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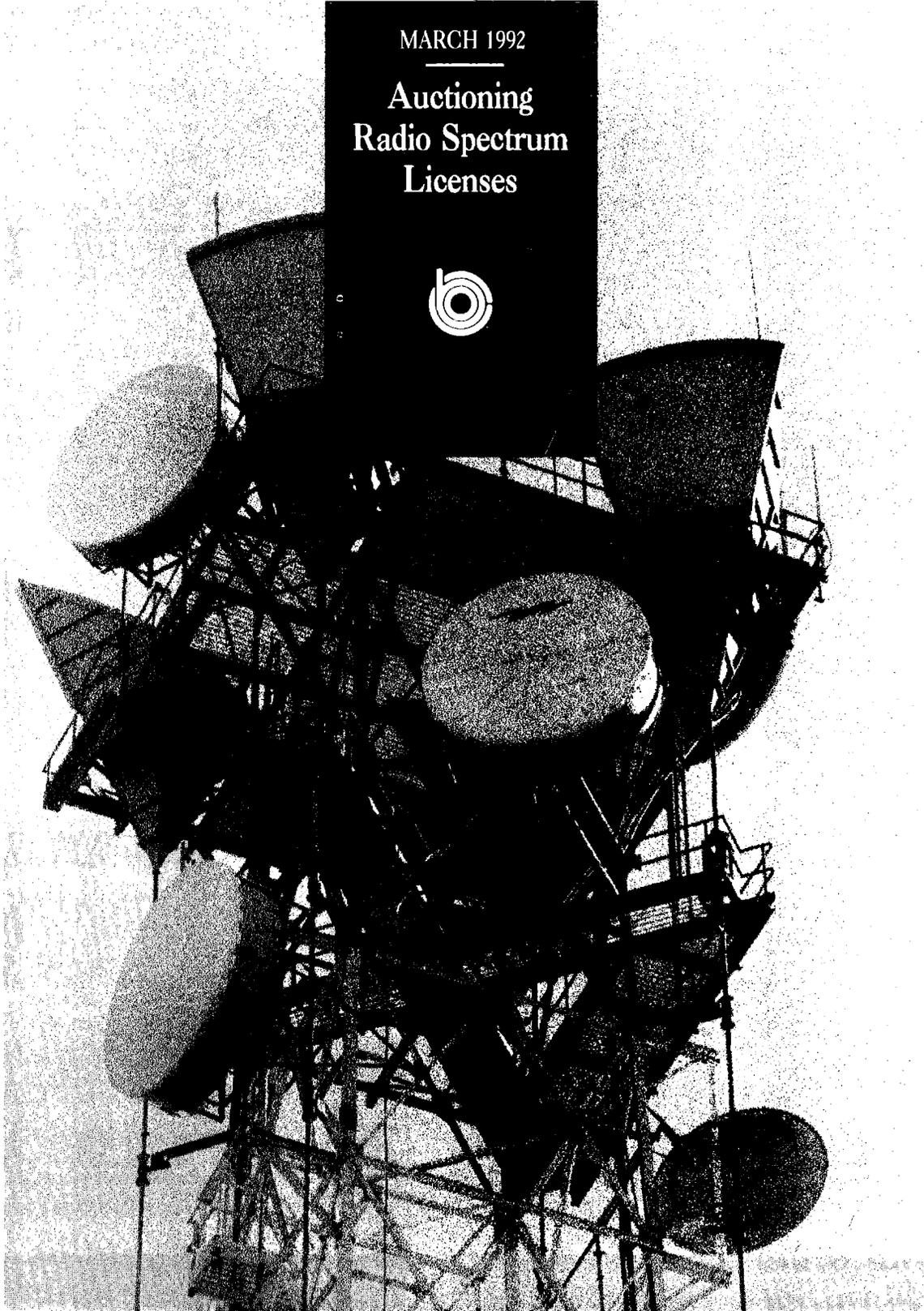
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**CBO**

**STUDY**

MARCH 1992

**Auctioning  
Radio Spectrum  
Licenses**





# **AUCTIONING RADIO SPECTRUM LICENSES**

The Congress of the United States  
Congressional Budget Office

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**NOTE**

Cover photo: Microwave transmitter at Western Union in Washington, D.C., 1975. From the *U.S. News & World Report* Collection, Prints and Photographs Division, Library of Congress.

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# Preface

**A**uctioning, or competitive bidding, is frequently proposed as an alternative in assigning licenses permitting the private use of the radio spectrum. In response to a request by the House Committee on the Budget, this study examines the arguments for and against auctioning licenses to use the radio spectrum and provides an estimate of the revenues that an auction might raise. In keeping with the Congressional Budget Office's (CBO's) mandate to provide nonpartisan analysis, no recommendations are made.

Victoria A. Greenfield and David Moore of CBO's Natural Resources and Commerce Division wrote the report under the supervision of Jan Paul Acton and Elliot Schwartz. Michael Crider provided research assistance. A meeting of experts from industry, academia, and government held in November 1991 provided useful information. Eric Toder and John Webb of CBO offered insightful comments and criticism. The authors wish to thank Mark Bykowsky, James Gattuso, Joseph Gattuso, Henry Geller, Edward Greenberg, Joel Gross, Thomas Hazlett, Charles Jackson, Evan Kwerel, Molly Macauley, Bridger Mitchell, Vernon Smith, and David Wye for their helpful comments.

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Robert D. Reischauer  
Director

March 1992



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# Summary

**T**he radio spectrum is that part of the electromagnetic spectrum that is used for communications. The right to use the airwaves is an indispensable ingredient in producing such private goods as mobile telephone service and radio and television broadcasting, and such public goods as law enforcement and national defense communications. Currently, the Federal Communications Commission (FCC) allocates the radio spectrum to specific uses, and then assigns licenses to specific parties outside the federal government by comparative hearings or lotteries. Both of these processes of assignment have drawn criticism as being too costly to society and unfair to the public. Auctioning or competitive bidding for new license assignments is frequently proposed as an alternative method of assignment.

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## An Estimate of Auction Revenues

The Congressional Budget Office (CBO) estimates that an auction of licenses to use the spectrum could raise \$1.3 billion to \$5.7 billion under a set of assumptions that limit some of the uncertainties associated with an auction. Unconstrained by these base-case assumptions, revenues could vary outside the range depending on the frequencies made available, the use to which they were allocated, and a variety of other conditions surrounding an actual auction.

## The Base-Case Assumptions and Economic Context

The base-case assumptions stem from recent Administration budgetary initiatives, legislative proposals, and current FCC proceedings. The base case assumes that a band of 50 megahertz (MHz) between 1,700 MHz and 2,200 MHz on the radio spectrum is allocated to advanced land-mobile services, which constitute the next generation of communications services that will build on the success of the cellular telephone industry. Two licenses of 25 MHz each are offered at auction on either a national or local basis. Each of the licenses is assigned nationally if the bid for the national license is greater than the sum of bids for local licenses granting access to the same frequencies. The licenses offered under the base case grant the same property rights as current licenses. The licensee has exclusive use of the frequencies that are auctioned, can expect FCC approval in selling the license to another qualified party, and has a very high expectation of renewal upon expiration. The license will not be reaucted when it expires. The base-case auction is open to all bidders who would qualify to hold an FCC license under current law. The federal government conducts the auction as a first-price sealed bid process.

A key assumption of the base case is that the licenses assigned by auction will be allocated to advanced land-mobile services. Advanced land-mobile services are expected to provide higher-quality and lower-priced voice, data, and even video communications to a

larger segment of the population. The success of the cellular telephone industry indicates the potential market for these services. Since 1985, industry revenues have increased from \$482 million a year to \$5.7 billion a year. As of the end of 1991, more than 7.5 million people subscribed to cellular telephone services. Although other new private uses of the spectrum, such as digital radio broadcasting, have market potential, it is generally agreed that advanced land-mobile services are the most valuable private use for new assignments of spectrum.

FCC administrative decisions and a lack of additional spectrum assignments have shielded the suppliers of cellular telephone services from competition and allowed them to maintain relatively high prices. There are only two suppliers of cellular telephone services--a duopoly--in each of more than 700 metropolitan statistical areas (MSAs) and rural statistical areas (RSAs). Financial analysts anticipate that cellular telephone companies will earn rates of return on investment in physical capital of 40 percent to almost 100 percent as they exploit the combination of a desirable service and the freedom from serious price competition permitted by the duopolistic market structure. The expectation of above-average profits, or rents, influenced both the prices paid for cellular telephone franchises in recent corporate acquisitions and the stock values of the companies providing cellular telephone services.

Proposals to make additional spectrum available for private licenses have often noted the bright prospects of new land-mobile services and the potential benefits to consumers of creating more competition in providing these services. The FCC is currently moving toward a new allocation of frequencies for land-mobile services in its personal communications services (PCS) proceedings. PCS is based on the concept of a call linking people, not places. If more spectrum is made available, technologies under the PCS umbrella could provide a wireless network linking pocket-sized mobile phones, notebook computers, and small facsimile machines.

Advocates of new spectrum allocations for PCS foresee multibillion dollar markets in the next decade. A broad range of private businesses hope to participate in these markets.

By some accounts, PCS could compete seriously with current cellular services. Firms expressing interest in PCS include the local telephone companies that were formerly part of the Bell System, new cellular telephone companies, providers of long distance telephone service, computer and telecommunications equipment manufacturers, and a variety of start-up businesses. The bidders in an auction for new land-mobile licenses would be drawn from this pool of firms. Nevertheless, questions remain concerning the economic prospects of PCS. Firms entering the market for new land-mobile services face major uncertainties about the acceptance of their products and the pressure that competition will exert on future rates of return. The range of the CBO estimate of auction revenues reflects these uncertainties.

### **The Base-Case Range**

The low end of CBO's estimate of auction revenues, \$1.3 billion, translates into \$3.50 per person for each license for the 193 million people in MSAs as of 1990. This estimate is based on the prices accepted by specialized mobile radio (SMR) license holders in selling their licenses to Fleet Call, Inc.--a company that sought and obtained FCC approval to provide land-mobile services similar to cellular telephony. Before Fleet Call's initiative, the frequencies allocated to SMR were used for radio dispatch services, such as taxicab fleets. Although profitable, this market is smaller and more competitive than the cellular market that Fleet Call plans to enter. The licenses sold to Fleet Call for \$210 million will allow the company to enter a market of 60 million people in six metropolitan areas. One can view these transactions as representative of the value of a license for land-mobile services in a very competitive market. But the estimate is not a perfect benchmark. The licenses that have been sold include fewer

megahertz of frequency than the base-case licenses. In addition, the acquisition prices included going concerns and facilities as well as license values. The markets in which Fleet Call intends to operate, however, are better than average.

The high end of the range of the CBO estimate for auction revenues is \$5.7 billion, or \$15 dollars per person. The high end of the range is based on a financial simulation developed by Morgan Stanley & Co. of new entry into land-mobile services. The simulation shows that if a firm entering the market is willing to accept a rate of return of 13 percent to 15 percent after taxes, it could afford between \$35 and \$37 per person in capital investment and early operating losses to get started. The capital investment necessary to provide cellular service ranges from \$10 to \$15 per person. If initial operating losses range from \$7 to \$12 per person, there is an approximate gap of \$15 per person between the sum of a system's cost and initial operating losses and the maximum amount a firm entering the market could afford and still obtain the target rate of return. One can view this \$15 per person as the maximum amount that a firm entering the market would pay for a license. The simulation results are used as an upper bound because they reflect a firm's optimism about competition and are modeled on better-than-average markets.

The base-case range of the CBO revenue estimate is far below the values implied by the prices that have been paid for businesses holding licenses to provide cellular services. The stock values of some companies offering these services are also outside the range. For example, in a recent analysis, the National Telecommunications and Information Administration (NTIA) estimated that the total net worth of all current cellular licenses in the United States is between \$45 billion--an estimate based on producers' stock values in early 1991--and \$80 billion--an estimate based on mergers and acquisitions made during 1990

that involved cellular telephone companies. CBO has discounted these high values because it expects that new competition will lower rates of return and therefore bids. The value of frequencies used in the more competitive radio and television broadcast markets illustrates this effect. NTIA estimates that the more than 400 MHz of spectrum allocated to broadcasting were worth only \$11.5 billion based on license sales made in 1990.

Spectrum auctions held outside the United States and estimates by the Office of Management and Budget (OMB) also shed light on the question of how much revenue might be raised by a spectrum auction. In support of the Administration's proposals to auction new license assignments, OMB has estimated revenues just above the CBO range--\$4.5 billion for an auction of 30 MHz proposed in the 1992 budget and \$6.8 billion for an auction of 45 MHz proposed in the 1993 budget. Foreign experiences with spectrum auctions do not provide direct evidence of the revenues that a U.S. auction might produce but suggest that a conservative estimate of revenues may be appropriate. In the two most recent auction cases, New Zealand and the United Kingdom, actual auction revenues fell far short of preauction estimates.

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## Varying the Base-Case Assumptions

The consequences of changing the assumptions underlying the range of the base-case revenue estimate can only be addressed in general terms. The effects cannot be measured with precision because the range is not the product of a formal model. In some cases, however, it is possible to judge whether auction revenues are likely to increase or decrease when a specific assumption is changed.

## Characteristics of What Is Being Auctioned

The base case specifies the characteristics of the commodity that is being auctioned. These include the number of licenses offered, the amount of spectrum each license covers, the area of the spectrum from which the frequencies are drawn, the rights each license conveys, and the option to bid for national and regional licenses as well as for local rights.

The number of licenses available at auction is probably more important than the amount of spectrum each license covers, as long as the license covers enough spectrum to permit a firm to enter the land-mobile market successfully. Increasing the number of licenses offered will increase the number of competitors in the land-mobile market. Potential bidders will offer less for the opportunity to enter a more crowded market. They will anticipate increased price competition and lower rates of return that will lead to lower bids. Small changes in the amount of spectrum per license, however, may have little effect on revenues. A new licensee can establish a successful business by investing in new technologies that do not cost much more than current technology but dramatically increase the information-carrying capacity of a fixed amount of spectrum. A substantial increase in the amount of spectrum each license assigns--keeping the number of licenses and the rights they convey unchanged--would increase auction revenues. However, offering two 50 MHz licenses rather than two 25 MHz licenses would be unlikely to double revenues.

Technology to use the radio spectrum for communications is more available below 2,000 MHz than above. If the FCC clears spectrum for new assignments substantially above 2,000 MHz, revenues are likely to be less than the base-case range of the estimate. Revenues would be lower because the technical risk of establishing a communications service in this area of the spectrum is greater than in lower frequencies. Fewer bidders are likely to ac-

cept this risk. Higher research and development costs that lower expected profits will also decrease auction revenues.

The base case also includes assumptions about the geographic scope of the licenses. The estimate is broad enough to accommodate either a local or national result. Under the base-case assumptions, assignments of frequencies may be divided geographically into local licenses, as are current cellular telephone licenses, or granted as a single national license. If the bid for a national license exceeds the sum of bids for local licenses, the license is awarded nationally. If there are economies of scale in the production of telecommunications services at the national level, a national bid would be expected to exceed the sum of local bids. If, however, the market for a national license is relatively thin--if it attracts fewer bidders than the auction for local licenses--the sum of local bids could exceed a national bid. Economists have found that thin markets tend to generate low revenues. New Zealand's experience with spectrum auctions points to the same conclusion.

The licenses auctioned under the base case grant the same property rights as current licenses. Changing these property rights may change auction revenues, but probably not enough to alter the range of the CBO estimate. For example, changing the expectation for renewal of the license by indicating that it will be reaucted on expiration would have a negligible effect on auction receipts if the expiration date is set in the distant future. The bid for a license is based on the discounted value of expected future earnings. Expected earnings in the distant future are relatively unimportant in the present. However, as the expiration date of a fixed-term license approaches, a reaucting policy could deter investments in new capital and new technology, but competitive market factors would probably intervene. Successful bidders and losing incumbents would have incentives to negotiate capital transfers, and potential entrants would have incentives to innovate. Finally, a reaucting policy would

almost certainly add to the government's costs of administration.

Another way of changing the property right associated with the license is to grant the license holder a spectrum management right. The owner of a spectrum right has more options than current license holders and would probably bid more for this right. A spectrum management right is an extreme example of flexible use of a frequency assignment. The license holder can offer any service--for example, cellular telephone or ultra high frequency (UHF) broadcasting--as long as it does not interfere with other license holders' signals. The frequencies controlled by the holder of a spectrum management right can be subdivided by use or by geographic region and sublet to third parties. Revenues would be decreased by moving in the opposite direction and limiting the flexibility of the license holder to choose technologies and define classes of service within land-mobile communications services. Imposing restrictions on a license will decrease revenues because winning bidders will be more limited in the strategies they can apply to achieve profitability.

### **Auction Processes, Restrictions, and Payment Terms**

A different set of variations on the base-case assumptions could change the auction process, place restrictions on participation, or extend the payment schedule for winning bids. The base case assumes that the government conducts a first-price sealed bid auction. In this process, the winning bidder submits the highest bid, the selling price equals the highest bid, and all bids are sealed. Despite a rich literature describing relationships among auction processes, auction revenues, and economic efficiency, economic theory provides little or no direct guidance for the base-case scenario. When potential collusion among bidders is a concern, the literature suggests that a sealed process is preferable to an open process. However, when the true value of an object, such as a license, is uncertain, the

literature indicates that a more open process is preferred.

Both collusion in bidding and the uncertainty of values could be relevant issues in a license auction. The second-price sealed bid auction might offer a workable compromise. In this process, the winning bidder submits the highest bid but pays a price equal to the second highest bid. A second-price sealed bid auction, however, "leaves money on the table." When the process is complete, it leaves a visible gap between the highest and second highest bids. If this gap is large, as was evident for some licenses in New Zealand, it can be politically embarrassing. Simplicity and the lack of a definitive alternative make the first-price sealed bid auction the preferred option for the base case.

Critics charge that auctions, as opposed to comparative hearings and lotteries, would allow larger firms to dominate the assignment process. Although this charge lacks merit in the face of an active resale market, various remedies, such as, set-asides for small businesses, have been proposed. If local licenses were set aside for small firms, or if the participation of large firms in the auction were limited, both revenues and economic efficiency could suffer. Other alternatives might allow installment payments of winning bids or royalty payments. Both approaches would lower federal revenues in the short run. In addition, royalty payments might reduce the efficiency of services in the land-mobile market.

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## **A Comparison of Assignment Mechanisms**

Proposals to auction licenses for the use of the radio spectrum are not new. Using the market to assign spectrum property rights was suggested as early as the 1920s. Auctioning licenses by the government was discussed as an option for U.S. spectrum management in

the 1950s. Since then, the option has been raised periodically but never carried out. In 1989, New Zealand conducted auctions for spectrum licenses similar to those that the United States could offer, and for broader spectrum management rights. The United Kingdom auctioned the rights to broadcast on Independent Television Channel 3 in 1991. The discussion surrounding proposals to use auctions in the United States, as well as these recent experiences, inform the arguments for and against auctioning as an assignment mechanism. The summary table presents an overview of this comparison.

## Economic Efficiency

Auctioning compares favorably with comparative hearings and lotteries as an assignment mechanism promoting economic efficiency. Once spectrum is allocated to a specific use, the comparison in efficiency focuses on two considerations: is the license promptly assigned to the agent who values it most, and is the assignment process accomplished at the lowest cost to society? Auctioning, however, could present a unique danger in the broad context of overall spectrum management if the prospect of increasing revenues distorts decisions about allocating spectrum.

**Summary Table 1.  
License Assignment Methods Compared**

Method	Efficiency	Fairness	Revenues
Comparative Hearing	Might not assign the license directly to the user who values it most. Secondary markets allow license sales to the users who value them most. Consumes substantial private resources in license-seeking activity and inflicts high administrative and delay costs on society.	Can ensure a specific distribution of licenses. Legal and administrative costs of the process give larger financial interests an advantage.	Revenues limited to license application fees. Total FCC fees for 1991 were \$46.6 million, including renewals and fees for lotteries. New license fees range from \$35 to \$70,000. Comparative hearing fee for a new applicant for land-mobile services was \$6,760 in 1991.
Lottery	A random process unlikely to assign the license directly to the user who values it most. Secondary markets allow license sales to the users who value them most. Less prone to delay than hearings, less prompt than auctions.	Allows all applicants equal opportunity if they can pay the application fee. By awarding licenses to applicants who do not intend to provide services, grants lottery winners a windfall not shared by the public.	Lottery revenues are included in totals noted above. Fees for specific lotteries can be substantial. The digital electronic message service lottery, the 220-222 MHz filing of 1991, drew 60,000 applicants and total fees of \$4.4 million.
Auction	Is likely to assign the license directly to the user who values it most. Should assign licenses more quickly and at a lower cost to society than alternatives.	Gives taxpayers a share of spectrum rents. Can be structured to accommodate small bidders.	CBO estimates an auction of 50 MHz of spectrum for two additional land-mobile licenses could generate between \$1.3 billion and \$5.7 billion in fiscal years 1993 through 1995.

SOURCE: Congressional Budget Office.

As long as the FCC allows licenses to be transferred in post-assignment sales, they will tend to migrate to the users who value them most, regardless of the mechanism used to assign them initially. Auctioning, however, is likely to accomplish this objective more quickly at a lower cost to society. A 1985 FCC study estimated that the cost of an auction would be only 15 percent of the cost of a comparable lottery or comparative hearing. The same study concluded that the processing time for an auction would be one-quarter of that for a lottery and one-sixth of that for a comparative hearing process. New Zealand's entire auction process took 13 months to issue numerous licenses for radio, UHF television, cellular telephones services, and broad spectrum rights. In the previous two years, a comparative hearing process was successful in issuing only a handful of television licenses. In the United States, the large profits enjoyed by some winners of cellular telephone lotteries have attracted tens of thousands of entrants to every new license opportunity. Lotteries, initially applauded for their speed, have bogged down and become more costly to society.

Assigning licenses by auction is likely to raise more federal revenue than lotteries or comparative hearings. But with this prospect comes a danger that the demand for revenues will distort spectrum management decisions and lead to inefficient use of the spectrum. For example, auction revenues may be higher if the supply of licenses is restricted, but consumers, as well as the nation's economy, may be better off by making more licenses available quickly. In the same vein, some uses of the spectrum, such as allocations to household electronic devices, do not require exclusive licenses and are thus not a source of auction revenues. If the prospect of revenues were to influence the allocation of spectrum between exclusive and open uses, overall efficiency might not be served.

## Fairness

Fairness is a much-discussed issue in evaluating alternative mechanisms for assignment. A concept of fairness underlies the argument sometimes made against auctioning by broadcasters; namely, that a license to use the radio spectrum is granted in exchange for socially responsible behavior on the part of the licensee. The United Kingdom's experience illustrates, however, that a public interest standard can be combined with assignment by auction. Under the United Kingdom's auctioning formula, regulators can reject the highest bid for a license if the bidder's plan fails to meet financial practicality or program quality standards. In any case, under U.S. law all licenses to use the spectrum are granted under a public interest standard, regardless of how they are initially assigned.

Auctions are likely to be as fair as either of the alternatives in sorting through the contending claims for a specific license. Lottery advocates complain that the hearing process unfairly grants advantages to large firms able to endure and pay for lengthy administrative proceedings. Fairness is also a theme raised by auction advocates in denouncing the profits randomly bestowed on the winners of cellular telephone lotteries. Auctions are uniquely fair to the taxpayer because they grant the public a share of the returns gained by private parties in selling services requiring a piece of the radio spectrum. The major equity argument against auctioning is that it grants licenses to those who have the resources to pay for them. Although that is true, the secondary market for licenses provides compelling evidence that licenses eventually reach those most willing and able to pay for them, regardless of how they were initially assigned. Nevertheless, auctions can be designed to accommodate set-asides for small businesses or to meet other social concerns.

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## Conclusion

The central objectives of U.S. policy for spectrum management include ensuring efficient and effective use of the radio spectrum that is consistent with the public interest and available to consumers at reasonable charges.

Auctioning license assignments can play a role in improving the ability of the U.S. spectrum management system to meet these objectives. This role, however, will be limited unless the process by which new frequencies are made available for new uses is streamlined and license holders are permitted flexibility in responding to changing technologies and consumer demands.

# Introduction

**T**he right to use part of the radio spectrum is a valuable economic and social commodity. The federal government grants that right by license, which in turn is a requirement in producing a wide variety of public and private goods. Operating revenues from domestic telecommunications services are expected to reach \$170 billion in 1992, and shipments of telephone and radio communication equipment could be worth more than \$70 billion during the same year.<sup>1</sup> Radio frequency licenses are necessary for radionavigation, public safety and satellite communications, and meteorology. In the future, radio frequency assignments will be vital to the economic success of small and highly portable telephones and computers, higher quality television and radio broadcasts, and wireless networks connecting computers, facsimile machines, and telephones.

Laws passed in the 1920s and 1930s that culminated in the Communication Act of 1934 made the federal government responsible for the management of the radio spectrum.<sup>2</sup> These laws created federal ownership of the spectrum in all but name, and were explicit in stating that private licensure would not grant

ownership. Instead, licenses would convey the right to use the radio spectrum under a public interest standard established by the law and administered with broad latitude by the Federal Communications Commission (FCC). Although broadcasters generally expect to have their licenses renewed, periodic renewal is not a legal right. The FCC usually permits transfer of license rights with the sale of a licensee's assets, if the buyer meets the basic standard required to hold a license.<sup>3</sup> Debate among scholars persists about whether, in the early days of broadcasting, de facto federal ownership and the limitation on private ownership were necessary to curb harmful signal interference, or whether industry and government created the mechanisms to protect the profitability of "homesteading" broadcasters who had already established themselves.<sup>4</sup>

The structure that was created, while stopping short of granting private property rights of spectrum ownership, allowed broadcast pioneers access to the radio spectrum in much the same way as early homesteaders claimed western lands. Regulators were forthcoming with new areas of the spectrum when private investors required it. Therefore, the U.S.

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1. Department of Commerce, International Trade Administration, *Industrial Outlook 1992* (January 1992), pp. 28-1, 29-1, and 30-1.

2. Thomas Hazlett, "The Rationality of U.S. Regulation of the Broadcast System," *Journal of Law and Economics*, vol. xxxiii, no. 1 (April 1990), pp. 133-175, reviews issues surrounding the development of federal regulation of the radio spectrum.

3. Some aspects of the legal standing of a private license holder's property right continue to be the subject of judicial action. For example, the courts have not yet decided whether a license can be used as collateral to obtain a loan. The issue above indicates the economic value of the radio spectrum. Ellen Joan Pollock and Arthur S. Hayes, "Boston's Gaston & Snow Folds, Reforms," *The Wall Street Journal* (September 30, 1991), p. B8.

4. Hazlett, "The Rationality of U.S. Regulation of the Broadcast System," pp. 135-143.

public has enjoyed the benefits of wireless communication and a diversity of suppliers unrivaled by those in any other nation. This success, however, brings with it the concern that usable bands of spectrum may be in short supply. Consequently, both the Administration and the Congress have considered legislation that would make appropriate parts of the radio spectrum available for new uses.

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*Technological  
advances have opened  
the possibility that  
new wireless  
communications services  
will contribute to the  
growth of the economy.*

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The federal government can use market mechanisms in fulfilling its responsibility to manage current and anticipated uses of the radio spectrum. When auctions, or competitive bidding processes, are used to assign new licenses, they can raise federal revenues and play a role in improving the efficiency of spectrum use and management. Auctioning makes it likely that the user who places the highest value on a license will receive it directly. Auctioning is also likely to lower the costs to society of assigning licenses, including those of government administration, private efforts to win licenses, and delays in assigning licenses. Moreover, the auctioning of licenses to private users of spectrum could generate substantial revenues, providing compensation to the public for the private use of the spectrum resource.

Estimating the revenues that could be produced by using auctions as a tool of U.S. spectrum management policy is the primary focus

of this study. The study also compares the fairness and economic efficiency of auctioning with that of current assignment mechanisms, namely comparative hearings and lotteries. It should be clear from the outset, however, that other changes in U.S. spectrum management policy could be as, or more, important in promoting economic efficiency. Box 1 reviews the larger context of U.S. spectrum management policy and the potential of increasing society's benefits by changing the overall allocation system of the radio spectrum and the rights granted by a license to use it.

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## A Spectrum Shortage?

The demand for radio licenses currently outstrips the supply of spectrum in many areas of use. Many experts, however, believe that if the spectrum was priced properly and allocated more efficiently, the apparent shortage would disappear.

## What Is the Radio Spectrum?

The radio spectrum is the array of electric and magnetic waves arranged in the order of their frequency, defined as the number of times that their peaks pass through a fixed point over a specific period of time.<sup>5</sup> A wave completing one cycle per second is described as having a frequency of 1 hertz (after early radio experimenter Heinrich Hertz). The term radio spectrum is used to describe a subset of the larger electromagnetic spectrum, which extends below the radio spectrum to very low frequency infrasonic waves, and above the radio spectrum to extremely high

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5. Office of Technology Assessment, *The 1992 World Administrative Radio Conference: Issues for U.S. International Spectrum Policy* (November 1991), Chapter 2; and David B. Hack, *Release of Government-Held Radio Spectrum for Non-Government Use*, Congressional Research Service Issue Brief (September 20, 1991), pp. 2-4. Each provides an overview of technical issues concerning the radio spectrum. The discussion herein draws from both.

**Box 1.**  
**Allocation and Assignment of the  
 Radio Spectrum, and Economic Efficiency**

Economists generally agree that the spectrum resource is most efficiently divided among uses and users when frequencies are granted to the combination of public and private activities that produce the greatest net value for society. Application of this seemingly simple criterion for an economically efficient division of the spectrum requires an examination of the entire system of spectrum management, a task beyond the scope of this study. Assigning, or licensing, is the last step in the process of granting a right to use a part of the spectrum and has only limited consequences for economic efficiency in the context of the overall system. Proposals to auction new radio frequency licenses can improve the economic efficiency of the current system of spectrum management if they offer lower transaction costs and assign licenses more rapidly than their alternatives. Further improvements in economic efficiency, however, require changes that allow license holders to increase their responsiveness to changes in technology and consumer preferences. The system of allocation and the limits on the rights that are granted license holders are critical issues in improving responsiveness.

Block allocation is the designation of a band of frequencies for a specific use. For example, frequencies from 54 MHz to 72 MHz are allocated to television broadcasting channels 2 through 4. Once allocated, a band of frequencies can be assigned on an exclusive, shared, or open entry basis. In the television example, frequencies are assigned on an exclusive basis. Frequencies from 890 MHz to 902 MHz are set aside for nongovernmental land-mobile use and governmental radiolocation use, one of many examples of sharing. Open entry, or nonexclusive use, is an option that does not make use of an exclusive license. Instead, use of the band of frequencies is open to all, with the extent of use limited only by congestion. Common household electronic devices--for example, cordless telephones, baby monitors, or garage door openers--use frequencies on an open entry basis. In these cases a combination of the high cost of limiting interference, the low power of transmission equipment, and substantial consumer benefits suggests that an open allocation is economically efficient.

The block allocation system is simple, stable, and predictable. Both its strengths and weaknesses spring from these characteristics. Block allocation is a straightforward and low-cost means of promoting interference-free use of the spectrum. Governmental spectrum managers can assure adequate spectrum for public services by allocating frequencies and directly assigning them. Block allocation is also consistent with the international system of spectrum manage-

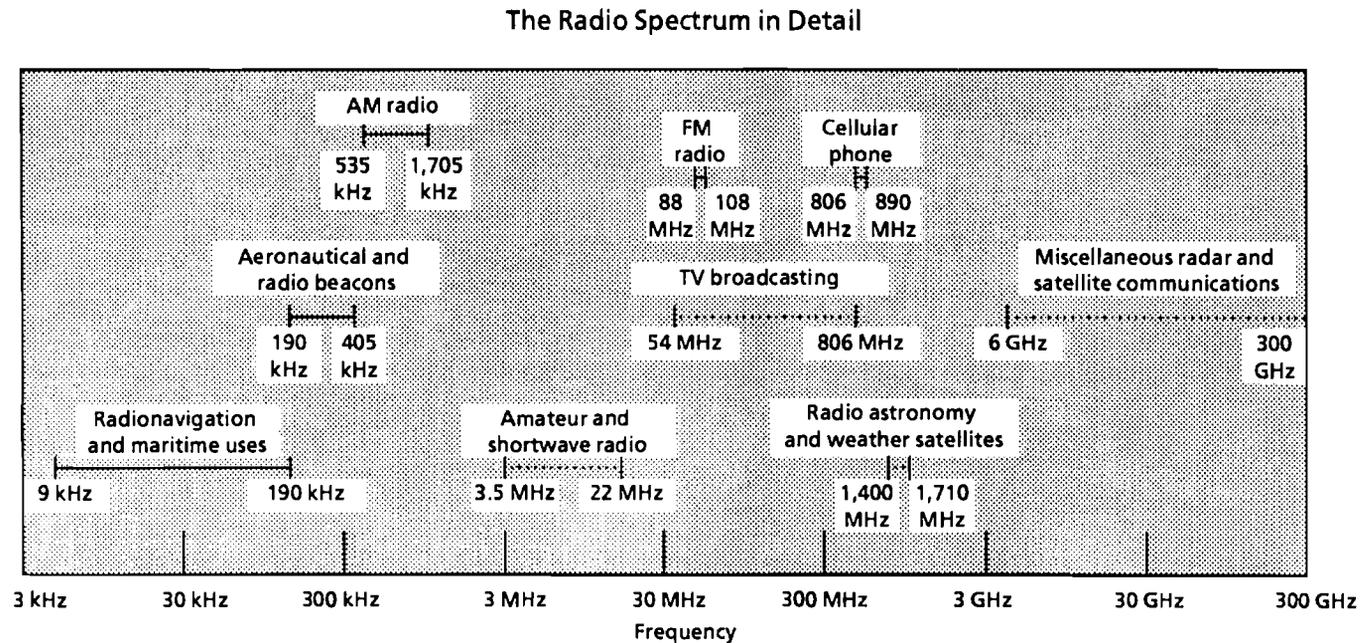
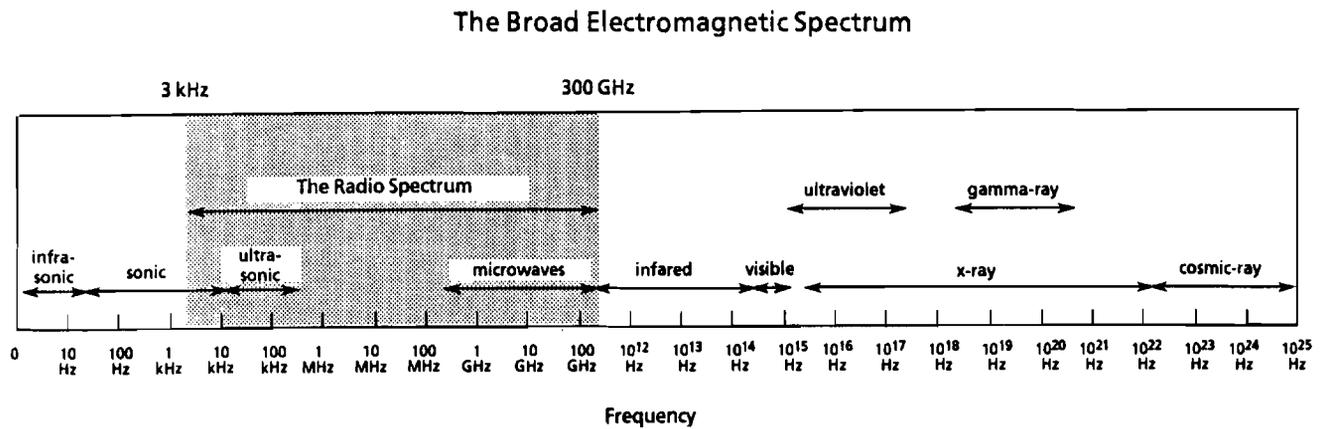
ment, which operates in a similar way. By establishing the frequencies to be used for a specific service, block allocation provides equipment manufacturers with a stable and predictable environment in which to design and manufacture their products.

The block allocation system's stability and predictability are not without cost. Block allocations take a long time to establish, and once established are difficult to change. Difficulty in responding to changes in technologies and consumer preferences can leave parts of the spectrum underused. In some instances, a limited allocation of spectrum gives license holders control over prices and accompanying high profits or rents. Accordingly, the radio spectrum is not distributed among different services in an economically efficient way. Rising prices for licenses within areas of the spectrum allocated to services that are in increasing demand can coexist with much lower prices for technically similar parts of the spectrum that are allocated to other nongovernmental services. Under the block allocation system there is no smooth path that permits spectrum to move easily from lower to higher value services.

The National Telecommunications and Information Administration's proposals to improve the current system of spectrum management emphasize granting license holders more flexibility in using their license rights within a system of block allocation. For example, the current system includes sub-allocation of mobile satellite radio among land-mobile, maritime, and aeronautical services. Permitting license holders to make these divisions by responding to users' demands would assure a more efficient use of the frequencies. This concept could be further extended to allow license holders to provide almost any service that was technically compatible with the frequencies in question and did not interfere with other license holders in adjoining bands. Allowing a license holder to offer cellular telephone services over frequencies currently allocated for UHF broadcast television is an example of a more aggressive application of the principle of flexibility.

The current U.S. system of spectrum management relies on wise planning decisions to promote an economically efficient distribution of the radio spectrum. An alternative is to allow spectrum license holders more flexibility, essentially broader rights of use, in bringing desirable consumer services to the market. Inflexible and strict definitions of allocations may not allow an efficient distribution of frequencies among uses even when licenses for new uses are auctioned and private markets allow trading in existing licenses.

**Figure 1.**  
**The Electromagnetic Spectrum**



SOURCE: Department of Commerce, National Telecommunications and Information Administration, Office of Spectrum Management, March 1987.

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 usage are shown; frequencies not shown are allocated to various other fixed and mobile communications services. Dotted lines indicate that usage does not occur on all frequencies within that range.

frequency cosmic-ray waves. (See Figure 1.) Radio waves allocated for communication range from 3,000 hertz (3 kilohertz, kHz) to 300 billion hertz (300 gigahertz, GHz). The most widely used telecommunications services include AM radio, stretching from 535 kHz to 1,705 kHz; broadcast television in various areas of the spectrum from 54,000,000 hertz (54 megahertz, MHz) to 806 MHz; FM radio from 88 MHz to 108 MHz; and cellular telephone services in the 800 MHz to 900 MHz range.<sup>6</sup>

The technical task of spectrum management is to ensure that a user of the spectrum can transmit or receive signals without interference from other users. One means of controlling interference is to allocate frequencies to specific uses. Geographical limitation is another. Television stations all over the country use the same frequencies but in different geographical areas. The characteristics of different wavelengths along the spectrum, the power of transmitters, and the altitude of antennas all play a role in limiting the geographic area that a signal covers, thereby allowing a frequency to be reused in different areas. The many electronic devices used in the home provide a common example of frequency reuse. Garage door openers, for example, transmit at such low power that interference with nearby households is minimal. Users of these devices, called "part 15 devices," do not require a license. Limiting the time of day that a frequency is used also permits reuse.

New digital compression technologies are the most recent advances that will allow more information to flow without interference. Analog transmissions use an information signal directly to vary or modulate one of the characteristics of a carrier wave. Amplitude modulation (AM) and frequency modulation (FM) are the most common types. Digital transmission first samples the information signal at fixed intervals of time and encodes

the amplitude of the signal into on/off pulses that can be transmitted directly or by an AM or FM carrier wave. The receiver then decodes the pulses to reconstruct the information signal. Digital transmission requires a broader bandwidth than analog transmission to send a given amount of information. However, digitalization also allows redundant and unimportant parts of the information signal to be eliminated. This process, known as signal compression, can more than make up for the broader bandwidth required by digital transmission. Accordingly, less of the spectrum is necessary for the listener or viewer to receive the essential message.

### Is There Enough?

The demand for telecommunications services has created the demand for radio spectrum licenses. The economic importance of meeting

**Table 1.**  
**Revenues for 1990 of Selected U.S. Industries Requiring Radio Frequency Assignments (In billions of dollars)**

Industries	Revenues
Video Services (Including television broadcasting and cable) <sup>a</sup>	28.4
Radio Broadcasting <sup>a</sup>	8.7
Cellular Telephone Services <sup>b</sup>	4.5
Satellite Communications Services <sup>c</sup>	.8
Paging Services <sup>d</sup>	1.4

- a. McCann-Erickson, Inc., *Estimated Annual U.S. Advertising Expenditures 1980-1990* (New York: McCann-Erickson, Inc., 1991), transmitted to the Congressional Budget Office (May 21, 1991).
- b. Cellular Telecommunications Industry Association, *U.S. Cellular Industry CTIA Data Survey* (Washington, D.C., 1992).
- c. Department of Commerce, *U.S. Industrial Outlook 1991*, pp. 28-29.
- d. Mid-year 1991 revenue estimate, RCR Publications Inc., *Radio Communications Report*, Vol 10, no.18 (September 23, 1991), p. 1.

6. Department of Commerce, National Telecommunications and Information Administration, Office of Spectrum Management, *United States Frequency Allocations: The Radio Spectrum* (March 1987).

this demand is illustrated by the hundreds of billions of dollars in service and product revenues in the telecommunications sector. Selected private telecommunications services using the spectrum are outlined in Table 1. Public license holders who use the spectrum to produce a broad array of public goods and services are excluded. Public uses of the radio spectrum range from emergency and law enforcement services to air traffic control and scientific research. Although there is no readily available estimate of the contribution of radio frequency assignments to the value of the public goods and services, one rough calculation indicates an annual level of \$34 billion to \$178 billion.<sup>7</sup>

Technological advances have opened the possibility that new wireless communications services will contribute to the growth of the economy. Revenues from mobile or cellular telephone services grew at a compounded annual rate of 60 percent during the 1984-1989 period.<sup>8</sup> Even in the recession year of 1991, revenues grew by 25 percent.<sup>9</sup> Over the next decade, new frequency allocations for services of this type could complement technological advances and open the prospect of improved and less expensive services for consumers.

In the most elaborate version of extended mobile communications services, voice, video, data, and facsimile will all be available on a seamless wireless network. Individuals will have access to nationwide telecommunications services through portable devices that move with them from home to work. Frequency allocations are likely to be sought for two major types of wireless network: those that would be open to any consumer who is willing

to pay and those that would be restricted to a select group of users, such as public safety agencies or private businesses.<sup>10</sup> Technology is also waiting in the wings to provide worldwide digital audio radio transmissions that use satellites as relays. Improved television broadcasts could also require new allocations or changes in the use of allocations currently set aside for television broadcasts.

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*There is considerable  
debate over whether  
the "spectrum shortage"  
is real or merely a product  
of the current  
regulatory system.*

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Over the last half century most of the desirable frequencies from 3 kHz to 300 GHz have been allocated to specific uses (for example, broadcasting or satellite services) and licenses assigned to specific users (for example, television channel 4 in New York City is assigned to WNBC). The frequencies most sought after because of their technical characteristics, those under 2 GHz, are tightly packed with users and uses. Motorola Inc. has produced an analysis indicating that 317 MHz of new spectrum allocations will be needed by the year 2000 in order to accommodate the growth in wireless communications.<sup>11</sup> The problem is not only one of the spectrum's physical availability for new uses, but of timely availability. One recent study

7. Molly Macauley, "Some Spectrum Value Calculations" (remarks before the Annenberg Washington Program Conference "Spectrum Allocation: Rethinking the Invisible Resource," April 30, 1991).

8. North American Telecommunications Association, *1991 Telecommunications Market Review and Forecast* (Washington, D.C., 1991), p.163.

9. "Number of Cellular Users is up 40 percent, Industry Reports," *The New York Times* (March 18, 1992), p. D7.

10. Networks open to any consumer willing to pay are sometimes referred to as "public" or common carrier networks. Networks restricted to a selected group are referred to as "private."

11. Motorola, Inc., *The Future Vision for the Wireless World: Technology Review* (November 1991), p. 3.

estimated the cost to the U.S. economy of delays in allocating frequencies to cellular phone services to be \$86 billion.<sup>12</sup>

There is considerable debate over whether the "spectrum shortage" is real or merely a product of the current regulatory system.<sup>13</sup> Some observers argue that if current spectrum users were granted more flexibility, current allocations could accommodate additional services.<sup>14</sup> Charging current licensees a fee for spectrum use could also provide an incentive to conserve spectrum, although devising an effective fee is likely to be a complicated task.<sup>15</sup> Technical change, most importantly digital communications technology, also offers the prospect of spectrum conservation, if spectrum users have the proper incentives to adopt these technologies. Finally, it is possible that additional spectrum will become available, for example, if fiber optic cables someday carry much of the broadcast load directly into the home. As a consequence, large blocks of spectrum that broadcast television currently occupies could become available for other uses.<sup>16</sup>

The U.S. system of spectrum management is being reconsidered in the context of economically promising technologies and concerns that the current approach lacks flexibility and cannot respond quickly enough to new opportunities. The proposals to auction spectrum licenses considered in this study are but one element of this larger discussion.

## The Current System of Spectrum Management

The FCC and the National Telecommunications and Information Administration (NTIA) of the Department of Commerce coordinate the domestic management of the radio spectrum. NTIA is responsible for managing the U.S. government's use of the radio spectrum. Established by the Communications Act of 1934, the FCC manages all nonfederal use of the spectrum. This responsibility includes defining classes of service, allocating radio frequencies to provide those services, and assigning licenses to specific users.<sup>17</sup>

International coordination of spectrum allocations is another important management function that involves the Department of State as well as NTIA and the FCC.<sup>18</sup> Much of this activity is focused on defining common allocations of frequencies for specific classes of service under the auspices of the International Telecommunications Union (ITU), and in particular through the mechanism of periodic World Administrative Radio Conferences (WARCs).

WARCs, held every few years, have always been significant, particularly in defining allocations necessary to produce public goods and services. Among these defining functions

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12. Jeffery Rohlfs, Charles Jackson, and Tracey Kelly, "Estimate of the Loss to the United States Caused by the FCC's Delay in Licensing Cellular Telecommunications" (Washington D.C.: National Economics Research Associates, November 1991), p. 1.
  13. See, for example, George Gilder, "What Spectrum Shortage?" *Forbes* (May 27, 1991), pp. 324-332.
  14. Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), Chapter 3.
  15. For a review of a number of different approaches to spectrum fees, see National Telecommunications and

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Information Administration, *U.S. Spectrum Management Policy*, pp. 119-126.

16. This proposition remains controversial. See, for example, Leland Jonson and David Reed, *Residential Broadband Services by Telephone Companies?* (Santa Monica, California: RAND, 1990).
17. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*. Chapters 2 and 3 provide an extensive review of the NTIA and FCC roles in spectrum management.
18. Office of Technology Assessment, *The 1992 World Administrative Radio Conference*, provides a detailed review of issues in international spectrum management.

is the designation of common frequencies for air traffic control, which permits international travel without forcing airplanes to carry multiple sets of transmitters and receivers. The most wide-ranging WARC since 1979 convened in February 1992 in Spain. As wireless networks become global, private investors will have an increasing stake in WARCs' functions. A case in point is Motorola's Iridium proposal to establish a global land-mobile communications system based on satellites in low Earth orbit.<sup>19</sup>

Conceptually, market mechanisms could be applied to most spectrum allocation and assignment decisions, including the licensing of government users. Most auction proposals, however, focus on the FCC's assignment process for new licenses when more than one private user seeks to obtain the license. Currently, the FCC uses either a comparative hearing process or a lottery to assign new licenses.

The law establishes the public interest as the basis on which the FCC is to assign licenses. The licensee uses the airwaves under this standard as a trustee of the public. Thus, the assignment standard is sometimes referred to as the Trusteeship Model.<sup>20</sup> Although the public interest standard is the legal underpinning of all licenses the FCC assigns--regardless of the method of assignment--the standard is most strongly associated with the award of broadcast licenses by comparative hearing. Broadcasters have argued that serving the

public interest by carrying educational programming, for instance, can be viewed as partly compensating the government for a license. Debate exists about whether the Communications Act requires or even implies this social contract.<sup>21</sup> Critics have pointed out that a serious evaluation of social merit is not a part of the process in renewing broadcasters' licenses.<sup>22</sup> Also, for many nonbroadcast services, such as cellular telephone services, the comparative hearing method has been criticized because it is impossible to grant superior social merit to one contender or another. Finally, the comparative hearing process has been criticized as very time-consuming and costly to society.

Lotteries for new license assignments emerged during the 1980s as a response by the Congress and FCC to these criticisms. The commission first used the process to assign licenses for cellular telephone operators. Initially, it was faster and less costly to society than comparative hearings.<sup>23</sup> As the low cost of entry and the potential for large windfalls became widely known, however, the number of lottery entries skyrocketed. The benefits of lower private application and government administrative cost, as well as timeliness, were lost. Equity considerations also arose. Lottery winners who never intended to provide cellular services were able to sell their licenses at an enormous profit to firms that did intend to provide cellular services. The sale of the Cape Cod, Massachusetts, service area by a

19. Motorola, *Iridium Personal Communications for the World: System Overview and Spectrum Considerations* (October 1991).

20. Mark S. Fowler and Daniel L. Brenner, "A Marketplace Approach to Broadcast Regulation," *Texas Law Review*, vol. 60 (1982), pp. 213-217.

21. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 106-107, finds no support for the broadcast concept of a social contract.

22. Henry Geller and Donna Lampert, *Charging for Spectrum Use* (Washington, D.C.: Benton Foundation Project on Communications and Information Policy Options, 1989), pp 11-17.

23. Subsequently, however, the financial windfalls reaped by lottery winners have drawn huge numbers of applicants for even lower value license assignments, increasing the cost to society of the process. For example, Peter Passell, "Radio Waves Can Be Solid Gold," *The New York Times* (December 4, 1991), p. D4, indicates more than 60,000 applications were made in just two days for a license to provide data transfer services.

lottery winner for \$41 million in 1990 is perhaps the most notorious example.<sup>24</sup>

The lottery process has been criticized because it randomly bestows enormous profits; profits that flow from a publically managed resource. Private firms or individuals obtain access to the spectrum resource at little or no cost, and often do nothing to contribute to the value of that access before profiting from its

sale. Auctions that channel these profits to the public are seen as a remedy to this problem. One should note, however, that the lottery winner's windfall and the receipts that an auction could generate flow from the same ultimate source--the consumer. Regulation and a lack of flexibility in current spectrum management practices have created a market for land-mobile services in which a limited number of producers in each market can extract excessive profits from consumers. Eliminating these profits by introducing more competition may ultimately serve society better than a short-term increase in revenues to the federal government.

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24. Peter Passell, "Administration Seeks Profits In Plan to Auction Airwaves," *The New York Times* (May 30, 1991), p. A1.



# Auction Proposals

**P**roposals to use auctions as a tool of spectrum management are not new. Neither are they limited to the assignment of licenses, nor to spectrum management in the United States. The most recent proposals to auction new license assignments can be understood in the context of the history of auction proposals and their place in changing spectrum management practices.

The persistence of auction proposals is explained in part by the strength of the general arguments in favor of auctioning spectrum licenses. Compared with other methods of assignment--lotteries and comparative hearings--auctions are faster, less costly to society, produce more federal revenues, and are more likely to place licenses directly in the hands of the applicants who value them most. The limitations on auctions that are included in most proposals stem from the arguments against auctioning licenses to use the radio spectrum. Many proposals limit auctions to private users. Some include provisions that seek to offset the perceived advantage of large firms over small firms by allowing winning bids to be paid off over time or by setting aside specific licenses for smaller firms. Other proposals exempt broadcasting and amateur radio uses.

Proposals to use the market to allocate the spectrum resource date back to the earliest days of radio. Foreign governments have conducted auctions for the right to use the radio

spectrum. Proposals are being actively considered in the United States.

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## Past Proposals

In a 1959 article entitled "The Federal Communications Commission," Nobel Laureate R.H. Coase proposed auctioning the right to use radio frequencies.<sup>1</sup> The central theme of that analysis, first developed by economists in the 1920s, was that a clear definition of property rights was essential to a rational public policy toward the airwaves.<sup>2</sup> Coase's proposal, which many still consider radical, would have allowed the market to sort out not only the assignment of licenses to operators seeking to provide the same service, but also the allocation of different parts of the spectrum to competing uses. In the same article, Coase notes that as early as 1951 a proposal to auction broadcast licenses was offered in a Federal Communications Commission proceeding addressing the problem of standards in color television. In 1958, the Congress considered legislation for a proposal to assign television licenses by auction when more than one applicant was highly qualified. Additional proposals surfaced during the 1960s

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1. R.A. Coase, "The Federal Communications Commission," *The Journal of Law and Economics*, vol. II (October 1959), pp. 1-40.
  2. Thomas Hazlett, "The Rationality of U.S. Regulation of the Broadcast System," *Journal of Law and Economics*, vol. xxxiii, no. 1 (April 1990), pp. 174-175.

and 1970s.<sup>3</sup> Proposals were made in legislation several times during the 1980s, but failed to become law.<sup>4</sup>

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## Foreign Auctions

Other countries have actually carried out proposals to auction the spectrum. New Zealand and the United Kingdom (U.K.) have auctioned rights to use the spectrum.<sup>5</sup> Canada and Australia are currently exploring the subject of license auctions, and similar options have been proposed in Italy and the European Community as a whole.

### New Zealand

The New Zealand Radiocommunication Act of 1989 installed auctioning as part of the world's most market-oriented system of spectrum management.<sup>6</sup> The objectives of the New Zealand law were broad. The law was established to promote economically efficient use of the spectrum, rapidly assign new licenses, and increase government revenues. But the New Zealand experience is recent and its full implications have yet to be realized, let alone analyzed. The experience, however,

provides useful background in examining U.S. proposals to auction the spectrum and in estimating the potential effects of these proposals on federal revenues and economic efficiency.

Significantly, the New Zealand experience indicates that the auction of licenses is only a small and relatively noncontroversial step toward using market mechanisms for spectrum management. A more central issue is the nature of the property rights granted by licenses. New Zealand's law provided for the auction of the use of spectrum licenses to supply specific local services under government management. A similar type of limited auction is included in the legislative proposals currently being offered in the United States. The New Zealand law also provided for the auction of spectrum management rights. These rights allow the winning bidder to establish a private and nationwide system of spectrum management within the confines of the frequencies won at auction. The private manager allocates and assigns the use and geographic limits, subject to a noninterference constraint regarding other management rights or license holders.

The New Zealand example also illustrates some of the issues faced by proposals to introduce market mechanisms into spectrum management in the United States. For example, New Zealand already had a number of broadcast license holders before the commonwealth passed its spectrum auction law in 1989. Consultants to the New Zealand Ministry of Commerce recommended against grandfathering; they felt that incumbents' licenses should be revoked and reauctioned.<sup>7</sup> As passed, however, the law allowed incumbent license holders to retain their licenses, but instituted a spectrum license fee. Other exemptions were granted for public safety licenses and for licenses held by New Zealand's indigenous

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3. Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), pp. 97-98, notes a series of these proposals. See also Harvey Levin, *The Invisible Resource: Use and Regulation of the Radio Spectrum* (Baltimore: Johns Hopkins University Press for Resources for the Future, 1971).

4. Henry Geller and Donna Lampert, *Charging for Spectrum Use* (Washington, D.C.: Benton Foundation Project on Communications and Information Policy Options, 1989), pp. 3-11.

5. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 93-97, provides an overview of foreign experience and proposals.

6. Milton Mueller, *Reform of Spectrum Management: Lessons From New Zealand* (Los Angeles: Reason Foundation, November 1991), provides a review and analysis of the New Zealand experience from which this paper draws heavily.

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7. New Zealand Ministry of Commerce, *Management of the Radio Frequency Spectrum in New Zealand*, prepared by National Economic Research Associates (November 1988), p. 135.

people. Among spectrum auction issues raised in the United States are fairness toward current license holders, licenses used to produce public goods and services, and the social policy implications of broadcast licensing.

## United Kingdom

Before 1991, the British government assigned broadcast rights to private parties by a process similar to the comparative hearings the United States uses. The Broadcast Act of 1990 required that auctions replace that process, although the law retained as a threshold criterion a regulator's judgment about whether a bidder meets a public interest standard.<sup>8</sup>

In February 1991, the United Kingdom began to auction the rights to offer programming on Independent Television Channel 3. Forty production companies vied for the rights to 16 television franchises defined by region, time of day, or day of the week.<sup>9</sup> The auction was conducted by sealed bid and the franchises were awarded to the highest bidder in most circumstances. Sealed bids were submitted in May 1991, and the winners were announced in October 1991. In the interim, public comment was solicited on the program plans submitted by each bidder, and the government's Independent Television Commission (ITC) evaluated each bidder's ability to meet the public interest standards included in the law.

The law under which the auction was held permitted the ITC to award a franchise to a bidder other than the highest, if in the commission's judgment the highest bidder could not provide high-quality programming or would not be financially sound during the term of the franchise. The quality standard included providing news and informational

programming, regional programming, diversity, a general quality element (the "Masterpiece Theater" factor), and a "local content" production rule requiring the franchisee to produce programming in the region served and to include a "proper" portion of programming of European origin. About a third of the bidders were disqualified on the basis of the public interest standard, and roughly half of the franchises were awarded to bidders that did not make the highest offer.

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*Two major considerations  
underlie the arguments  
for and against  
spectrum auctions:  
economic efficiency  
and fairness.*

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The U.K. experience reveals the potentials and pitfalls of combining license auctions with a public interest standard. The public interest elements of the U.K. auction can be seen as a mechanism to provide the social benefits of broadcast franchises--such elements as news, information, and regional programming--that private advertisers may undervalue.<sup>10</sup> Application of these elements to reject a winning bid could be consistent with an economically efficient distribution of the franchises, if the social value of the elements in the standard is greater than possible losses of efficiency expressed, for the most part, as higher production costs for programming. Some critics counter, however, that the standard in effect allowed the ITC to perpetuate the old system

8. *Outline of Procedure in the Broadcasting Act of 1990 for Inviting Applications and Awarding Channel 3 Regional Licenses*, provided to the Congressional Budget Office by the British Embassy, Washington (January 23, 1992).

9. "Television Franchises: Blind Date," *The Economist* (May 18, 1991), p. 64.

10. Severin Borenstein, "On the Efficiency of Competitive Markets for Operating Licenses," *Quarterly Journal of Economics* (May 1988), pp. 379-382, argues that auctioning broadcast licenses can lead to an inefficient distribution of frequencies when social and market values diverge.

**Box 2.****United States Auction Proposals from 1989 Through 1992**

The current proposal to auction licenses for radio spectrum use was preceded by the Administration's budget request of 1989 that included receipts from auctioning Federal Communications Commission licenses described as a federal asset sale.<sup>1</sup> The receipts estimated for that proposal, and for similar initiatives in 1990 and 1991, were to come from the licensing of 4 MHz to 6 MHz of new frequencies.<sup>2</sup> These proposals were not specific about how frequencies could be used, or whether they were to be offered locally or nationally. In retrospect, they were significant because they again placed the idea of auctioning in the public policy arena.

More specific and detailed proposals were provided by the budget request for 1992, the National Telecommunications and Information Administration (NTIA) report on spectrum management, and some versions of the proposed Emerging Telecommunications Technologies Act of 1991. The budget proposal for 1992 included an FCC auction of licenses to use 30 MHz of spectrum.<sup>3</sup> The spectrum was to be cleared for auction by the two-step process retained in the 1993 request. Licenses would be

assigned, primarily on a local basis, by auction. The proposal foresaw three to 10 regional auctions held over the 1994-1996 period. The gross revenues produced by the auctions were estimated to be \$4.5 billion (\$150 million per megahertz). The budget estimate included only \$2.5 billion in net receipts (\$83 million per megahertz) because costs of \$2 billion (\$67 million per megahertz) were estimated as necessary to relocate federal users. These "per-megahertz" cost and revenue assumptions continue to be used to estimate the receipts that would be generated by the 1993 budget's license auctioning proposal. The 1992 proposal assumed that the spectrum made available could be put to more than one use. Cellular telephone services, personal communications networks and broadcasting were mentioned.

Closely related to the 1992 budget proposal was NTIA's analysis, *U.S. Spectrum Management Policy: Agenda for the Future*, released in February 1991.<sup>4</sup> The NTIA analysis also recommended competitive bidding for license assignment as a tool of spectrum management. It advocated bidding as a part of a broader reform package that emphasized flexibility in the rules governing the services license holders could provide and the technologies they could use to provide them. Flexibility, when combined with

1. *The Budget of the United States, Fiscal Year 1989* (1988), pp. 5-167 and 5-168.
2. *The Budget of the United States Government, Fiscal Year 1990* (1989), pp. 5-182 and 5-183 and *The Budget of the United States Government, Fiscal Year 1991* (1990), p. A-55.
3. Office of Management and Budget, "Spectrum Competitive Bidding Proposal," transmitted to the Congressional Budget Office (February 14, 1991).

4. See Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), pp. 3-12 for a summary of the report's overall recommendations, including those for competitive bidding in the assignment of licenses.

of the "magic circle," a term corresponding loosely to our "old-boy network."<sup>11</sup> Nevertheless, four of the 16 incumbents were displaced, among them Thames Television, which had held the London weekday franchise for more than 20 years.

While the social benefits of the public interest standard can be debated, its consequence for auction revenues was unambigu-

ous: higher bids were replaced by lower bids. Although many U.S. auction proposals exempt broadcast licenses, they include limitations on auctioning nonbroadcast licenses with the objective of providing benefits unaccounted for by market prices--for example, setting aside franchises for small businesses. These limitations would be subject to the pluses and minuses that emerged in the United Kingdom case.

The Channel 3 franchise sale included other features frequently discussed in pro-

11. "And the Winners Are ...," *The Economist* (October 19, 1991), p. 67.

the private market for businesses holding spectrum licenses, is a move toward New Zealand's spectrum management concept.

The auctioning of spectrum licenses proved to be a major point of contention in Congressional deliberations surrounding the Emerging Telecommunications Technologies Act of 1991.<sup>5</sup> A primary feature of that proposal directed the NTIA to make available 200 MHz of spectrum in frequencies under 5 GHz for allocation to new private uses and users. Based on similar legislation introduced in 1990, the legislation was clearly intended to address the same set of problems identified in the NTIA analysis. Action was necessary to make spectrum available for new private opportunities. As proposed, however, the act did not authorize the FCC to use competitive bidding to assign new licenses. Opponents of auctioning appeared flexible enough in hearings held late in the last Congress to consider a limited experiment.<sup>6</sup>

A proposal to auction spectrum licenses again surfaced during the Senate debate on extending unemployment compensation in the fall of 1991.<sup>7</sup> The receipts from a license auc-

tion were to be used as an offset to increased spending for unemployment compensation. Drawing on the Emerging Telecommunications Technologies Act of 1991, various legislative proposals to extend unemployment compensation included the auctioning of licenses to use 45 MHz or 50 MHz. Unlike previous proposals that foresaw two to five years to relocate federal users, allocate the new spectrum, assign new licenses by auction, and deposit the receipts in the Treasury, the new proposals required that all of these steps take place before the end of fiscal year 1992. The first frequencies made available were to be under 3 GHz and allocated to land-mobile or land-mobile satellite services.

The Administration's estimates of the gross revenues and costs of relocating government users were notably lower in the fall 1991 proposal than those included in the 1992 budget proposal and the similar estimates included in the 1993 budget proposal.<sup>8</sup> The revenue projections totaled \$1.9 billion in gross auction receipts (as compared with \$4.5 billion in the 1992 budget), a consequence of the accelerated process required by the law. The cost of relocating federal users was also dramatically different--only \$360 million for the three years following relocation, versus \$2 billion to \$3 billion in the 1992 and 1993 budget proposals. Unlike the lower gross revenues, the dramatic difference in the cost of relocation cannot be explained by referring to the accelerated process.

5. Emerging Telecommunications Technology Act of 1991 (H.R. 531), 102 Congress, 1st Session.

6. "Emerging Telecommunications Technology Act of 1991," hearing before the House Committee on Energy and Commerce Subcommittee on Telecommunications and Finance, October 9, 1991; and "The Feasibility of Auctioning Radio Spectrum," hearing before the Senate Committee on Commerce, Science, and Transportation Subcommittee on Communications, October 17, 1991.

7. *Congressional Record*, September 23, 1991.

8. Letter from Richard Darman to Senator Jim Sasser, "Preliminary OMB Scoring of the Deficit Neutral Unemployment Compensation Act of 1991" (October 7, 1991).

posals for auctions of spectrum licenses in the United States. In the tradition of the previous U.K. assignment mechanisms, the franchises would be reauctioned in 10 years. Under an auction, however, expectations for renewal must be considerably lower--four incumbents were dethroned in the first sale, whereas only two franchises changed hands in the previous renewal process. Payments of bids in the United Kingdom auction are spread out over time, a feature often suggested for the United States to "level the playing field" for small businesses. Finally, although no minimum or

reservation price was used in the franchise auction, a fixed tax on revenues, set by the ITC and paid in addition to the annual franchise levy, served a similar function.<sup>12</sup>

12. "Television: Can Channel-5 Survive?" *The Economist* (February 15, 1992), p. 69, notes that in the planned auction for Channel 5, winning bidders will not be required to pay a fixed levy because the revenue potential of the new franchises is doubtful. This action in effect reduces the reservation price to any positive bid.

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## Current U.S. Proposals

The President's budget request for 1993 includes the most recent auctioning proposal. It would require the FCC to use auctioning or competitive bidding for assigning licenses to many of the private users of the radio spectrum.<sup>13</sup> The current proposal has evolved from a series of budgetary and legislative initiatives, starting with the budget proposal of 1989. These proposals reflected broad general agreement about making more spectrum available for allocation and assignment to new private uses, but substantial disagreement about whether auctioning should be used to assign new licenses. As late as the fall of 1991, however, there were signs of agreement to experiment with auctioning for at least some licenses. An overview of U.S. proposals made since 1989, leading to the most current proposal, is presented in Box 2 on page 14.

Specifically, the proposed Emerging Telecommunications Technologies Act of 1992, referred to in the President's request, would require the FCC to auction license assignments. Major exceptions to the auction requirement include license renewals and new licenses granted for federal, state, or local government use, public safety services, public broadcasting, amateur radio, and radio astronomy.

The act would make new frequencies available for assignment by transferring 200 MHz that is currently assigned to governmental use to the private sector. The new allocation would be from the area of the spectrum under 6 GHz and made available over a 15-year period. The law recognizes that relocating federal users would cost money and authorizes the subsequent appropriation of funds to cover those costs. An initial 45 MHz of spectrum is to be identified and allocated within 24 months of the legislation's passage. At that

time, an auction process would also be established. The legislative proposal requires bidders to file a first-stage application, including information that the FCC deems necessary, and a second-stage screening by the FCC to qualify the winning bidder for final assignment of the license. The proposal does not specify the services to which the 45 MHz of spectrum should be allocated, nor does it provide additional details of the bidding process. The proposed law mentions flat fees, fixed or variable royalties, or a combination of both as options for the payment of winning bids.

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The Office of Management and Budget (OMB) estimates that the auction proposal included in the 1993 budget would produce about \$3.7 billion in net revenues between 1995 and 1997. Using the same assumptions as in 1992, OMB estimates \$6.8 billion in revenues from the auction of new licenses, but at a cost of relocating displaced federal users of about \$3 billion.<sup>14</sup>

If the legislation referred to in the President's budget were enacted during the current Congress, it would require that the FCC auction all new nonexempted licenses, not only those made available by the relocation of gov-

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13. *Budget of the United States Government: Fiscal Year 1993*, Part 2-18, and *The Economic Growth Act of 1992: Title XXXIII-Emerging Telecommunications Technologies Act of 1992* (H.R. 4150), pp. 915-942.

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14. Office of Management and Budget, "Spectrum Competitive Bidding Proposal," transmitted to the Congressional Budget Office (February 14, 1992).

ernment license holders. The FCC is currently making available a new allocation of 220 MHz between the frequencies 1.85 GHz and 2.2 GHz for personal communications services, including advanced land-mobile services. License assignments will probably be available from this allocation before they become available as a result of reallocating spectrum from government to private use.

The base-case estimate presented in Chapter 3 is broad enough to incorporate either new licenses made available through the FCC proceedings or the reallocation actions called for in the President's request, even though the latter could require additional spending to relocate displaced federal users. Over the years, the Administration has provided very different estimates of these costs (see Box 2). In analyzing the proposed law and its predecessors, the Congressional Budget Office (CBO) has maintained consistently that the cost of relocating federal users to make 30 MHz to 50 MHz of spectrum available would range from \$200 million to \$500 million. This range is consistent with the proposed law's direction to minimize relocation costs as well as the fall 1991 estimate prepared by OMB (see Box 2). It is far less, however, than the \$2 billion to \$3 billion in federal relocation costs included in the net revenue estimates in the Administration's budget proposals of 1992 and 1993.

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## Arguments For and Against Spectrum Auctions

Two major considerations underlie the arguments for and against spectrum auctions: economic efficiency and fairness. Each of the three mechanisms for assignment--the auction, the lottery, and the comparative hearing--can be compared in terms of its effect on the economic efficiency and the fairness of the spectrum assignment process. Table 2 presents a comparison of the assignment methods, including the implications of each mechanism

*Auctions may be superior to either comparative hearings or lotteries in the areas of administrative ease, transaction costs, and timeliness.*

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for federal revenues, as well as a survey of the processes' efficiency and fairness.

The term "economic efficiency" embraces a broad range of efficiency concepts. In the assignment process for spectrum licenses, economic efficiency suggests that each license should be granted to the user who values it most, and that once assigned, the spectrum resource should be used in combination with other factors to minimize production costs.<sup>15</sup> The public and private costs of transactions and the cost of delays in assigning licenses reflect the efficiency of the actual process; what does it cost society to get the license to the user?<sup>16</sup>

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15. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 98-99.

16. The National Telecommunications and Information Administration discusses "spectrum efficiency," an engineering concept that refers to the use-intensity of the spectrum resource. A radiocommunications system is said to be "spectrum efficient" if it uses the least possible spectrum resource to convey a desired body of information. Spectrum efficiency does not imply economic efficiency: the most spectrum-intense production technology does not necessarily cost the least. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 127-128.

The term "fairness" refers to the impact of the mechanism for assignment on the accessibility of the spectrum resource, the distribution of spectrum licenses, and the distribution of the profits flowing from the use of the spectrum resource. Is the mechanism for assignment fair to all potential users of the spectrum resource? Does it allow "fair access" to the resource? Is the mechanism for assignment fair to the public? Does it guarantee that the public receives its "fair share" of the profits that flow from the spectrum resource?

## Arguments for Spectrum Auctions

There are two general arguments for including an auction mechanism in a spectrum management program: auctions promote economic efficiency, and they provide the public fair compensation for the private use of the spectrum resource.

**Economic Efficiency.** If properly designed and administered, the auction mechanism ensures that each spectrum license goes to the

**Table 2.**  
**License Assignment Methods Compared**

Method	Efficiency	Fairness	Revenues
Comparative Hearing	Might not assign the license directly to the user who values it most. Secondary markets allow license sales to the users who value them most. Consumes substantial private resources in license-seeking activity and inflicts high administrative and delay costs on society.	Can ensure a specific distribution of licenses. Legal and administrative costs of the process give larger financial interests an advantage.	Revenues limited to license application fees. Total FCC fees for 1991 were \$46.6 million, including renewals and fees for lotteries. New license fees range from \$35 to \$70,000. Comparative hearing fee for a new applicant for land-mobile services was \$6,760 in 1991.
Lottery	A random process unlikely to assign the license directly to the user who values it most. Secondary markets allow license sales to the users who value them most. Less prone to delay than hearings, less prompt than auctions.	Allows all applicants equal opportunity if they can pay the application fee. By awarding licenses to applicants who do not intend to provide services, grants lottery winners a windfall not shared by the public.	Lottery revenues are included in totals noted above. Fees for specific lotteries can be substantial. The digital electronic message service lottery, the 220-222 MHz filing of 1991, drew 60,000 applicants and total fees of \$4.4 million.
Auction	Is likely to assign the license directly to the user who values it most. Should assign licenses more quickly and at a lower cost to society than alternatives.	Gives taxpayers a share of spectrum rents. Can be structured to accommodate small bidders.	CBO estimates an auction of 50 MHz of spectrum for two additional land-mobile licenses could generate between \$1.3 billion and \$5.7 billion in fiscal years 1993 through 1995.

SOURCE: Congressional Budget Office.

user who values it most. If a secondary market for spectrum licenses is available, however, the benefit is not unique. A comparative hearing or lottery ultimately leads to the same outcome as an auction. Consider two possible cases. In the first, the initial recipient of the license, by comparative hearing or lottery, is the user who values it most. In this case, the recipient retains the license and a secondary market transaction is unnecessary. In the second case, the initial recipient is not the user who values it most. In this case, the recipient takes the license to the secondary market and offers it to the highest bidder. In effect, the recipient conducts a private auction. In either case, the mechanism for assignment--whether it is a comparative hearing or lottery--leads to the same final outcome. The license goes to the user who values it most. In the latter case, however, the use of the secondary market adds a transaction cost not incurred by the basic auction mechanism.<sup>17</sup> If properly established, an auction mechanism is more direct and less costly.

No strong evidence exists to suggest that auctioning alone would do more to promote economic efficiency in day-to-day operations than assignment by comparative hearing or lottery, if there is an active secondary market for spectrum licenses. A spectrum management program that redefines the spectrum property right, when combined with the auction mechanism, may in theory be more efficient than any other management formula. By granting a management right, as in New Zealand, incentives are created for both managers and tenants to use frequency assignments more efficiently in production activities.

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17. Although unlikely, the additional cost could prohibit the secondary market transaction even if the initial assignment is inefficient (if there is a potential user that would value the license more highly than the initial recipient). This could occur if the cost of the additional transaction outweighed the additional value placed on the spectrum license by the user with the highest valuation. Evan Kwerel and Alex D. Felker, *Using Auctions to Select FCC Licensees*, Federal Communications Commission, Office of Plans and Policy, Working Papers Series, no. 16 (1985), p. 8.

Auctions may be superior to either comparative hearings or lotteries in the areas of administrative ease, transaction costs, and timeliness. A 1985 FCC study developed a hypothetical, but reasonable, estimate of how much it would cost to assign a license for each mechanism. It concluded that the sum of the costs of transactions--private spending to obtain the license and FCC administrative costs--and the cost of delays in the assignment process were roughly the same for comparative hearings and lotteries, but only about one-sixth of that level for an auction. The same study estimated that the processing time for an auction was one-quarter of that for a lottery and one-sixth of that for a comparative hearings process.<sup>18</sup>

Comparative hearings are time-consuming and costly. Lotteries are faster, but take longer than auctions and increase the cost to society of spectrum management because they encourage speculative entries. After the windfall profits of cellular lottery winners became widely known, lottery entries for virtually any FCC offering with commercial potential attracted literally tens of thousands of entries within days after the application period opened. Assigning licenses by competitive bidding is likely to discourage speculative license-seeking activity, thereby lowering private spending undertaken to obtain a license and the FCC's cost of administering the assignment process.

New Zealand's experience in offering ultra high frequency (UHF) television licenses supports these informed speculations.<sup>19</sup> Only 13 months passed between the invitation for expressions of interest and the issuance of licenses. In contrast, it took only two months to conduct bidding and actually resolve the auction. Previously, it had taken New Zealand two years just to get through the ad-

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18. Kwerel and Felker, *Using Auctions to Select FCC Licensees*, pp. 16-20.

19. Mueller, *Reform of Spectrum Management: Lessons from New Zealand*, pp. 16-17.

ministrative procedures necessary to issue a small number of VHF television licenses.

Auctioning licenses, while reducing the cost of transactions and enabling the timely issuance of licenses, would not by itself avoid the much larger social cost of delaying the introduction of new technology. Only more aggressive moves toward auctioning management rights, increasing license flexibility, or developing the open entry concept of non-exclusive use offer solutions to this problem.

**Fairness.** Finally, many feel that auctioning spectrum is superior to the comparative hearing and lottery options because it is fairer to the public. This claim seems justified in the context of the current U.S. system of spectrum management. The best example is the cellular telephone industry, where market regulation has limited the number of providers of cellular services. By creating a duopoly in each market, the regulatory system has created a source of excess profits. Each of the providers enjoys profits that exceed the "intrinsic" contribution of the spectrum resource to the provider's value of production. (The "intrinsic" contribution is the contribution of the spectrum resource to the value of production in a competitive market.) It is these excess profits, or rents, that provide spectrum lottery winners with the bulk of their total return. Many argue that capturing these rents for society through the federal treasury would be fairer to the public than allowing the service providers in each market to benefit from a regulated market structure.

Some observers say that auctions open the possibility of "warehousing," or hoarding licenses. According to this argument, allowing the FCC to auction new license assignments would result in large, rich firms snapping up all license opportunities. The argument ignores the fact that if hoarding were profitable, the existing secondary market for licenses would allow it to occur. Moreover, the existence of a secondary market imposes a significant "opportunity cost" on hoarders of frequency--the price the hoarder could obtain for the license in the market.

In a broad context, the fairest solution may be changes in spectrum management beyond auctioning. For example, regulatory policies could limit the rate of return to license holders who earn persistently above-average profits because spectrum for their service is in short supply. But, if an alternative exists that allows additional competitors to enter the market, it is likely to be more efficient and fairer to the public. Recent legislative proposals and FCC proceedings that would allow more spectrum to be allocated to high-profit service areas, combined with the auctioning of new licenses for that spectrum, are likely to offer such alternatives.

### Arguments Against Auctions

Three general arguments can be made against assigning licenses by auction. These are the need for regulation for public trust, the prospect that the superior ability of auctions to raise revenues will lead policymakers to sacrifice the other objectives of spectrum management, and the presence of substantial market failures in the telecommunications sector.

**The Spectrum as an Input in Producing Public Goods and the Public Interest Standard.** A radio license is a necessary contributor to public safety, the national defense, and many types of scientific knowledge. Critics contend that auctioning licenses for these purposes would inhibit the production of these public goods and services.

A public good or service is one that can be used by any consumer without reducing the amount available to others.<sup>20</sup> Private markets generally do not provide an efficient amount of such goods or services. Societies typically determine through their political systems the amount and type of public goods produced. Governments make these decisions through an implicit benefit-cost calculation. To be

20. William H. Oakland, "Theory of Public Goods," in Alan Auerbach and Martin Feldstein, eds., *Handbook of Public Economics*, vol. II (New York: North-Holland, 1987), pp. 485-486.

accurate, this calculation must include the cost of all of the resources used to produce the good or service, including the value of the spectrum. If prices for the spectrum were established that represented its intrinsic value--prices cleansed of the effect of monopoly created by regulation--auctions would promote rather than obstruct the efficient use of spectrum in the production of public goods. The cost, and seeming absurdity, of the government paying the government for the use of a public asset would be counterbalanced by gains in efficiency. The recognition that spectrum prices reflect more than just the scarcity of the radio spectrum, however, has caused most auction proposals to exclude public users.

The public interest standard that underlies assigning radio spectrum to private users has also been raised as a fundamental objection to auctioning licenses. Broadcasters have argued that license assignments are half of a social contract under which the private holder of the license profits from business activities. In exchange for this opportunity, broadcasters say, the license holder produces services that contribute to a public good--for example, a well-informed electorate. Forcing license holders to pay for their assignments in this context, they maintain, breaks the social contract. But there is reason to question this line of reasoning. NTIA's review of history and legislative intent found no basis for the social contract claimed by broadcasters.<sup>21</sup> Instead, the public interest standard was found to be compatible with any mechanism for assignment. If licenses are assigned by auction and the burden of the standard imposes additional costs on the licensee, bids will be lower.

**The Camel's Nose.** Once the camel's nose is inside the tent, goes an old adage, the rest of the animal will surely follow. Once the political system absorbs the substantial revenues that an auction is likely to produce, additional auctions and spectrum fees are likely to fol-

low. These could lead to inefficient use of the spectrum. The crude analogy points to a potential problem with auctions and again makes the point that auctions alone need not substantially increase efficient use of the spectrum.

In the short run, raising federal revenues and promoting economically efficient use of the spectrum may be complementary goals. For example, the proposals to make additional spectrum available for assignment by auction where monopoly profits are evident will produce revenues for the government and at the same time offer consumers lower prices. If the government were to pursue a strategy that maximized auction revenues, however, it would seek to preserve monopoly profits in various markets so that it could share in them when auctioning new assignments or taxing existing license holders. The consumer at large would suffer the burden of monopoly: too little of a service being brought to the market at too high a price.

Economic efficiency might also be sacrificed if the political system were to introduce an explicit revenue goal into decisions about spectrum allocation. The right to use a part of the radio spectrum exclusively is not always necessary. If the prospect of new revenues were to bias allocations toward exclusive use and away from open use when the latter produced greater social benefits, economic efficiency would not be served.

For example, in the proceedings on personal communications systems currently before the FCC, some parties have argued for open allocations for local area networks or data transmissions between portable computers.<sup>22</sup> Open allocations for these purposes,

21. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 106-107.

22. An allocation permitting open entry regulates use of the spectrum by congestion. Critics of open entry argue that, without a defined property right, users of an open allocation have no incentive to use the allocated frequency efficiently. Advocates of open entry contend that technical standards imposed on equipment can minimize interference and the cost of congestion and, by allowing many consumers to use the same allocation, can provide benefits in excess of cost in appropriate circumstances.

however, compete with allocations for exclusive use by public wireless telephone systems. The auctioning of licenses for exclusive use could raise revenues. Allocating the same spectrum for nonexclusive use would not. The revenue potential of allocating spectrum to exclusive--rather than to open--use is but one factor, and perhaps a small one, in evaluating the overall social benefits and the cost of allocating frequencies to exclusive or open use. If auction revenues are pursued to the exclusion of other social benefits, the long-term efficient use of the spectrum could be sacrificed for short-term increases in federal revenues.

**Market Failures in the Telecommunications Sector.** The "public good" argument is a specific example of a more general concern: that many of the standard assumptions made in economics textbooks do not apply to the telecommunications sector. To the extent that these assumptions are inappropriate, the claims of efficiency by auction advocates overstate the benefits of competitive bidding processes and fail to recognize the imperfections of the market.

Both of the previous arguments include the idea that the prices for spectrum derived from the private sales of licenses include monopoly

rents. Although short-term efficiency goals are consistent with the idea that broader competition should be introduced to reduce these rents, a contrasting view emphasizes the importance of high profits as an incentive to innovate. For example, the prospect of above-average profits provides incentives to develop technologies that make use of higher frequency parts of the spectrum. Trial licenses are currently being granted to provide personal communications services in the 6 GHz range. If the innovators know they must share these future profits with the government, their incentives are diminished. Patent protection, however, offers some relief because the innovator would face little competition if it were the only business able to exploit new technology in the higher regions of the spectrum.

The "deep pockets" criticism of auctions is also ultimately one of market failure. This argument holds that large firms have superior access to capital and can outbid smaller firms. Comparative hearings could offset the advantage of large firms by using firm size as a criterion for awarding licenses. Protection for small firms could also be offered within a larger auction by permitting bidders to pay off a fixed bid or make royalty payments over time.

## Base-Case Revenue Estimate

**T**he Congressional Budget Office estimates that under the assumptions of a base-case scenario, an auction to assign new land-mobile communications licenses could raise \$1.3 billion to \$5.7 billion in revenues from 1993 through 1995. Previous proposals for a spectrum auction provide the outlines of a typical, or base-case, auction scenario. Estimates of the receipts that a spectrum auction could produce are highly uncertain, as indicated by the \$4.4 billion difference between the high and the low ends of the range. Although the base-case assumptions establish what would be auctioned and the terms on which it would be sold, the markets from which bidders would emerge are characterized by major uncertainties about technology, competition, demand, and regulation.

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### The Economic Context of the Base Case

The success of the cellular telephone industry is the starting point in understanding why an auction assigning new licenses for land-mobile services could produce substantial federal revenues. While other business prospects also require new spectrum allocations--for example, satellite-based radio that could provide digital-quality sound--none seems quite so bright as that of building on the success of the cellular telephone industry, the first generation of common carrier, land-mobile communica-

tions. New land-mobile services have been singled out in some of the legislative proposals calling for reallocating spectrum and, under the more expansive umbrella of personal communications services (PCS), are a primary focus of the Federal Communications Commission's current proceeding to make new licenses available for assignment. Accordingly, the base case assumes that the initial licenses assigned by auction will be allocated to advanced land-mobile services.

Investors expect the cellular telephone industry to be highly profitable in the near future. These expectations are based on the recent growth of the industry and the limits imposed on new competition by the scarcity of new license assignments. The substantial prices paid by businesses to acquire other businesses holding cellular licenses are perhaps the best indicators of the enthusiasm of investors. If new licenses were made available for land-mobile services, the prices they would command at auction would be driven by the perception of future profitability in the cellular telephone industry, but tempered by the recognition that the new competition will lower profitability. Thus, the prices paid to acquire existing cellular telephone franchises and the stock prices of cellular telephone companies far exceed the revenue that could be expected from a license auction.

### The Cellular Telephone Industry

The cellular industry takes its name from its basic communications node, the cell. The cell

### Box 3. Cellular Telephone Systems

Cellular telephone systems include a number of low-power radio transmitters and receivers spread over a geographic service area.<sup>1</sup> The cells currently in use transmit and receive within a radius of one-half mile to 10 miles of the cell site, depending on terrain and capacity requirements. This geographic limit allows the same frequencies to be reused within the operator's license area. Cellular telephone operators expand their capacity by building more cell sites closer together.

The cellular phone searches for the strongest cell signal it can detect when initiating a call and makes contact with that cell transmitter. The transmitter then relays the signal to a central switching unit, a mobile telephone switching office (MTSO), that either routes the call into the wireline network (for example, a car-to-home call) or to another cell (a car-to-car call). The transmissions between the cell site and the MTSO are carried either by wirelines or microwaves. When the portable phone originating the call is in motion, the MTSO also hands off the call to a better cell site when the calling unit moves closer to it.

Cellular systems currently in operation use analog technology. It is anticipated that, in the future, investment in new technology will expand the call-carrying capacity of cellular systems. One option, N-AMPS, is a recently announced improvement in analog technology that could triple the capacity of existing systems.<sup>2</sup> Investment in digital technology

is a second broad option. Two variations are most often considered.<sup>3</sup> In May 1990, the cellular telephone industry adopted an interim standard for digital service: time division multiple access (TDMA). This technology could increase the capacity for calls by a factor of six. Code division multiple access (CDMA), a spread spectrum technique, is the other prominent digital variation. CDMA has not been tested as extensively as TDMA, but its proponents claim it is capable of increasing capacity by 15 to 20 times over current levels. Operators of systems that are at or near capacity, such as those in Los Angeles, are likely to invest in one of the capacity-enhancing technologies in the next five years. The cost of a CDMA cellular telephone system is estimated to be no more than 50 percent greater than a conventional cellular system.<sup>4</sup>

The anticipated widespread but gradual adoption of digital technology by the cellular industry will create a transition period. During this period, the portable phones of customers wishing to "roam" (that is, to move from one franchise area to another) could need both digital and analog capability.

The personal communications services that auction winners would be likely to provide are a type of cellular service using "microcells." These smaller, lower-power cells permit even greater reuse of frequencies because they are expected to employ digital technology and their operational area is limited to a radius of about 100 yards from the cell site.

1. For overviews of the basics of cellular telephone systems, see Office of Technology Assessment, *The 1992 World Administrative Radio Conference* (November 1991), pp. 36-38, and, "How Cellular Works," Cellular Telecommunications Industry Association, undated press release.
2. Dennis Leibowitz, Joel Gross, and Eric Buck, *The Cellular Communications Industry* (New York:

Donaldson, Lufkin, and Jenrette, Winter 1990-1991), p. 27.

3. Office of Technology Assessment, *The 1992 World Administrative Radio Conference*, p. 45.
4. Edward Greenberg and Catherine Lloyd, *Telecommunications Services, POP Out: The Changing Dynamic of the Cellular Telephone Industry* (New York: Morgan Stanley, April 1991), p. 5.

is a low power receiver/transmitter that transmits to, or receives a signal from, a small portable telephone. (Box 3 provides an overview of the technology of cellular telephone systems.)

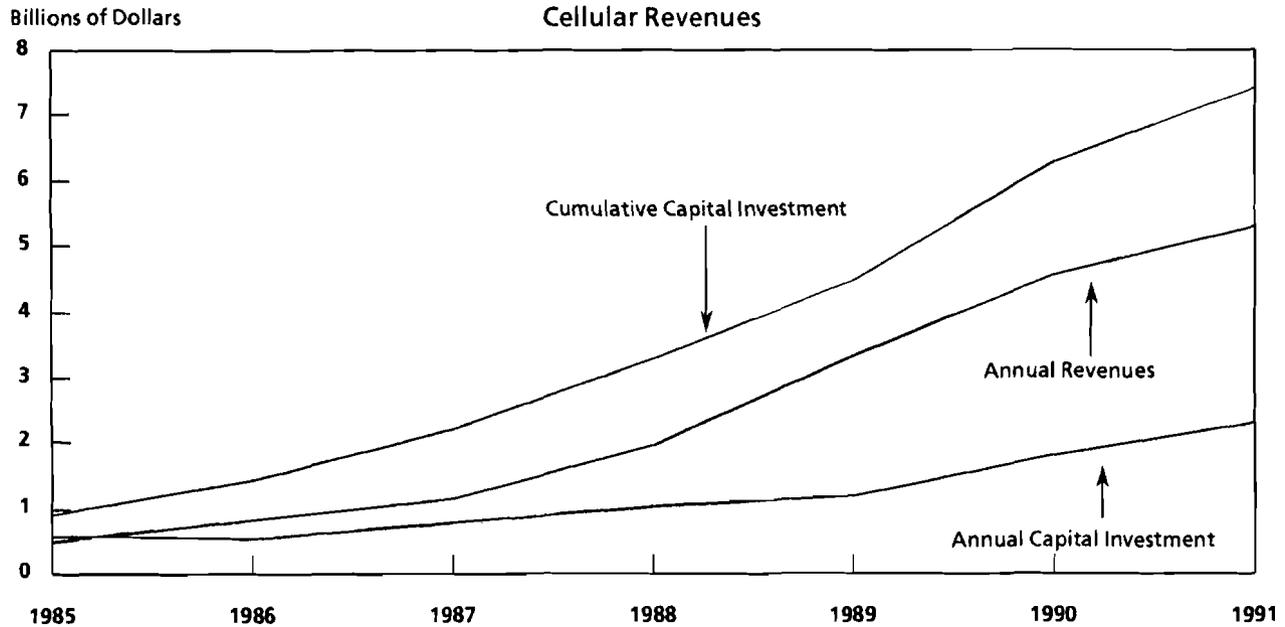
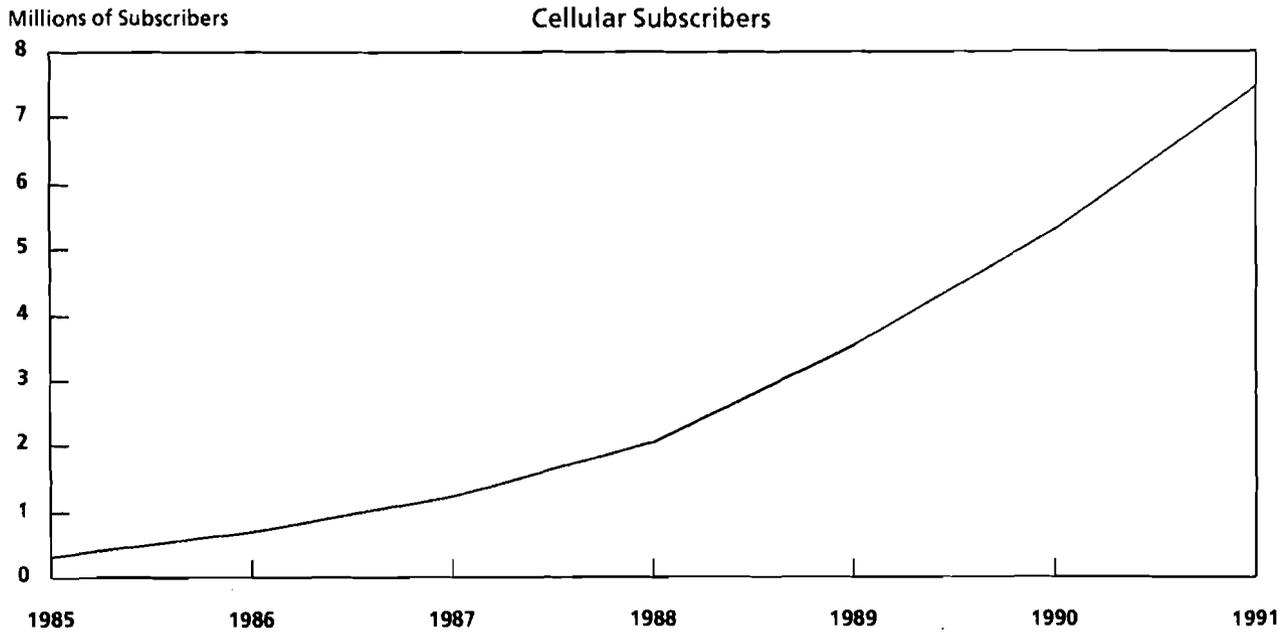
The first cellular telephone systems began operating in late 1983. From 1985 through 1991, the number of people subscribing to cellular telephone services increased from 203,000 to almost 7.6 million (see Figure 2). During the same period, revenues increased from \$482 million to \$5.7 billion. By the end

of 1991, an estimated \$8.7 billion had been invested in an industry that was less than a decade old. Financial analysts predict rates of return on invested capital of 40 percent to almost 100 percent by the end of the decade.<sup>1</sup>

FCC decisions have contributed significantly to creating the cellular telephone indus-

1. 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.

**Figure 2.**  
**Growth in the Cellular Telephone Industry**



SOURCE: Cellular Telecommunications Industry Association.

NOTE: 1991 data is projected.

try's market structure.<sup>2</sup> In 1983, the FCC created a duopoly--a two-firm market--when it divided the first 40 MHz of frequency allocated for cellular services into two 20 MHz licenses for each of the nation's 306 Metropolitan Statistical Areas (MSAs) and more than 400 Rural Statistical Areas (RSAs).<sup>3</sup> One license in each area was set aside for the local wireline telephone company. Where more than one wireline operator was present a comparative hearing was used, although pre-hearing settlements occurred in some markets. The second license in each area was assigned to a competitor. Roughly the first 30 of the second licenses were assigned by comparative hearing or negotiated settlements among applicants. The remaining second licenses were assigned by lottery.

The consequences of these FCC decisions of the mid-1980s continue to be felt. In each local market, service providers have only limited incentives to engage in price competition. Above-average profits can be defended by keeping prices well above costs. Producers hoping to create a national or regional service base have only one option: they must acquire one of the two franchises in each local area where they seek to expand. Together, these two factors propel the trend of rising prices for cellular telephone licenses traded in secondary markets.

**Costs, Revenues, and Profits.** Industry analysts have adopted a population-based measure in evaluating various elements of the cel-

lular telephone industry.<sup>4</sup> The fixed cost of establishing a current technology cellular system is about \$10 dollars a person.<sup>5</sup> Included in this cost are the engineering services necessary to establish a system, equipment for cell and central processing units, and rental of cell sites. The operating costs of providing service to a subscriber are \$6 to \$10 a month plus \$.05 for a minute of service. The most significant other cost is for marketing--about \$300 net per new subscriber.

Average gross revenues per cellular telephone subscriber stand at around \$80 a month.<sup>6</sup> Currently, about 80 percent of subscribers are business customers who use an average of 175 minutes of service a month, which translates into an average monthly operating cost of under \$20.<sup>7</sup> The \$60 difference between the monthly operations cost of service and monthly revenue is by most accounts more than sufficient to cover fixed capital and marketing costs, and to account for very high profits.<sup>8</sup> Financial analysts estimate that if the current duopoly is maintained and rate-of-return regulation is not imposed, the return on investment in plant and equipment

2. Jeffrey H. Rohlfs, Charles Jackson, and Tracey E. Kelly, "Estimate of the Loss to the United States Caused by FCC's Delay in Licensing Cellular Telecommunications," (Washington, D.C.: National Economic Research Associates, November 1991), pp. 1-5, and Cellular Telecommunications Industry Association, "A Brief History of Cellular" (undated), provide brief reviews of the landmark events in FCC decisionmaking about cellular telecommunications.

3. A second allocation of 10 MHz of frequency was made available for cellular services in 1986. The FCC decided to divide that spectrum between the existing license holders, rather than permit a third entrant.

4. Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), p. 90, notes that industry analysts of the cellular telephone industry have adopted a "per pop" or per person standard of measurement in evaluating performance of the industry. This standard is used to recognize the potential of the industry as a direct function of population and to normalize measures of cost and investment--particularly acquisitions costs across markets.

5. For the cost data on cellular systems, see Greenberg and Lloyd, *Telecommunications Services, POP Out*, pp. 24-26.

6. Press release, Cellular Telephone Industry Association, "Cellular Again Bucks Recession, Adds 1.1 Million Users in Six Months," September 9, 1991.

7. Greenberg and Lloyd, *Telecommunications Services, POP Out*, p. 22.

8. Even this rough estimate of a \$60 a month difference is low. The monthly average cost of less than \$20 per month is based on the average business customer's use, while the average revenue figure includes residential customers who use cellular phones less.

could range from 40 percent to almost 100 percent.<sup>9</sup>

This simple comparison of monthly average revenues with monthly average costs is consistent with the expectation of economists that, in markets with only two producers, prices will remain well above costs. Producers make limited use of pricing as a competitive weapon. Targeted groups of users are offered off-peak rates and combinations of monthly access charges and per-minute rates intended to increase their usage.<sup>10</sup> The general level of rates is maintained, however, to preserve the returns on the more profitable, high-use business customer. The absence of aggressive price competition from the cellular telephone industry is so well established that a single instance of dramatic price reductions in Rochester, N.Y., is recognized throughout the industry as a costly mistake.<sup>11</sup> Nevertheless, the price of cellular telephone services has decreased in inflation-adjusted terms by 30 percent since 1984.<sup>12</sup>

**Consolidation.** Mergers and acquisitions have been a prominent feature in the cellular telephone industry over the last eight years. The prospect of capturing the attractive rate of return offered by the industry's market structure was one motivation. Another was the lure of even higher returns that might be won if a national or regional franchise allowed lower service costs or a more desirable communications product. Initially assigning most of the nonwireline licenses by lottery also propelled this activity. The licenses granted to lottery winners who did not intend to build cellular systems provided a ready supply of franchises

**Table 3.**  
**Largest Cellular Telephone Service Providers**  
**Ranked by Population Served**  
**at 1990 Year End (in thousands)**

Providers	Population	Subscribers
McCaw Cellular	56,428	687
Southwestern Bell	45,505	667
Bell South	30,800	667
GTE/Contel	29,970	594
Pactel Cellular	28,416	509
LIN	26,016	338
Ameritech	19,319	325
NYNEX	19,278	259
Bell Atlantic	18,105	257
U.S. West	15,324	210
Centel	14,040	190
Metro Mobile Cellular	10,969	155
Communication	9,509	105
Comcast	7,951	68
U. S. Cellular	5,262	57
Vanguard Cellular	4,711	54
Associated Comm.	3,600	46
So. New England	3,447	45
ALLTEL	2,956	44
Century Telephone	2,745	36
Radiofone	2,655	24
Puerto Rico Telephone	2,602	22
Century Comm.	2,258	19

SOURCE: Dennis Lebowitz, Joel Gross, and Eric Buck, *The Cellular Communications Industry* (New York: Donaldson, Lufkin, and Jenrette, Spring 1991), p. 15.

for acquisitions. The fact that licenses were only issued locally forced firms wishing to establish regional or nationwide service into adopting acquisition strategies.<sup>13</sup> Both the new cellular telephone firms and the regional Bell Operating Companies have bought local cellular franchises. The cellular market has attracted the traditional telephone companies, which are experiencing only slow growth in the land-line business.<sup>14</sup> The leading firms in

9. Greenberg and Lloyd, *Telecommunications Services, POP Out*, p. 2.

10. Bridger M. Mitchell and Ingo Vogelsang, *Telecommunications Pricing: Theory and Practice* (New York: Cambridge University Press, 1991), pp. 159-161.

11. Dennis Lebowitz, Eric Buck, and Joel Gross, *The Cellular Communications Industry* (New York: Donaldson, Lufkin, and Jenrette, Spring 1990), p. 14.

12. Herschel Shostek Associates, LTD., "Quarterly Survey, December 1990," *Data Flash Cellular Subscribers and Forecasts*, vol. 6, no.1 (September 1991), Figures 5-2 and 5-4.

13. Dennis Patrick, Statement before the Federal Communications Commission en banc Hearing on Personal Communications Services, December 5, 1991, p. 3.

14. Dennis Lebowitz, Joel Gross, and Eric Buck, *The Cellular Communications Industry* (New York: Donaldson, Luftkin, and Jenrette, Spring 1991), pp. 49-55.

the industry, ranked by the populations of the markets they hold, are listed in Table 3.

**Great Expectations?** The growth of the cellular telephone industry has generally exceeded that projected by industry analysts. Going into the recession of 1990 and 1991, the value of cellular stocks and the prices for cellular licenses paid in acquisition were consistently rising. Most analysts project a growing number of subscribers. The percentage of the population buying cellular services is expected to increase from the current level of less than 2 percent to between 10 percent and 15 percent by the year 2000.

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*The success of the  
cellular telephone industry  
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communications.*

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Residential consumers are expected to be the fastest growing segment of the market. Compared with business customers, residential subscribers' use of cellular telephone services is sensitive to price changes.<sup>15</sup> New residential customers are expected to spend less per month, partly because they use higher-priced services less intensively than business customers. Consequently, the average monthly bill for each customer is expected to fall from its current level of \$80 a month to as low

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15. Rohlfs, Jackson, and Kelly, "Estimate of the Loss to the United States," p. 12, cites a review of studies that provide estimates of the elasticity of demand--a measure of the change in the quantity of a service consumers are willing to buy as the price of the service is changed. Demand is said to be elastic when consumers increase the quantity they purchase by a greater percentage than

as \$50 as the market expands. The industry will attempt to preserve its high profitability by differentiating the services offered to the less price-sensitive--and more profitable--business market from those offered to the newer and more price-sensitive residential market. Aggressive new competition could disrupt this strategy, however, and force prices and monthly revenue per customer down in all markets.

Competition is then the most important factor that will tie together subscriber growth, pricing, and profits for the cellular industry in the future. Morgan Stanley analysts make the point well through a financial modeling exercise.<sup>16</sup> The simulation exercise computes the financial outcomes for a pure cellular telephone firm under different assumptions about the degree of competition in the industry. When the prevailing duopoly is assumed to persist for the remainder of the decade, service prices either maintain their current nominal levels or increase with the rate of inflation. Under these circumstances, the asset value of the firm is estimated to be \$159 to \$188 per person. Monthly revenues per subscriber vary from \$86 to \$103, and the percentage return on investment in physical capital ranges from 61 percent to 88 percent. By contrast, in circumstances where competition is intense, service prices fall and marketing expenses for new subscribers increase. The asset value per person falls to a range of \$72 to \$77. The average monthly revenue per subscribers falls to a range of \$60 to \$73. The return on physical capital falls to 26 percent to 30 percent.

Indications are that competition is coming. Recently, the FCC permitted a specialized

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a given percentage decrease in price. When demand is elastic, total expenditures for the good or service in question will increase as its price falls. The estimates of the elasticity of demand for cellular services range from zero to more than 2. Implicit in the vision of an increasing number of cellular subscribers is an elastic demand for services--the high end of the cited range.

16. Greenberg and Lloyd, *Telecommunications Services, POP Out*, pp. 26-29.

mobile radio (SMR) license holder--Fleet Call, Inc.--to expand its operations and to compete on a limited basis with cellular producers.<sup>17</sup> Before the Fleet Call initiative, SMR license holders provided only dispatch services, such as those between a central station and taxi cabs. If Fleet Call is successful, other SMR license holders may follow its lead. Currently, the FCC is allocating new spectrum for personal communications services, a subset of advanced land-mobile service. New allocations may also become available for satellite systems that could compete at the edge of the market for current cellular services.<sup>18</sup>

### The Next Generation: Under the PCS Umbrella

The success of the cellular telephone industry has shown that a large and growing market exists for mobile communications. Personal communications services denote the broad array of technologies and businesses that some observers see as building on that success, and competing with current cellular providers as the market for land-mobile services expands. The base-case estimate assumes that the frequencies auctioned will be used to provide PCS/advanced land-mobile services, on a common-carrier basis similar to those of currently operating cellular systems. The primary market will be voice, although data and even video segments could grow. The wide range of the estimate of auction revenues is, to a large extent, attributable to uncertainty about the economic prospects of PCS as a common carrier alternative.

**What is PCS?** Bellcore, the research consortium of the regional Bell Operating Companies, offered a typical definition of PCS in a 1991 FCC hearing:

... PCS should provide a telephone quality family of personal and portable services that will enable systems to (1) locate and efficiently route calls to people rather than places, (2) offer advanced call handling services (voice mail, three way calling, call screening, etc.) and (3) transport data as well as voice.<sup>19</sup>

When fully realized, the PCS concept requires integrating wireline and wireless technologies with intelligent networks. Intelligent networks are necessary to follow the person from home, to the street, and to work. They are also needed to sort through the technical and billing challenges that accompany the provision of services in these many different environments.

The market potential and competitive threat to cellular producers posed by PCS is a matter of some debate.<sup>20</sup> Wireless communication is only one link in the PCS chain of services. But the value of the wireless link offered by the holder of an exclusive license can be overstated.<sup>21</sup> Observers skeptical that PCS can repeat the success of cellular telephone services as a common carrier emphasize this point. The manufacturers of telephones and telephone equipment could benefit before the provider of the service. The ownership of the intelligent network and cus-

17. Fleet Call, Inc., "Form S-1 Registration Statement Under the Securities Act 1933," Securities and Exchange Commission (October 18, 1991), pp. 3-13, provides basic data on the company's plans to enter the cellular telephone market.

18. John Schneidawind, "Calling for Change, Cellular for Less?" *USA TODAY* (February 11, 1992), p. 2B, describes a plan by Celsat, a California company, to provide new competitive cellular services in 1993. Not all satellite system operators intend to compete with ground-based cellular systems. Motorola plans to market its Iridium services through current cellular operators.

19. Donald C. Cox, Statement before the Federal Communications Commission en banc Hearing on Personal Communications Services, December 5, 1991, p. 4.

20. "Cellular Carriers Told of Need for New Frequencies to do PCS," *Advanced Wireless Communications* (March 4, 1992), p. 8, outlines a recent debate on this issue at the 1992 conference of the Cellular Telecommunications Industry Association.

21. Herschel Shostek Associates, *Personal Communications Networks: The Economics, Politics and Technologies* (Silver Spring, Md.: Herschel Shostek Associates, LTD., September 1991), Chapter 3.

tomers data files could prove more profitable than either the equipment or communications services. For companies holding other links in the chain, such as long distance carriers, local phone companies, or cable television providers, however, a wireless license could still be of substantial value.

Full realization of a ubiquitous PCS could occur in a single step or in an evolution of ever more available services.<sup>22</sup> Some observers foresee a transition that first extends the usefulness of the cordless telephone from the home to high-traffic public places by the introduction of "telepoint" services.<sup>23</sup> This so-called cordless telephone 2, or CT/2, is currently being offered in the United Kingdom, where its market strength is in question.<sup>24</sup> CT/2 in the United States is envisioned as a service offered in public places, such as airports, that would allow the phone user to make outgoing calls and be charged as would a credit card caller on a conventional public phone. A combination of paging and outgoing call service could follow CT/2, and successive generations of cordless telephones could ensue. An initial improvement would allow the user to be paged, indicating an incoming call. The paging message would include the number from which the call was made. Subsequently, the capability to make and receive calls would probably develop, but would still be limited to the telepoint area.

The full PCS capability will be realized when cell sites are extended beyond public places and the caller is able to use a portable phone virtually anywhere. If that point is reached, PCS could compete seriously with

both cellular telephone producers and local landline telephone companies. Some analysts argue that this potential will cause the intermediate stages of PCS to be skipped over.

**Market Projections.** Projections of the growth of PCS services begin with the cellular telephone industry and wireless communication devices currently in use. The number of pagers is expected to grow at a rate of 9 percent to 11 percent a year, reaching 9 million units by 1993. The growth of private mobile radio units is projected in the same range with an estimate of just under 20 million by 1993. The number of cordless telephones is expected to grow at an even faster rate: more than 20 percent a year to almost 60 million units by 1993. Finally, the number of cellular telephone units is expected to grow at a rate of more than 40 percent, exceeding 25 million units by 1993.<sup>25</sup>

At a recent hearing, a representative of a would-be PCS provider stated to the FCC that in a decade PCS would serve 150 million people worldwide and generate \$50 billion to \$60 billion in revenues. During the same proceedings, Arthur D. Little, Inc. projected revenues of \$30 billion to \$40 billion for services provided to 60 million people.<sup>26</sup> These figures are typical of the communication industry's expectations for PCS. They are also typical of the optimism that pervades groups pleading for a new allocation of spectrum before the FCC. These and other experts assume that PCS services will be priced closer to current residential services than to cellular telephone service.

22. Dennis Lebowitz, Joel Gross, and Eric Buck, *The Cellular Communications Industry* (New York: Donaldson, Lufkin, and Jenrette, Fall 1989), pp. 16-21, and Charles Jackson and Jeffrey Rohlf, "What Can You Do With a Cordless Telephone," 19th Annual Telecommunications Policy Research Conference (September 1991).

23. Arthur D. Little, Inc., Statement before the Federal Communications Commission en banc Hearing on Personal Communications Services, December 5, 1991, for example, finds that the currently available services of paging and cordless telephones restricted to the home will reach their peak share of the market during the

1990s, then give way to newer services. The transitional services of CT/2 and the CT/2 paging combination, are expected to penetrate the market during the 1990s, but be quickly restricted to niche markets as Personal Communications Services microcells become ubiquitous.

24. Lebowitz, Gross, and Buck, *The Cellular Communications Industry* (Spring 1991), p. 29.

25. R.A. Miska, "The Wonderful World of Wireless and the Evolution to Personal Communications," AT&T Bell Laboratories, unpublished briefing, December 10, 1991.

26. A. D. Little, Inc., *Statement*, p. 7.

**Private Investors.** If spectrum were allocated for PCS, the technologies and markets that the PCS concept brings together would help to identify the investors who are likely to bid for assignments. During the FCC proceeding on PCS, McCaw Cellular Communications, Motorola, Apple, Time Warner, AT&T, and Bellcore were all represented.

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*Under the base-case  
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"Pure" cellular companies do not own wirelines. But some operators, like McCaw Cellular, own many local cellular franchises and could seek new licenses to broaden their geographic scope. The traditional wireline telephone companies, in particular the Bell Operating Companies, are also likely to invest for a variety of reasons, not the least of which is the fear that PCS may bypass the local wireline network and make significant inroads into their primary business. Equipment manufacturers may also have an interest in integrating downstream. For example, the proposed Iridium wireless communication system, based on 77 satellites in low Earth orbit, is intended to provide a type of global PCS. An investment in PCS, particularly on a nationwide basis, could fit within Motorola's overall strategy. AT&T, involved in both the manufacturing of equipment and the provision of long distance service, has also expressed an interest. Its

major long distance rivals, Sprint and MCI, could also be expected to invest, if only to keep up with the competition. Time Warner and other cable television producers also are seen as entrants into wireless communications. These firms bring with them the advantages of preexisting cell sites, customer and revenue bases, and billing infrastructures.

If the PCS concept is to succeed, its entrepreneurs must induce both potential cellular and current wireline users to subscribe. The range estimate for auction revenues reflects uncertainty about this outcome. But the base-case assumption of flexibility in the class of service offered should allow producers to capitalize on the trend and perhaps bid the high end of the range. The expectation of substantial competition from current cellular providers and the wireline producers may make bidders cautious, however. As the simulation results for current cellular telephone operators show, financial outcomes can be dramatically different depending on whether a market is competitive.

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## The Base Case

The base case is derived from the proposals to auction new license assignments and the economic context in which they are made (see Table 4 for a summary of the base case assumptions). The economic potential of new technologies and the services that they could provide if spectrum assignments were available motivates regulators to release new spectrum for allocation and assignment. The potential of expanded and improved land-mobile services stands out in comparison with other prospects. Land-mobile services include those currently provided by the cellular telephone industry, as well as the broad array of new PCS services that could be offered in the future.

The base case assumes that the FCC makes available 50 MHz of frequencies between 1.7

**Table 4.**  
**The Base Case: Characteristics and Assumptions**

Characteristic	Assumption
Regulatory Agency	FCC
Market Definition	Land-mobile services
Spectrum Availability and Frequency Locations	50 MHz, located between 1.7 GHz and 2.2 GHz
Number of Franchise Licenses	Two additional licenses of 25 MHz each
Geographic Scope of Franchise Licenses	National, regional, or local
Property Rights Attributed to Franchise Licenses	Identical to current FCC licenses
Permissible Technologies	Current cellular technologies and new PCS technologies
Relocation Costs	New licensees bear responsibility for private license holders
Licensee Qualifications	Identical to current FCC requirements
Auction Form	First-price sealed bid
Payment Scheme	Full payment upon receipt of license
Timing and Revenue Collection	Auction process completed and revenues collected over a three-year period

SOURCE: Congressional Budget Office.

GHz and 2.2 GHz.<sup>27</sup> The amount of spectrum is equal to that currently allocated to cellular telephone service in the 800 MHz to 900 MHz range, and sufficient to allow two new licenses of 25 MHz each to be granted for operation on a local, regional, or national basis. Experiments in new land-mobile services are being actively pursued, under the FCC experimental authorization and pioneer's preference policy, in the area from which the new allocation is drawn.<sup>28</sup>

The area of the spectrum in which the new allocation is made is currently allocated and

assigned to a variety of public and private uses. Both federal and private license holders could be displaced in making the new allocations available for land-mobile services. As proposed in the Administration's budget requests, a two-step process could be used. The cost of relocating displaced federal users is assumed to be a separate issue. It is assumed that the new licensees would bear the responsibility of compensating, or developing a mutually satisfactory sharing scheme with, the displaced private license holder. The new licensees, however, are granted priority over current private license holders after 15 years.<sup>29</sup>

27. Federal Communications Commission, *Policy Statement and Order FCC No. 91-388*, In the Matter of the Commission's Rules to Establish New Personal Communications Services, GEN Docket No. 90-314 RM-7140, RM-7151 and RM-7618 (October 25, 1991), p. 2., suggests an allocation of spectrum between 1.8 GHz and 2.2 GHz.

28. R. Michael Senkowski, John C. Hollar, and Aliza Katz, *Status Report on the Experimental Authorizations and Pioneer's Preference Requests in New Personal Communications Services* (Washington, D.C.: Wiley, Rein, and Fielding, September 1991).

29. "FCC Suggests Incentives for Migrating Microwave Operators," *Advanced Wireless Communications* (March 4, 1992), p. 5, reviews the issue of sharing and compensation. Motorola, "Comments of Motorola, Inc.," before the Federal Communications Commission In the Matter of the Commission's Rules to Establish New Personal Communications Services, General Docket No. 90-314, (December 5, 1991), pp. 20-23, includes a two-step transition plan to make the frequencies from 1.8 GHz to 2.2 GHz available, and a five-year, rather than a 15-year, period of shared use during which the new license holder and the incumbent would negotiate a settlement.

The license that is being assigned by auction is identical in its grant of property rights to current FCC licenses.<sup>30</sup> As NTIA puts it, the license provides a "quasi-property right." The federal government does not recognize the license holder as the owner of the assigned spectrum. The license holder, however, has exclusive use of the assigned spectrum, can profit from its use, and can transfer the license in a sale of its assets to a qualified party with a high expectation of FCC approval. The term of the license is limited to 10 years, the same for the licenses of cellular telephone operators. As with other FCC licenses, the holder can expect the initial license to be renewed on expiration. The assignment will not be subject to reauctioning. The licenses to be assigned are assumed to permit a flexible application of technology to provide the class of services defined by the license. This approach is consistent with the FCC stance toward current cellular licenses and licenses for specialized mobile radio services.

It is assumed that the licenses would be offered to the potential bidders on a local, regional, or national basis. This assumption requires the FCC to assess the results of an auction of local franchises against a national offer for the same frequency assignment.<sup>31</sup> The auction is open to all parties passing a preliminary screening. To qualify, parties must meet the same basic requirements as any FCC license holder. Winning bidders would be subject to a final screening. The auction would be conducted as a first-price sealed bid process. Each bidder would submit a written offer, the highest bidder would win, and the selling price would equal the highest bid.

30. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, pp. 111-114.

31. Sorting through the problem of whether local bids for geographically separated uses of a band of frequencies are greater than a single national bid for the same frequencies is well within current capabilities. Kevin A. McCabe, Stephen J. Rassenti, and Vernon Smith, "Smart Computer-Assisted Markets," *Science* (October 25, 1991), pp. 534-538, poses and offers solutions for far more complex auctioning problems.

The base case assumes that the auctioning process could be completed, and revenues realized, over a three-year period. If the Administration and the Congress were to agree to an auction as specified in the base case by the end of fiscal year 1992, revenues would not be realized until fiscal year 1993 and could even extend into 1995. In the fall of 1991, proposals were made to use auction revenues to offset new spending for extended unemployment compensation. The proposals waived requirements for administrative procedures and parts of the Communications Act of 1934 in order to accelerate the realization of revenues. If these waivers had been included in the base case, some revenues might have been realized in fiscal year 1992. The three-year time assumed in the base case is shorter than that included in some plans, such as the Administration's 1993 budgetary proposal. The reason is that the process of allocating spectrum for new land-mobile uses has already begun. For example, the FCC is currently holding hearings on allocating new spectrum to personal communications systems. The base case assumes three years to allow the FCC to make allocation decisions, to give bidders enough time to learn of the new allocation, and to permit them to raise money to support their bids.

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## Revenue Estimate

Under the base-case assumptions, a spectrum license auction could raise between \$1.3 billion and \$5.7 billion in federal revenues. The range of the estimate is broad enough to reflect the various expectations of competition and risk that bidders could bring to a spectrum license auction. Limiting the population base of the estimate to MSAs--some 193 million people--recognizes the focus of businesses on these markets and the generally lower market potential for the types of services offered under the PCS umbrella in rural

areas.<sup>32</sup> Presenting the estimates on a per-person, or per-pop, basis allows comparison with other evidence and estimates.

The low end of the range is based on the price that specialized mobile radio operators were willing to accept in selling their license rights to Fleet Call, Inc. Fleet Call acquired these licenses hoping to obtain a waiver from the FCC to provide cellular-like service in selected markets. The low end of the range suggests that licenses in those markets are worth \$3.50 a person and reflects the value of new land-mobile licenses to bidders who are expecting dramatic increases in competition in the second half of the decade. In the same markets, the high end of the range is \$15 a person, based on the results of financial modeling exercises that simulate the entry of a firm into the land-mobile communications market. Bidders expect more competition at the high end of the range than is currently evident in the cellular service duopolies, but less competition than that implied by the low-end estimate.

## The Low Estimate

A wave of mergers and acquisitions has rolled through the cellular telephone industry during the past eight years. The prices paid for cellular franchises in these transactions have received considerable attention. A less heralded set of transactions, Fleet Call, Inc.'s acquisition of SMR companies and their licenses, provides data for the low end of the range of CBO's estimate of federal revenues.

The low end of the range is defined by the \$210 million that Fleet Call, Inc., paid SMR operators for the 74 licenses it acquired from 1987 through early 1991.<sup>33</sup> The low end is based on what SMR operators were willing to accept for their rights, not the value of those rights after Fleet Call won FCC approval to offer services in the more lucrative cellular telephone market.<sup>34</sup> The acquisition cost is converted to a value of \$3.50 per person for the 61.1 million potential customers that Fleet Call plans to serve beginning in 1993. The total revenue estimate of \$1.3 billion is obtained by multiplying the per-person value by the population of all metropolitan statistical areas and then by two, to account for the two additional licenses offered under the base-case assumptions. The acquisition cost is only a rough indicator of license value. It overstates the value of the licenses sold because Fleet Call's license holdings include management and operations contracts as well as full ownership.<sup>35</sup> At the same time, the price accepted by SMR operators included payments for assets in addition to the value of the licenses to use the spectrum, most notably equipment and established income-generating businesses.<sup>36</sup>

The low end of the range is probably extreme. It represents an auction at which bidders expect that new entries into the land-mobile services will soon be so pervasive that the current duopoly will become a competitive market. In a highly competitive market the reference point for the value of a license is closer to the price that SMR operators accepted from Fleet Call during a time when SMR market prospects were not as strong as those of cellular.<sup>37</sup> The price that SMR li-

32. See, for example, Mathew Schifrin, "Phone, Phone on the Range," *Forbes* (November 11, 1991), pp. 50-51.

33. Fleet Call, Inc., "Form S-1 Registration," pp. 3-13.

34. Financial analysts placed the value of Fleet Call's licenses at around \$15 per person when the company first publicly offered stock in early 1992. This valuation, unlike that revealed in Fleet Call's initial purchase of licenses, alludes to the potentially more profitable cellular market. The change in the value of the licenses illustrates a spectrum moving from a lower value use to a higher value use under a system of block allocation that encourages flexibility.

35. Fleet Call, Inc., "Form S-1 Registration," pp. 12, 19, and 20.

36. Fleet Call, Inc., "Form S-1 Registration," pp. 35 and 36, describes the company's current SMR business.

37. Following to the FCC's ruling on Fleet Call, the prospects for holders of SMR licenses have dramatically changed. Gary Slutsker, writing in "The Taxicab as Phone Company," *Forbes* (January 6, 1992), p. 41, observes that Motorola and other holders of SMR licenses may follow Fleet Call's lead. Also recently, as noted in

cense holders were willing to accept to part with their licenses is used to represent the value of a license in a smaller and less profitable market. In considering variations on the base case in Chapter 4, the effect of making more land-mobile licenses available than the two assumed in the base case would make a more competitive future more certain and could drive revenues per license toward, and even below, the low end of the range.

The low end of the range is also consistent with a final contingency--that of assertive state regulation of land-mobile service providers. Currently, 10 states regulate the cellular industry, but none has moved to limit profits. Should states move in this direction, bids on new licenses will be lower.<sup>38</sup>

### The High Estimate

The high end of the range of estimated auction revenues is based on financial simulation exercises performed by analysts at Morgan Stanley, Inc. As with the low end, the high end assumes that bids for new land-mobile licenses will reflect an expectation of greater competition than that in the current cellular duopoly. But the high end of the range reflects a lesser degree of competition and consequent willingness of bidders to make higher offers. The high end of the range suggests a value of \$15 a person for the same market as the low end.

The financial simulation results show that a firm entering the land-mobile market could afford \$35 to \$37 a person in capital costs and initial operating losses and still make an after-

tax return of 13 percent to 15 percent, even with prices 35 percent below current levels and customers using 20 percent fewer minutes per month on average.<sup>39</sup> Capital cost for current technology systems are roughly \$10 a person. Even new higher-capacity digital technology is unlikely to cost more than \$15 a person. The high end of CBO's estimate assumes initial operating losses in addition to these capital costs of \$7 to \$12 a person. A new entrant with combined capital costs and operating losses of \$20 to \$22 a person could afford to bid up to \$15 a person for a new license and still achieve the target rate of return in terms of the present discounted value of the license over the life of the firm. Bidders would lower their offers if capital costs and initial operating losses are expected to be higher. If entry could be achieved with a price decrease smaller than 35 percent, a bidder could make a higher offer. The basic idea of the Morgan Stanley work is aptly expressed in the following excerpt:

... someone [an entrant] should be able to earn a decent rate of return on an investment of \$15 to \$20, or even \$35, per pop, when presumably rational businessmen in the past thought the return merited an investment twenty times that.<sup>40</sup>

Morgan Stanley's simulation was for better-than-average markets, imparting an upward bias. The high end also represents some optimism about competitive conditions in the land-mobile market of the future. Bidders could expect returns consistent with bids at the high end of the range, if they assume that new entry into the land-mobile market pro-

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"Digital SMR Consortium Aims for Nationwide Roaming Capability," *Advanced Wireless Communications* (February 19, 1992), p. 3., a group of SMR operators that does not include Fleet Call announced its intention to form a Digital Mobile Network Roaming Consortia to offer their subscribers the same type of seamless national network sought by two contending groups of cellular producers, MaCaw Cellular and a new group including Nynex, Bell Atlantic, and Ameritech among others.

38. Carl Danner, "The Oligopoly Paradox: Cellular Telephones and a Difficult Regulatory Problem,"

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*Journal of Policy and Analysis*, vol. 10, no. 4 (Winter 1991), pp. 671-675, examines various mechanisms to capture cellular rents and suggests that such regulation is under active consideration in California.

39. Greenberg and Lloyd, *Telecommunications Services, POP Out*, pp. 5-7.

40. Greenberg and Lloyd, *Telecommunications Services, POP Out*, p. 6.

ceeds at a slow pace. If a rush of new entrants over the next five years could be avoided, incumbents and winners in the base-case auction would be able to accommodate one another after an initial period of intense price competition. Without that kind of accommodation, unrestrained price competition could drive rates of return and bids toward the low end of the range.

## Other Indicators

The most notable set of indicators excluded from the range of the CBO revenue estimate is the stock prices of cellular telephone companies and the prices paid in recent years to acquire businesses holding cellular telephone licenses. The CBO estimate would be too low by both of these measures. The range of estimates developed by the Office of Management and Budget in support of the budgetary and legislative proposals are closer to CBO's estimate. The results of the New Zealand and United Kingdom auctions suggest caution in estimating the range of revenues that an auction would raise in the United States.

**Acquisition Values.** NTIA has estimated that cellular licenses in the more than 300 MSAs would be worth \$80 billion. The estimate was predicated on a sample of 24 transactions made in 1990. Based on these transactions, NTIA calculated an average per pop value for large, medium, and small areas, as shown in Table 5. Average net values per-pop were obtained by developing estimates of the total replacement cost of tangible assets for each size class of MSA and subtracting the estimate from the gross value estimates for that size class.

NTIA calculated the nationwide estimate of \$80 billion by multiplying the net values by the population in each size class and then multiplying by two to account for the presence of two franchises in each MSA. The NTIA transaction estimate is an upper bound. It is based on a small sample, although many other transactions support the levels used. It

**Table 5.**  
**Per-Person Value of Current Cellular Licenses by Size of Market, Based on National Telecommunications and Information Administration Estimates (In dollars per person)**

Metro-politan Statistical Area Size	Gross Value	Replacement Cost of Equipment	Net Value
Small	131	20	111
Medium	169	14	155
Large	251	19	232

SOURCE: Congressional Budget Office, based on data from Department of Commerce, National Telecommunications and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), Appendix D.

incorporates the value of the existing duopoly regulatory structure, and thus would have to be adjusted downward if conditions closer to a competitive market were to be created by new entrants.

The transaction-based estimate is useful in showing the wide spread of value among different market sizes. This spread is consistent with such factors influencing the demand for cellular services as overall business activity and income.

**Stock Values.** The trading value of the stocks of companies providing cellular telephone services is a second indicator of the value of licenses to provide land-mobile services. NTIA estimated an average per-pop value of \$122 based on the stock values of a sample of 10 pure cellular stocks as of February 8, 1991. An average value per person for the areas served by the 10 service providers was calculated and then multiplied by the population of urban areas (190 million) to produce an estimated value of \$46.3 billion for all current cellular licenses. The estimate of value per person was obtained by multiplying the outstanding shares of each company by its stock price, adding its long-term debt, and then netting out each firm's other assets. The NTIA stock price estimate is based on a small sample that excludes the cellular operations of

wireline telephone companies and other communications firms, such as GTE Corp., that provide services in addition to cellular.

**Why Not?** Competition is the factor that has lead CBO to discount the information provided by acquisitions and stock prices in formulating an estimate of auction revenues. As NTIA recognized in its own analysis, a substantial part of the value evident in acquisitions and stock values can be attributed to the prevailing market structure. As NTIA states,

If additional competitors were to enter the market the profits of cellular providers would presumably fall (*i.e.*, monopoly rents would drop), so that the value of spectrum devoted to cellular uses would likely be lower.<sup>41</sup>

NTIA's analysis of transactions in broadcasting provides an illustrative counterpoint to the value of \$80 billion for the 50 MHz of spectrum allocated for licenses to provide cellular telephone services. Based on 1990 transactions, the value of the over 400 MHz of spectrum allocated to all commercial broadcasting licenses--AM radio, FM radio, and VHF and UHF televisions--was estimated to be \$11.5 billion. This estimate suggests an approximate value of \$1.3 billion for 50 MHz of frequency.<sup>42</sup> Unlike cellular telephone services, broadcasting is already a mature, highly competitive industry.<sup>43</sup> In this environment,

the spectrum allocated for commercial broadcasting is stripped of most of the excess profits that underly the value of the spectrum allocated for cellular telephone service licenses. Although the 50 MHz of spectrum additionally allocated in the base case to land-mobile services will not create a competitive market overnight, the decision by the FCC to make such an allocation would signal the beginning of a policy aimed at creating more competition. Bids for new licenses are more likely to reflect the anticipation of this development than the recent history of high returns guarded by duopoly.

**Office of Management and Budget Estimates.** OMB has produced several estimates of the revenues that new licenses might generate at auction (see Box 2 on page 14). Depending on the specifics of the proposal, assigning about 50 MHz of frequencies for unspecified private use is expected to raise between \$1.9 billion and \$6.8 billion in gross revenues. Under assumptions similar to the CBO base case, those amounts translate into a range of \$5 a person to slightly more than \$17 a person. The low-range estimate for the accelerated process was necessary to provide revenues within one year of enactment. The high end of the range is for a more reasonably paced process and is equivalent to \$150 million per megahertz. No additional detail is available on the process used to produce these estimates. But the OMB range does lie closer to the CBO range than it does to an estimate based on the acquisition value of current cellular licenses or the value of cellular stocks.

**Foreign Experiences.** The auctions for radio spectrum rights and licenses held in New Zealand and the United Kingdom differed in many respects from the base-case auction for which the CBO estimate is made. Neither experience provides direct evidence of how much revenue an auction could raise in the United States. Comparing the actual revenues for the two experiences with preauction esti-

41. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, Appendix D-6, note 17.

42. National Telecommunications and Information Administration, *U.S. Spectrum Management Policy*, p. 91.

43. See, for example, Florence Setzer and Jonathan Levy, *Broadcast Television in a Multichannel Marketplace*, Federal Communications Commission, Office of Plans and Policy, Working Papers Series, no. 26 (June 1991).

mates suggests caution and lowered expectations in the U.S. context. In New Zealand, estimates before the auction were projected at NZ\$240 million, but actual revenues were only NZ\$36 million to NZ\$40 million.<sup>44</sup> Revenues were also overestimated in the United Kingdom, where £250 million was anticipated before the auction, but the sale produced only £40 million.<sup>45</sup> In New Zealand, a large disparity was also evident in the actual prices paid for nearly identical cellular telephone bands, with one assignment fetching NZ\$25.2 million and another only NZ\$5,000.<sup>46</sup>

In each case, extenuating circumstances might explain why actual revenues fell below expectation. In neither auction was the highest bid for a particular opportunity always ac-

cepted. In the United Kingdom, public interest standards and financial requirements intervened, while in New Zealand, antitrust considerations were a significant factor. The thinness of the New Zealand market--the absence of bidders--probably contributed to the wide disparities in bids, prices, and revenue expectations. Simply put, there were too few bidders, bidding on too many licenses. Some of the disparities might have been avoided had the New Zealand auction specified a reservation price--a minimum bid--for each license or management right. Although the particular circumstances might not repeat themselves in the United States, the message is clear: expectations of auction revenues may be overblown; a conservative estimate may be best.

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44. Milton Mueller, *Reform of Spectrum Management: Lessons from New Zealand* (Los Angeles: The Reason Foundation, November 1991), p.19.

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45. "And the Winners Are ...." *The Economist* (October 19, 1991), p. 67.

46. Mueller, *Reform of Spectrum Management*, pp. 20-22.

# Varying the Base-Case Assumptions: Theory and Evidence

Varying the major assumptions of the base case could affect the range of the CBO revenue estimate and, in some instances, would imply a significant change in the federal government's spectrum management policy. The base case is built on assumptions defining the characteristics of spectrum licenses, the bidding process by which they would be sold, and the universe of potential bidders. The range of the CBO revenue estimate depends on these assumptions. The consequences of changing the assumptions underlying the range of the base-case revenue estimate can only be addressed in general terms. The effects cannot be measured with precision because the range is not the product of a formal model. In some cases, however, it is possible to determine whether auction revenues would be most likely to increase or decrease when a particular assumption is changed.

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## Assumptions Defining Spectrum Licenses

The base case assumes that the Federal Communications Commission makes 50 MHz available to land-mobile services and auctions two licenses to provide these services. Five major assumptions define the characteristics of these licenses: first, each license grants its holder the exclusive use of 25 MHz of spectrum; second, each license is located on fre-

quencies between 1.7 GHz and 2.2 GHz; third, each license is offered on a local, regional, or national basis; fourth, each license carries renewal expectations identical to current FCC licenses; and fifth, each license allows considerable flexibility concerning decisions about the adoption of technology and the provision of specific land-mobile services. Renewal expectations and user flexibility partially define the property rights granted by each license.

## Changing the Amount of Spectrum

The amount of spectrum offered in the base case could be varied by offering a different number of licenses, each covering the same amount of spectrum, or by changing the amount of spectrum covered by each license, holding the total number of licenses fixed. As long as each license provides enough spectrum to enter the land-mobile market, changing the number of licenses is likely to have a more significant effect on federal revenue than changing the amount of spectrum covered by each of a fixed number of licenses. Competition--as implied by the number of franchises in each market--is the key factor driving spectrum values in the CBO approach.

For example, suppose that the FCC allocated 100 MHz of frequency to new land-mobile services rather than the 50 MHz assumed in the base case. Creating four rather than two 25 MHz licenses would promote competitive behavior; each license holder

would face more rivals. Price competition, in particular, would be a likely response. With more providers in each area, expected profits would be lower.<sup>1</sup> Consequently, spectrum licenses would be worth less to potential bidders, and auction receipts would be expected to decline from the base-case revenue estimate. The alternative variation, doubling the size of each license by offering two 50 MHz licenses rather than two 25 MHz licenses, would increase the service capacity of each provider but would not affect the total number of franchises in each market. The increase in capacity could be profit-enhancing, but it is doubtful that doubling the size of each license would double the value of each license.

Similarly, if less spectrum were made available and each license were assigned less frequency, auction receipts might be somewhat lower but not dramatically so. For a moderate decrease in the size of each license, such as an offer of two 15 MHz licenses rather than two 25 MHz licenses, receipts would not be likely to change appreciably. The winner of a 15 MHz license could create a successful land-mobile communications business by investing in advanced analog or digital systems that cost only slightly more than existing technologies, but provide more carrying capacity than current cellular systems. Fleet Call, Inc., anticipates creating such a business with even less spectrum in each of the six markets it plans to enter.

Trade-offs between monopoly rents, auction receipts, and economic efficiency are evident. Current FCC regulations and license assignments limit competition and enhance profit-making opportunities in the market for land-mobile services. By limiting the number of providers in each market, the regulatory system has created a source of excess profits. These profits, in part, determine the value of each spectrum license. If the FCC offered additional licenses, the economy would bene-

fit--more licenses would promote competition and efficiency--but competitive pressures would reduce or eliminate monopoly rents. With each additional license, the bidding process would generate less revenue. However, the economic value of improvements in efficiency would probably outweigh the difference in auction receipts.<sup>2</sup>

## Higher Frequencies

Another variation on the base case would be to offer licenses from the high frequency end of the spectrum. The history of spectrum use has been one of "climbing" up the spectrum to use ever higher frequencies for communications purposes. For example, AT&T and others are actively involved in research to use spectrum in the neighborhood of 6 GHz for PCS data services.<sup>3</sup> If spectrum from higher frequencies were offered for assignment, the auction would probably generate receipts below those estimated for the base case. Technical uncertainty would draw fewer bidders to the auction, and those that participated would face relatively high research and development costs. Fewer participants facing higher costs would result in lower bids.

## Local, Regional, or National Licenses

The base-case assumptions allow bidding on a national, regional, or local basis. The base case assumes that the FCC would sort through the offers and choose the option producing the most revenue. The estimate of revenues for the base case is wide enough to encompass various outcomes. Nevertheless, the question of whether local or national licenses are more valuable is important.

1. For a discussion of firm-level and industry-wide profits in a formal economic model, see Jean Tirole, *The Theory of Industrial Organizations* (Cambridge, Mass: MIT Press, 1988), pp. 218-221.

2. The trade-off between auction receipts and efficiency could be small. If potential bidders anticipate the "camel's nose," they will anticipate that more licenses will be auctioned in the future, and will offer less for each license in the current period, even if very few are offered.

3. Edmund L. Andrews, "Seeking to Use More of the Radio Spectrum," *The New York Times* (September 11, 1991), p. D2.

A series of local auctions, each one offering a license with access to a single local market, could generate more total revenue than a single auction offering a license with access to the national market. The number of bidders in an auction for a nationwide license could be limited by the availability of (or access to) investment capital. If that were the case, more bidders could participate in each local auction than in a national auction. Economic theory indicates that an auction in a "thin" market--a market with few bidders--would generate less revenue than an auction in a market with many bidders.<sup>4</sup> The receipts from a single nationwide auction, with a low level of participation, could be less than the sum of the receipts from a combination of local auctions. The effect could be compounded if the value of a particular local license is not the same for all bidders. For instance, pure cellular telephone companies may place very high values on particular areas that are geographic complements to their current operations. If specific bidders place a higher value on many of the local licenses, the sum of the winning local bids could exceed a national offer.

The bid offered for a nationwide license could exceed the sum of bids for local licenses, if, as many industry analysts indicate, the expected profit from a national operation exceeds that from all local operations.<sup>5</sup> Economies of scale in operating costs could generate this result.<sup>6</sup> The sources of such scale economies could include volume discounts in purchasing equipment, lower development cost for intelligent networks, and lower advertising and marketing cost per subscriber. In addition, gains from providing

better services through an extensive system of access for customers--a potentially "seamless" network--could result in a higher national bid.

### The Property Right Granted by the License

The "property right" granted by a franchise license describes the user's freedom to select technologies and services within a specified range of permissible options. The licenses auctioned under the base-case assumptions, while granting flexibility, do not approach the "spectrum rights" granted in New Zealand. The property right also describes the expected term of the license: the period over which the license is issued and the licensee's expectation of renewal. The licenses auctioned under the base case are offered with a high expectation of renewal. That is, it is expected that the licenses will not be auctioned again when they expire. Changing these conditions would represent a major change in U.S. spectrum management policy. Expectations for renewal and flexibility have important implications for federal revenues and economic efficiency.

**Spectrum Rights and Management Flexibility.** Offering spectrum rights that are more like property ownership than current licenses would probably increase the bids offered at auction. The owner of a spectrum right would have the options of subdividing and leasing rights to second parties and splitting the assigned frequency among different uses. If a right were granted nationally, these options could be pursued simultaneously at local, regional, or national levels. Because the owner of a spectrum management right has more options open, the owner can be more certain of future profits and bid higher.

Rigidly defining the classes of service permitted by the license would lower revenues and, just as important, could hinder economic efficiency. For example, if the license were to require an immediate jump to full PCS capability without permitting operators to begin with limited telepoint services, fewer

4. R. Preston McAfee and John McMillan, "Auctions and Bidding," *The Journal of Economic Literature*, vol. xxv, no. 2 (June 1987), p. 711.

5. Joel D. Gross, "Will AT&T Play a Major Role in the Evolution of the Nationwide Seamless Wireless Network?" (New York: Donaldson, Lufkin, and Jenrette, October 21, 1991), provides an overview of one firm's interest in nationwide wireless networks.

6. The assumption that the anticipated scale effect would outweigh any potential thin market effect is implicit in this result.

bidders would be willing to risk the initial investment necessary to bring PCS to the market. Revenues would probably be lower. Restricting flexibility could have a negative impact on developing an efficient land-mobile market. If the license were to require full compatibility with existing cellular systems, the requirement might increase competition in the short run, but it would lock new players into existing technology. If the FCC defines rigid classes of permissible services, license holders may have difficulty adapting their services to meet the evolving needs of private and public consumers.

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*Auctions are common  
in a variety of  
government-managed  
distribution processes.*

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**Renewal Expectations.** Under the base-case assumptions, licenses permitting the exclusive use of a frequency assignment are granted for a fixed term, but renewal is virtually certain. Alternatively, as in the United Kingdom and New Zealand, licenses could be auctioned again when they expire.

A reauctioning policy could affect auction receipts and capital investment decisions, and would almost certainly add to the costs of public and private transactions.<sup>7</sup> The term of the license would, in part, determine the revenue and investment effects. If the term is sufficiently long to allow the winning bidder to recover the value of his or her initial capital investment, the loss of efficiency in the initial investment decision--the tendency to underinvest--would probably be small.<sup>8</sup> A long-term license would be almost as valuable as

one with a high expectation of renewal. Bidders base their rate of return calculations on the discounted value of expected profits and, at a discount rate of 10 percent, \$1 of profit earned 20 years in the future would be worth only 15 cents today.<sup>9</sup> Thus, profits anticipated in the distant future would have a very modest effect on the value of a license and, as long as the expiration date of the license is set in "the distant future," a reauctioning policy would have a negligible effect on auction receipts.

An issue that is usually raised about license renewal and reauctioning policy is its potential to slow improvements in technology and investment in new capacity. Uncertainty about whether the license holder will be successful in bidding for renewal could discourage the licensee from making new investments in technology as the expiration date approaches. A potential entrant seeking to win a license from an incumbent, however, could be forced to innovate to enter the market. Moreover, a losing incumbent and a successful bidder would both have incentives to make a deal to transfer useful capital assets to the new license holder. This salvage value would help counter the incumbent license holder's concern about losing the value of investments made toward the end of the license term.

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## Assumptions Defining the Bidding Process

The base case assumes that the FCC uses a first-price sealed bid auction. There are, however, three principal alternatives to the first-price sealed bid form: the English auction, the Dutch auction, and the second-price sealed bid auction. The base case assumes that the FCC allows broad participation among private

7. New Zealand Ministry of Commerce, *Management of the Radio Frequency Spectrum in New Zealand*, prepared by National Economic Research Associates (November 1988), pp. 155-156.

8. New Zealand Ministry of Commerce, *Management of the Radio Frequency Spectrum in New Zealand*, p. 155.

9. Typically, investment analysts assume discount rates of 10 percent to 12 percent a year. See Edward M. Greenberg and Catherine M. Lloyd, *Telecommunications Services, POP Out: The Changing Dynamics of the Cellular Telephone Industry*, p. 27, and Dennis Lebowitz, Joel Gross, and Eric Buck, *The Cellular Communications Industry* (New York: Donaldson, Lufkin, and Jenrette, Spring 1991), p. 43.

bidders, but does not assume any special provisions explicitly promoting the participation of small firms. In varying the base-case assumptions, bidding restrictions and small-firm provisions could be included in the bidding process.<sup>10</sup>

Economic theory and the experience of governments in auctioning spectrum assignments and other resources offer insight into the question of auction form, but neither provides a definitive answer. Generally, analysts have found that each auction must be tailored to the commodity being offered, taking into account its specific characteristics and its industry.<sup>11</sup> The probable effects of restrictions on participation are relatively clear cut. Lower auction receipts would be expected if the FCC restricts participation in the license auction. If the FCC includes small-firm provisions, such as set-asides or deferred payments, lower or delayed receipts would also be expected. The benefits of participatory restrictions and small-firm provisions to satisfy antitrust concerns or to ensure that small businesses receive some fraction of the new licenses should be evaluated against the prospect of lower or delayed revenues.

## Auction Forms: Receipts and Economic Efficiency

To many, the word "auction" invokes images of oral bidding in warehouses and, to others, images of artwork on the block. Although these images draw from reality, they are incomplete. Competitive bidding processes (oral, silent, written, and sealed) play an important part in a remarkable array of private and public transactions. Auctions are common in a variety of government-managed distribution processes. In the U.S. public sector, the federal government uses auctions to distribute procurement contracts, financial instruments, and natural resources.<sup>12</sup> In New Zealand, the Ministry of Commerce used a series of spectrum auctions to distribute UHF television and cellular frequencies, microwave bands, and AM and FM broadcasting bands.<sup>13</sup>

Unique rules and procedures define each of the four principal auction forms. The English auction is "open" and interactive; participants typically submit oral bids. This form is often referred to as an "ascending-price" auction; the asking price rises until bidding stops; the final bid wins.<sup>14</sup> The Dutch auction, also "open," reverses the English procedure. Referred to as a "descending-price" auction, the Dutch auction drops the asking price until the first bid is offered; the first bid wins.<sup>15</sup> In both cases, the highest bid, whether it is the last or the first, determines the selling price. The first- and second-price sealed bid auc-

10. This section draws heavily from previous research. Key sources include Vernon L. Smith, "Auctions," in John Eatwell, Murray Milgate, and Peter Newman, eds., *The New Palgrave Dictionary of Economics* (New York: The Stockton Press, 1987), pp. 138-144; McAfee and McMillan, "Auctions and Bidding," pp. 699-738; Paul R. Milgrom, "The Economics of Competitive Bidding: A Selective Survey," in Leonid Hurwicz, David Schmeidler, and Hugo Sonnenschein, eds., *Social Goals and Social Organizations* (Cambridge, U.K.: Cambridge University Press, 1985), pp. 261-289; Paul Milgrom and Robert J. Weber, "A Theory of Auctions and Competitive Bidding," *Econometrica*, vol. 50(5) (September 1982), pp. 1089-1122; and William Vickrey, "Counterspeculation, Auctions, and Competitive Sealed Tenders," *Journal of Finance*, vol. 16(1) (March 1961), pp. 8-37. In varying degrees, the authors review each of the principal auction forms. They describe and interpret the conditions under which the forms yield, on average, equivalent outcomes, and they compare the results, in application, of each auction form.

11. Walter J. Mead, "Natural Resource Disposal Policy--Oral Auction vs. Sealed Bids," *Natural Resources Journal*, vol. 7(2) (1967), pp. 194-224.

12. The Forest Service uses English auctions in the second stage of the two-stage timber auction, while the Department of the Interior uses first-price sealed bid auctions to distribute off-shore oil leases, and the Treasury department uses a multiple-unit, first-price sealed bid auction to sell short-term securities.

13. The Ministry of Commerce employed a series of second-price sealed bid auctions to distribute 448 MHz of radio spectrum.

14. The auctioneer begins the English auction with a relatively low asking price, often the lowest price that the seller will accept--a reservation price.

15. The auctioneer begins the auction with a relatively high asking price--one that is well above the object's anticipated selling price. The auctioneer lowers the asking price at a steady rate, often using an electronic clock-like mechanism, until someone places a bid.

tions are "closed"; each participant submits a written bid. In the first-price auction, the highest bidder wins the auction and pays a price equal to his or her bid. In the second-price auction, the highest bidder wins the auction but pays a price equal to the second highest bid. Each of the four principal forms can be modified to accommodate single-unit or multiple-unit transactions.

Does the form of the auction matter? In many cases, the answer is yes. Under highly restrictive and often unrealistic assumptions, a simple economic model demonstrates that the English, Dutch, first-price sealed bid, and second-price sealed bid auction forms yield the same expected revenues and the same expected distribution of commodities.<sup>16</sup> However, the relevance of the model depends on the nature of the commodity and the character of the market. In most circumstances, some if not all of the assumptions underlying the model are violated. Case by case, the problem lies in recognizing which assumptions are unrealistic and then selecting the auction form that is most likely to produce the most desirable results.

Three major departures from the assumptions embedded in the simple model are evident in the market for licenses to provide land-mobile services. These are uncertainty about the "true" value of each license, the possibility of collusion among bidders, and the fact that not all bidders share the same basic characteristics. Theoretical research, unfortunately, provides no clear guide to the best choice of auction form when two or more departures are evident in the same market. The search for a simple and expedient process of distribution compounds the problem. The first-price sealed bid auction may be preferable on grounds of clarity and administrative ease. Procedurally and administratively, it is the simplest of the closed-form auctions.

**Market Value Uncertainty.** If the value of an object is defined by a unique "true" market

value--a value that is common to all potential bidders--but if that value is subject to uncertainty, economic theory suggests that an open bidding process, specifically the English auction, may be the best way to obtain the most auction receipts.<sup>17</sup> Key sources of uncertainty in the market for land-mobile services include the future of technology and the impact of a potentially radical change in market structure. If the common value of an asset is uncertain, theory indicates that the base-case assumption of a first-price sealed bid procedure ranks third among the four principal forms. The first-price sealed bid auction ranks no better or worse than the Dutch auction and, among the sealed-bid procedures, the second-price auction ranks above the first-price form (see Box 4).

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*Market diversity  
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policy.*

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**Collusion.** In a potentially collusive market--usually a thin market in which a cartel can readily coordinate its activities--closed auctions are generally preferred to open auctions.<sup>18</sup> A cartel's ability to maintain a collusive agreement is only as strong as its ability to observe the behavior of its members and to hold them accountable for their actions. Accountability requires a credible retaliatory threat; violations of the collusive agreement must be punishable. If such violations are un-

16. When each form generates the same expected revenue, "revenue equivalence" is said to hold.

17. This is also the case if the value of the object is partly defined by a common element and partly by an element that is specific to each potential buyer; see Milgrom and Webber, "A Theory of Auctions and Competitive Bidding," pp. 1089-1122. McAfee and McMillan, "Auctions and Bidding," p. 722, ranks the four principal auction forms.

18. McAfee and McMillan, "Auctions and Bidding," pp. 724-725.

**Box 4.****Value Uncertainty, Bidding Behavior, and Auction Form**

When the market value of an object is uncertain, each bidder must estimate the object's true worth. In the presence of uncertainty, theory indicates that, on average, the highest estimate will be *too* high. If the bidder with the highest estimate offers the highest bid, and the highest bid is the winning bid, then on average, the winning bid will also be *too* high. Economists refer to this phenomenon as the "winner's curse." Typically, each bidder recognizes the danger of the winner's curse and adjusts his bid downward. To the extent that the uncertainty surrounding the value of the object can be eliminated, the problem of the winner's curse can be avoided. Information can be used to reduce uncertainty and, in general, more information is better than less.

Why then does the English auction rank above each of the available alternatives? In the English auction, the bidding process conveys information. The "open" format is interactive--each new bid contains and communicates information. The bidding process reduces the level of uncertainty surrounding the value of the object.

Among "closed" bidding procedures, the second-price sealed bid auction ranks above the first-price form when the most revenue is desired. Although the second-price auction is sealed, the process reduces the impact of value uncertainty on bidding behavior. The second-price auction limits the strength of the winner's curse by assuring that the winning bidder will pay no more than the value of the asset to the second highest bidder. The winning bidder will always pay a price less than the amount of his own bid.

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SOURCES: Paul Milgrom and Robert J. Webber, "A Theory of Auctions and Competitive Bidding," *Econometrica*, vol. 50(5) (September 1982), pp. 1089-1122; James L. Smith, "Non-Aggressive Bidding Behavior and the 'Winner's Curse,'" *Economic Inquiry*, vol. 19 (July 1981), pp. 380-388; R. Preston McAfee and John McMillan, "Auctions and Bidding," *The Journal of Economic Literature*, vol. xxv, no. 2 (June 1987), pp. 699-738; and New Zealand Ministry of Commerce, *Management of the Radio Frequency Spectrum in New Zealand* (November 1988), pp. 131-132.

detectable or unpunishable, the cartel will falter. Thus, a cartel can best succeed if the bidding process is open. However, such an arrangement can also succeed if the bidding process is closed but the magnitude and source of each bid are revealed.

Evidence from the telecommunications industry suggests that there may be reasons to take precautions against collusion--explicit or tacit--in an auction for new land-mobile licenses. Mergers and acquisitions have been a significant factor in the cellular telephone service industry. The regional Bell Operating Companies and the large independent McCaw Cellular have amassed a substantial share of the nationwide market. These developments, along with a history of monopoly behavior in the telecommunications sector (the Bell System monopoly on wireline services is an example), raise concerns that the market for new land-mobile licenses may be potentially collusive.

The assumptions of the base case provide a reasonable guard against collusion. Economic theory indicates that the first-price sealed bid auction offers protection against market collusion, even when uncertainty about value is an issue.<sup>19</sup> To avoid a thin market, the base case allows broad participation in the bidding process. Restrictions on participation could increase the prospect of at least tacit collaboration. The base-case assumption that licenses would be offered locally and nationally, with the highest bids making the final decision, also guards against collusion. Coordinating a cartel would be difficult under these conditions.

**Characteristics of Bidders.** If the bidding population can be divided into two or more "types" or categories, the form of the auction

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19. Marc S. Robinson, "Collusion and the Choice of Auction," *Rand Journal of Economics*, vol. 16(1) (Spring 1985), pp. 141-145.

can influence the outcome of the bidding process. Economic theory, however, does not indicate the clear superiority of any one form.<sup>20</sup> Potential bidders in the land-mobile market fall into several distinct categories. On a local basis, each potential bidder is either an incumbent elsewhere, or a new entrant in the industry. On a local or national basis, telephone companies, cable television providers, equipment manufacturers, and pure cellular companies each display different entrepreneurial advantages.

When potential bidders fall into distinct categories, the English auction is efficient: it awards the license to the bidder who values it most, but it does not yield the same expected revenue as the first-price sealed bid auction. Comparing the first-price sealed bid and English auctions, the revenue yield is ambiguous. The first-price auction may generate more revenue than the English auction, but it may be inefficient--the bidder with the highest valuation may fail to obtain the license. Under limited conditions, a revenue-maximizing auction would discriminate among different types, or classes, of bidders.<sup>21</sup> In a market with only two bidding types, the auction would favor the class with the lower valuation. This process, according to McAfee and McMillan, "forces the bidders from the higher valuation class to bid higher than they otherwise would."<sup>22</sup> But a "preferential treatment" policy increases the likelihood that the award will be inefficient.<sup>23</sup>

Faced with a variety of concerns, collusion and value-uncertainty among them, the second-price sealed bid auction might present a workable compromise. The second-price auction, however, "leaves money on the table." When the process is complete, it leaves a visible gap between the highest and second highest bids. If this gap is large, it can be politically embarrassing. For example, in bidding on a UHF television station in the Christchurch area of New Zealand, the highest bidder offered NZ\$100,004 but paid only NZ\$6, the offer of the second highest bidder.<sup>24</sup> The thinness of the New Zealand market and the absence of a reservation price probably explain this result, but the embarrassment remains. Although it is likely that these particular conditions would not be repeated in the United States, since the market is larger and reservation prices could be specified, the example provides a dramatic warning. Simplicity and the lack of a definitive alternative make the first-price sealed bid auction the preferred form for the base-case scenario.

## Market Participation

In recent years, the United States has deregulated much of its telecommunications industry. The breakup of the Bell System's monopoly of wireline service is a notable example. The concern of policymakers that monopoly not reassert itself through the licensing of wireless alternatives could lead them to restrict participation in an auction for new land-mobile licenses. Restrictions on participation would probably reduce auction receipts.

Market diversity has long been a goal of U.S. telecommunications policy. Some ob-

20. McAfee and McMillan describe trade-offs between auction forms, "Auctions and Bidding," pp. 714-715.

21. McAfee and McMillan, "Auctions and Bidding," pp. 715-716, notes these conditions: markets must prohibit arbitrage, and the distributions of valuations in each bidding class must have the same variance but different expected values.

22. McAfee and McMillan, "Auctions and Bidding," p. 715.

23. McAfee and McMillan, "Auctions and Bidding," pp. 715-716.

24. Milton Mueller, "Reform of Spectrum Management: Lesson from New Zealand" (Los Angeles: Reason Foundation, November 1991), p. 21.

servers extend this concept to a mixture of large and small telecommunications providers. It has been suggested that licenses for small firms be set aside, that providers be allowed to make payments over time, or that royalties be included in the competitive bidding process.<sup>25</sup>

**Restrictions on Participation.** Among the options are limiting participation in auctions to new licensees who do not currently hold cellular licenses, or excluding entirely or limiting the participation of AT&T and the Bell Operating Companies. As indicated, the force of competition in the land-mobile market probably makes such prohibitions unnecessary. The relationship between bidding restrictions and auction receipts is relatively clear; in a comparatively thin market, auction receipts would almost certainly be lower.

**Spectrum Set-Asides.** Enacting "set-asides"--assignments limited to small firms--could decrease spectrum auction revenues. Set-asides would not restrict participation in the spectrum auction, but would reduce the number of likely participants (small firms with sufficient access to set-asides would find the bidding process unnecessary), as well as access to the set-aside component of the spectrum. Reducing access to the set-aside component of the spectrum could affect economic efficiency; if the user who values the assignment most does not qualify for licensing (for instance, if the user is too large), the assignment would be inefficient.

**Alternative Payment Provisions.** Enacting alternative provisions for payment, such as deferred payments or royalty payments, could decrease or delay the revenues produced by a spectrum auction. A provision for deferred payment would allow the winning bidder to make payments on a fixed bid over time. In effect, the federal government would act as a creditor. A provision for deferred payment would delay the revenues produced by a spectrum auction.

In some regards, royalty payments represent a variation of the deferred payment proposal. Suppose that the bidding mechanism were to include an up-front payment (equal to the full value of the winning bid) and a fixed royalty rate. The total payment to the seller would equal the sum of the initial payment and all future royalty payments. The value of the winning bid would equal the discounted present value of the expected return to the spectrum license (over the life of the license), net of anticipated royalty payments, and would be lower than it would have been without the anticipated royalty payments. Thus, the royalty provision would, in effect, spread total payments over a period of time, and thereby diminish the importance of "up-front" financing in the bidding process.

Royalty payments are not without drawbacks, however.<sup>26</sup> For example, if royalty payments are tied to the output of the winning bidder, or to output-related revenue, then the fixed royalty rate will act as a tax on the output of the firm. In this case, a royalty provision would distort the winning bidder's production decision. Furthermore, like deferred payments, royalty payments would reduce the immediate flow of funds to the Treasury.

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25. Herbert P. Wilkins, Statement before the Federal Communications Commission en banc Hearing on Personal Communications Services, December 5, 1991, p. 1. For a discussion of royalties and fixed bids, see Department of Commerce, National Telecommunication and Information Administration, *U.S. Spectrum Management Policy: Agenda for the Future* (February 1991), pp. 109-110.

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26. McAfee and McMillan, "Auctions and Bidding," pp. 717-718.







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