. Peter Cramton, Evan Kwerel, and John Williams, "Efficient Relocation of Spectrum Incumbents" (University of Maryland and the Federal Communications Commission, September 30, 1996).

Although the wrong initial distribution of rights between overlay licensees and incumbent users can lead to an inefficient outcome, giving the new entrants the right to move incumbents if they compensate the incumbents for the costs of the move leads to an efficient outcome in most cases.[24] The reason is that the incentives facing the entrants under those circumstances coincide with the efficient outcome in most of the possible configurations of relative spectrum values and relocation costs.

The distribution of rights between overlay licensees and incumbent users also raises equity issues. For example, giving entrants the right to relocate incumbents may be efficient but may nonetheless impose costs on the incumbents, and those costs may not be fully captured in any required compensation from the entrant. The FCC confronted that issue in allocating spectrum for broadband PCS, which was encumbered by thousands of users of fixed-point to fixed-point microwave services. In that case, the FCC chose to modify the right to move with compensation by delaying it three to five years, during which time the incumbent microwave licensees have the right to stay. That mix of rights attempts to balance the efficiency goal of clearing the spectrum quickly for a valuable new service and the equity goal of ensuring that some of those gains in efficiency are shared with the former users of that band of spectrum.

Reforming the Management and Use of Federal Spectrum

Federal spectrum users operate in a world that is insulated from many of the market forces that private users face, or could face after reform. This third broad area of reform would introduce some market-based mechanisms into managing the federal spectrum bands. Those mechanisms include direct private reimbursement of public relocation costs, private management of public spectrum bands, purchase of commercial telecommunications services, and leases or sales of federal spectrum to and from both public and private users. Those reforms appear promising from an efficiency perspective; they are untested, however, and could have unintended consequences.

A fundamental question raised by the prospect of such reforms is how much spectrum the federal government should use and how changing circumstances might affect that amount. For example, the amount of spectrum reserved for the federal government could be fixed at its current levels, and all future demands could be met from that pool. That pool could also be reduced to make more spectrum available for nonfederal users, as was the case with the reallocations made in the Omnibus Budget Reconciliation Act of 1993 and the proposal contained in the Spectrum Reform Discussion Draft. Alternatively, the federal government could reserve no spectrum and become an active participant in future spectrum markets. It could sell excess spectrum at market prices, much as it does with other surplus goods. As new demands for spectrum arose, the federal government could purchase spectrum from a market as it does other inputs, such as steel. In between those options are other ideas, including the reforms analyzed here, that would substitute private management of government communications systems for direct agency control over the spectrum.

The Department of Commerce and Related Agencies Appropriations Act of 1997 required federal agencies to pay a modest fee for using spectrum.[25] Although those fees are likely to be much less than the value of the spectrum to nonfederal users, they nonetheless create a cost of using spectrum for federal agencies and thus are an important first step in introducing decentralized incentives for more efficient use of spectrum. Other proposals build on those incentives.

Private Reimbursement of Federal Relocation Costs

One proposal made during the 104th Congress would have authorized private parties to reimburse federal

24. The exception is the case in which the value of the spectrum to the entrant is greater than the value to the incumbent but less than the cost of relocating. In that case, if bargaining broke down, the incumbent would stay even though terminating the incumbent's current use of the spectrum would be more efficient. The efficiency losses in that case, however, would be relatively small—equal to the difference between the spectrum's value to the entrant and to the incumbent. By hypothesis, both are less than the cost of relocating.

25. See *Congressional Record*, September 28, 1996, pp. H11654 and H11852, for the text of the legislation and conference report, respectively.

users directly for the costs of vacating a band of spectrum.[26] Thus, the approach taken in the personal communications services auctions in which the new licensees have to pay the incumbents' relocation costs would also apply to the new licensees of bands transferred from federal to nonfederal use. The proposal would require legislation allowing those relocation payments to bypass the annual appropriation process.[27]

Allowing nonfederal users to reimburse federal users for relocation costs has three advantages. First, direct reimbursement should make incumbent federal users more willing to move, since they would not have to fight in their annual budget appropriations for the money to relocate. Second, private entities would have an incentive to search the federal spectrum for lightly used or inexpensively relocated bands to develop commercially. That process would generate information that would make the reallocation costs lower than they would be under an administrative or legislative mandate. Third, only the incumbent federal users that are truly economical to relocate would be cleared out of their existing bands.[28] That point rests on the fact that a new licensee would pay the relocation costs and would relocate federal users only when it was to its economic benefit to do so. A new licensee who found it less expensive to work around an incumbent federal user would be free to do that.

Private Management of Federal Bands

A separate policy to introduce market incentives into federal spectrum management would be for a nonfederal entity to manage the communications services of a federal band, with the right to sell some or all of the excess capacity generated from increased efficiency in spectrum use. For example, a private company could manage the mobile communications for a federal law enforcement agency and sell the excess capacity created by replacing an analog communications system with a digital one. The same advantages of allowing nonfederal users to reimburse federal users would apply. With the mechanism in place for a private entity to capture some of the value of the gains in efficiency from investing in new equipment, that entity would have an incentive to search for the federal spectrum that is least efficiently used. A federal agency should be willing to enter such an agreement if doing so could increase the effective capacity of its wireless communications system, especially if the agency would have trouble getting money for equipment upgrades or additional spectrum.[29]

Purchase of Private Telecommunications Services

Another approach would be to reinvigorate the current policy that encourages federal agencies to buy telecommunications services from private companies rather than develop their own proprietary systems.[30] Under that approach, an agency would contract for a service—and, indirectly, for the spectrum needed to provide it—without directly controlling bands of spectrum. The growth in the types of telecommunications services provided by the private sector will expand the opportunities to carry out that policy. For example, federal law enforcement agencies need radio channels for communications during crises. Instead of reserving a number of channels for that purpose, they could buy a commercial service on a contingency basis that would give them priority access to the spectrum in the event the channels were needed. The channels could then be productively used by others when not needed for federal law enforcement.

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26. Larry Irving, "Spectrum Management: A Balancing Process," *IEEE Communications Magazine* (December 1995), p. 46.

27. Department of Commerce, National Telecommunications and Information Administration, *Spectrum Reallocation Final Report*, NTIA Special Publication 95-32 (February 1995), notes that private reimbursements to federal users would speed the reallocation process directed by OBRA-93.

28. In some cases, the optimal outcome would be for the federal user to terminate what it was doing, but that policy would still be efficiency enhancing.

29. Department of Commerce, *U.S. Spectrum Management Policy*, p. 67.

30. "In order to emphasize the Government's proper role as a user, any proposal designed to provide needed telecommunication service, which requires the Government to perform [the design, engineering, system management or operation, maintenance, or logistical support] shall be adopted only if commercial service is: a) not available to the user during the time needed; b) not adequate from either a technical or operational standpoint; or c) significantly more costly." See Department of Commerce, National Telecommunications and Information Administration, *Manual of Regulations and Procedures for Federal Radio Frequency Management* (May 1989, revised through May 1990), Chapter 4.

Leasing of Federal Bands

The federal government could also lease its spectrum to the private sector for a limited term. That approach would be a moderate version of a more extreme proposal to make the government a full participant in spectrum markets, with federal agencies actively selling and buying spectrum to and from each other and private entities. Leasing would have the advantage of putting unused federal spectrum to productive use now while reassuring federal users that they will still have access to spectrum in the future.[31]

Conclusion

Overall, introducing marketlike incentives into federal spectrum management is likely to improve the efficiency with which those bands are used. The common thread running through the above approaches is the goal of allowing both the incumbent federal users and potential private users to share in the gains from using the spectrum more efficiently, thereby giving the private sector incentives to generate information about which federal bands could be more valuable in other uses.

A cautionary note about introducing market forces into federal spectrum management is that the various reforms cited are untested. Government users of spectrum operate under a different mix of incentives than do private users. The reforms discussed above attempt to change those incentives so that federal users are more willing to participate in efficiency-enhancing reallocations of spectrum. Although introducing market forces into private resource management has a long history and is well analyzed, the same cannot be said about introducing market forces into government resource management. If the reforms mentioned above are implemented, they should be closely monitored for unintended consequences and perverse outcomes.

31. Department of Commerce, *U.S. Spectrum Management Policy*, p. 118.