CBO PAPER

COMPLETING THE TRANSITION TO
DIGITAL TELEVISION

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NOTE

The numbers in the text and tables of this paper may not add up to totals because of rounding.

PREFACE

Regulatory actions by the Federal Communications Commission (FCC) in conjunction with the Telecommunications Act of 1996 and the Balanced Budget Act of 1997 establish a framework for shifting the nation to a new form of television broadcasting. Within that framework, current television broadcasters receive a second channel for broadcasting digital television (DTV) signals to facilitate a transition from the current analog system to newer, more efficient digital broadcast technologies. The transition will free up significant amounts of valuable radio spectrum that the FCC can reallocate to nontelevision uses. The Balanced Budget Act directs that significant portions of the spectrum made available by the transition be auctioned no later than 2002. At the request of the House Committee on the Budget, the Congressional Budget Office (CBO) has analyzed factors that affect the timing of the transition to digital television—in particular, whether the transition is likely to continue beyond the currently scheduled end date of December 31, 2006. In keeping with CBO's mandate to provide objective, impartial analysis, this paper makes no recommendations.

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SUMMARY

For over half a century, television in the United States has been broadcast in an analog format, in which the electrical impulses that make up the programming are converted directly to radio waves for transmission. Now, at the direction of the Congress and under the management of the Federal Communications Commission (FCC), the country is engaged in a transition from analog broadcasting to one that uses a digital format, in which information is first converted to a series of zeroes and ones and then to radio waves. The new digital television (DTV) technology will allow better-quality TV pictures, a significant increase in the amount of TV programming available to consumers, and an array of new services provided by broadcasters (such as enhanced weather and traffic reporting). In addition, moving to the new system will free up a significant amount of radio spectrum for new uses. (The radio spectrum includes the blocks of frequencies over which TV stations broadcast their signals. Because digital TV signals tolerate interference better than analog signals, more DTV stations can be "shoehorned" into less spectrum than analog stations would occupy.) The FCC will auction licenses for the new commercial uses of current broadcasting spectrum—for additional television channels, nontelevision uses, or a combination of the two—with the proceeds going to the federal government.

To realize the benefits of the new digital broadcasting technology, both broadcasters and viewers must make additional investments. Those expenditures will not be made without the prodding of the government, largely the FCC, because the incentive for any one broadcaster or viewer to spend money on new digital technology depends on the decisions of others to do the same. Moreover, the incentives motivating viewers and broadcasters do not include the benefits to society of freeing spectrum for new uses. The framework of regulations and laws that directs broadcasters and viewers to move from analog to digital television establishes a process and timetable governing that shift. In this paper, the period during which broadcasters simultaneously transmit the older analog and newer digital signals is referred to as the transition to digital TV.

The Congressional Budget Office's (CBO's) initial estimate of the revenues from the auction of licenses to use radio spectrum formerly dedicated to analog television—$6.1 billion—was based on a number of assumptions, one of the most important of which was that the transition to digital TV would be successfully concluded by the end of 2006. It now appears likely that the transition will extend beyond 2006 in most markets, with its ultimate end date uncertain. Current law specifies that the receipts from auctioning licenses for spectrum freed by the

transition must be deposited in the Treasury by September 30, 2002. Extending the transition beyond 2006 and conducting the auctions required by current law would probably decrease receipts because it would increase the time between the auction and when the winning bidders could expect to fully use the spectrum covered by their licenses (and begin profiting from it). For example, if bidders expect an annual return of 10 percent on their spectrum investment, each year of delay could reduce the value of—and ultimately federal receipts for—licenses by approximately 10 percent. This paper examines the current status of the transition to digital television and concludes that it is likely to extend beyond 2006. The paper does not present estimates of auction receipts.

The transition will almost certainly continue beyond 2006 in any television market in which less than 85 percent of television households—the legally mandated goal for ending the transition—are considered DTV households. Currently available evidence suggests two reasons the 85 percent goal is unlikely to be met by 2006. First, the availability of DTV programming on cable systems, which is crucial to meeting the goal, is an unsettled question. Second, the adoption of digital TV by households that do not subscribe to a multichannel video programming distributor (MVPD) such as a cable or satellite service is uncertain. In choosing not to pay for their TV viewing, those households would appear to have a relatively low demand for video programming services. Yet in order to reach the goal of 85 percent market "penetration" signaling the end of the transition, some of those households will almost certainly have to adopt digital TV. Ironically, households that value television the least may be critical in determining when all viewers and society in general receive the full benefits of the new digital broadcast technology.

BACKGROUND

The transition to digital TV is governed by an FCC regulatory proceeding initiated in 1987 and two more recent laws, the Telecommunications Act of 1996 and the Balanced Budget Act of 1997 (BBA). In 1995, the FCC accepted industry-developed technical standards for digital television and decided to grant a second channel to each analog television licensee to begin digital broadcasting for a transition period, originally envisioned to last 15 years. In the Telecommunications Act, the Congress directed the FCC to provide the second, digital channel to existing broadcasters free of charge for advertiser-supported digital broadcasting. The BBA specified conditions under which the transition to digital TV would be completed by the end of 2006. The pivotal one was a market penetration threshold of 85 percent: analog stations would be turned off at the end of 2006 in any market in which 85 percent of television households were able to receive DTV signals. The BBA also directed that licenses to use the portions of spectrum that would ultimately be freed by ending analog broadcasting, regardless of when that occurred, be auctioned early enough to allow receipts to be deposited in the Treasury by September 30, 2002.

Although the details and timing of the transition to digital TV will continue to unfold over the next few years, policymakers, regulators, and industry experts agree on the generic process of shifting from a TV industry based on analog broadcasts to one based on digital signals. In the initial stages of the transition, early adopters of digital TV would purchase so-called high-end DTV sets. Like the first generation of color TVs or personal computers, those sets would be the most expensive ever. Early adopters would have only limited choices in the over-the-air digital programming they could view because at the beginning of the transition, programming that fully exploited the possibilities of the new technology would be scarce. As the transition proceeded, more stations would begin broadcasting a second, digital signal; more households would purchase DTV sets; and broadcasters would begin to offer more new programming. With time, the prices of sets would fall, and more consumers would join the DTV audience. At some point in the transition, digital programming would become available over cable systems and through other MVPDs—either because of regulatory requirements or consumer demand—which would further encourage consumers to purchase DTV sets. Finally, once enough consumers in a market were able to view the digital broadcasts, the older analog signals would be turned off and additional new digital TV stations created. At that point, a portion of the radio spectrum currently dedicated to over-the-air TV broadcasting could be reallocated to other valuable uses.

The above description seems clear and straightforward, but in reality the transition to DTV is a classic chicken-and-egg problem. Broadcasters do not have an immediate incentive to spend money upgrading their facilities for digital broadcasts if no viewers have TV sets capable of receiving them. Likewise, viewers have no current incentive to buy sets or digital-to-analog set-top converter boxes for receiving digital broadcasts until stations start broadcasting a digital signal. That problem is being addressed by FCC mandates to broadcasters to begin DTV broadcasts by specified dates over the next several years. Now that the transition is under way, however, broadcasters have only weak incentives to end it. Without a firm completion date, broadcasters will keep broadcasting both their analog and digital signals as long as it is profitable to do so.

FACTORS THAT COULD AFFECT THE TRANSITION TO DIGITAL TV

Because of the many uncertainties that surround the move to digital TV, predicting when a given market will reach a DTV penetration rate of 85 percent and the transition will end is difficult. Even the definition of the markets to which the 85 percent rule will apply is uncertain and has yet to be determined by the FCC, which has an available set of alternatives that can make the market penetration hurdle either more or less difficult to clear. This paper groups the factors governing the speed of the DTV transition into four broad areas: technology, broadcast startups, cable carriage of digital TV, and consumer adoption issues. Questions raised in each area

and the answers they call forth interact with each other in many ways. In essence, the problem has a circularity that makes it hard to say which step comes first. Nevertheless, for purposes of exposition, this paper describes the problem in stages, although the events in later stages necessarily become progressively more uncertain.

The first and most basic factor in the successful introduction of digital TV is broadcast technology that works as promised. The available evidence indicates that technology issues are unlikely to delay the transition significantly—that is, the technical standards for the video and audio formats and for signal compression, transmission, and reception are robust enough to work in the broadcasting marketplace. To view DTV signals, consumers need either a digital TV set or a digital-to-analog set-top converter box that translates the signals transmitted through a cable or over the air into a format viewable (at a lesser quality) on current television sets. Reasonably clear reception of DTV signals is important because digital television experiences a phenomenon known as the "cliff effect"—a small decrease in signal strength or quality causes a DTV receiver to go from a perfect DTV picture to nothing. Still in question is whether consumers will need a rooftop antenna to receive an adequate DTV signal over the air. Even if roughly 70 percent of television households ultimately receive DTV signals by cable, meeting the technical challenge of receiving signals over the air using relatively inexpensive equipment could be critical in some markets to attracting the marginal household to DTV and thus reaching the 85 percent threshold by 2006.

A second precondition for completing the transition by 2006 is that digital broadcasts begin relatively early in the period. As of July 2, 1999, 69 stations, 39 of them in the 10 markets with the most television households, were transmitting a digital signal. If stations continue to be successful in beginning digital broadcasting, by the end of 1999, over half of the U.S. population will have the option of receiving multiple DTV channels over the air. Digital broadcasts are necessary to begin the mutually reinforcing cycle of purchases of DTV sets by consumers and increases in the amount of DTV programming by broadcasters. To start that process, the FCC established a timetable for stations to be on the air; it calls for commercial stations in large urban markets to go first, followed by stations in smaller markets and rural markets, and finally public broadcasters. The largest obstacle broadcasters face in meeting the FCC's deadlines is the availability of tower space for a second antenna for the new digital broadcasts. CBO believes that most stations will meet the deadlines and begin broadcasting. The few that do not will not significantly delay the transition.

A third and fundamental element of the timely introduction of digital TV is the availability of digital programming on cable systems. Indeed, cable carriage of such broadcasts is perhaps the most important factor affecting how quickly digital TV reaches the largest number of households. (Technical issues involving the cable/DTV set interface, another factor influencing DTV adoption, are likely to be settled in the near future. Assuming that they are, their effect on the speed of the transition will be

minor.) Approximately 95 percent of the roughly 100 million television households in the United States have cable service available to them. About two-thirds of the nation's TV households currently subscribe, and that proportion may rise to 70 percent by 2006. Yet although cable penetration rates today average 67 percent, they vary from market to market. For example, only 4 out of more than 200 cable markets nationwide have adoption rates of at least 85 percent, and none of those markets are ranked high in terms of advertising revenues.

To count households that subscribe to cable as part of the DTV audience for meeting the 85 percent requirement, a cable system must retransmit at least one programming channel of each DTV broadcaster in its market. But will cable operators voluntarily agree to do so? The history of analog broadcasting may offer a model. FCC "must-carry" rules for analog broadcasters, which give them the option of demanding carriage of their signals on a cable system in their market, ensure that all analog broadcasts are carried—but at the cost of precluding other, potentially more valuable programming. The possibility that cable systems might find some nonbroadcast programming more valuable than some broadcast DTV programming implies that a strong must-carry requirement for cable systems to carry DTV signals—a digital version of the analog rules—will be necessary to achieve the mandated market penetration level by 2006 and end the transition.

The fourth element—indeed, the capstone—of a successful transition to digital TV is the speedy adoption of the new technology as a result of consumer demand and falling prices for DTV equipment. How quickly consumers adopt digital TV is the so-called wild card in the transition. Declining prices for DTV sets are an essential incentive for consumers to purchase the new product The history of the introduction of other consumer electronics products that have ultimately been successful indicates that their prices declined rapidly after their introduction—a 50 percent decline after 10 years is one rule of thumb. Typically, however, it takes longer than the eight years now allowed for the DTV transition.

Besides the cable subscribers discussed above, two other groups of consumers must adopt the new technology for successful completion of the transition. The first is the 15 percent to 20 percent of television households that in 2006 are projected to subscribe to a noncable multichannel video programming distributor. The demonstrated demand of those viewers for TV programming suggests that many, though not all, are likely to go to the extra trouble and expense necessary to receive over-the-air DTV broadcasts. The second group of households—those that do not subscribe to a cable or satellite service or to any other MVPD—appear to have a relatively low demand for TV programming. As noted earlier, whether enough of those consumers will be willing to adopt digital TV (and purchase new, more expensive equipment to view more television programming of higher visual and audio quality) to achieve the mandated 85 percent penetration goal cannot be known this early in the transition.

CONCLUSIONS

As noted above, the key test for ending the transition to digital TV and reaping its benefits is the adoption of the technology by 85 percent of the television households in a market (see Summary Table 1). In 2006, cable systems, accounting for roughly 70 percent of TV households, will probably be delivering digital broadcast programming to the largest number of viewers. Bringing those cable subscribers into the DTV audience in time to meet the BBA's deadline for completing the transition is likely to depend on regulations that extend to the digital broadcasting era the must-carry rules that now apply to analog broadcasters. Satellite and other MVPD subscribers, who are expected to represent between 15 percent and 20 percent of television households by 2006, receive their broadcast TV over the air. Those households seem to exhibit a relatively high demand for television, and many of them may be quick to expend the effort and money needed to adopt DTV technology.

A particularly important factor affecting the adoption of digital TV is a relatively low-cost solution (generally conceived as an affordable set-top converter box) to the technical problem of viewing the digital signal on analog television sets. Although the issue has relevance for noncable MVPD subscribers, it looms largest in providing the DTV signal to so-called marginal households—the 10 percent to 15 percent of households that are not expected to pay for television programming in 2006. The decision by some of those households to buy the equipment necessary to receive digital signals over the air will probably be an essential element in achieving the 85 percent penetration level by that date.

Some policy actions could reduce the uncertainty surrounding the transition, hasten its end, and increase its overall benefits to society. As 2002 approaches—when current law requires that receipts must be in the Treasury from auctions for licenses to use spectrum freed during the transition—policymakers will almost certainly have to decide whether to allow the auctions to proceed as scheduled. Delaying them, and thus shortening the time until the spectrum becomes available to the winning bidders, could increase the Treasury's receipts because bidders would be less uncertain about when the transition would end and they could begin to use the spectrum. In addition, any fee that analog broadcasters would avoid if the transition ended on time—such as the fee on analog broadcasters of $200 million per year proposed in the President’s fiscal year 2000 budget—would create an incentive, now absent, for broadcasters to work for the transition's timely end. Balanced against use of that incentive, however, is the fact that the money broadcasters spent on fees could be used instead to further the transition. Future research could explore the implications of such a fee for auction receipts and for a successful transition that improved society's welfare. Other policy options that might also warrant investigation include additional government mandates related to digital TV, relaxation of some of the legal requirements that must be met before analog stations can be taken off the air, and delays in auctioning licenses for freed-up spectrum.

SUMMARY TABLE 1. CATEGORIES OF TELEVISION HOUSEHOLDS AND FACTORS AFFECTING THEIR BEING CONSIDERED A DTV HOUSEHOLD

	Percentage of TV Households in 1998	Percentage of TV Households in 2006	Factors Affecting Their Being Counted as a DTV Household[a]		
			Must-Carry Rules[b]	Ease of Reception	"Affordable" Equipment
Households with Cable TV Service	67	70	Yes	n.a.	Maybe
Households with Noncable MVPD Service[c]	10	15 - 20	n.a.	Yes	Yes
Households Without Cable or Other MVPD Service	23	10 - 15	n.a.	Yes	Yes

SOURCE: Congressional Budget Office based on Federal Communications Commission, *Fifth Annual Report*, CS Docket No. 98-102, FCC 98-335 (December 23, 1998); Paul Kagan Associates, Inc., *Cable TV Financial Factbook* (Carmel, Calif.: Paul Kagan Associates, Inc., June 1998); Paul Kagan Associates, Inc., *Marketing New Media* (August 17, 1998); and C.E. Unterberg, Towbin, *The Satellite Book, First Quarter 1999* (New York: C.E. Unterberg, Towbin, 1999).

NOTE: DTV = digital television; MVPD = multichannel video programming distributor; n.a. = not applicable.

a. The Balanced Budget Act of 1997 calls for broadcasters to stop broadcasting analog signals in a given market when DTV market penetration reaches 85 percent—that is, when 85 percent of households meet specified conditions to be counted as DTV households capable of receiving digital signals. The cessation of analog signals in a market marks the end of the transition to digital TV—in broad terms, the period during which a TV station broadcasts both a digital and an analog signal.

b. Rules that require cable systems to carry the analog signals of broadcasters in designated market areas. The Federal Communications Commission is considering whether to apply such rules to broadcasters' digital signals during the DTV transition.

c. Percentages do not include households that subscribe to both a cable service and another MVPD. Noncable MVPDs include direct broadcast satellite, multichannel multipoint distribution systems (wireless cable), local multipoint distribution systems, satellite master antenna television, and open video systems.

CHAPTER I
INTRODUCTION AND BACKGROUND

The United States is now in the middle of a process designed to shift television broadcasting from its current format to a new one based on digital signals. Digital television (DTV) technology offers viewers a number of benefits—among them, better-quality television pictures, a significant increase in the amount of television programming, and an array of new services from broadcasters (for example, interactive advertisements and alternative camera angles for sporting events). The federal government has established a framework of regulations and laws that spells out a process and timetable to govern the gradual move to digital broadcasting. This paper considers several factors that affect whether that process will run smoothly and the timetable will be met. It refers to the period during which broadcasters will simultaneously transmit the old and new signals as the transition to digital television.

The transition has wide-ranging implications that affect not only broadcasters and consumers but also the federal budget. Once television broadcasters have moved to the new digital technology, some of the broadcasting frequencies (portions of the radio spectrum, discussed more fully below) required by the older signals will be available for new uses. The federal government will assign licenses for portions of that spectrum to new users through auctions. The Balanced Budget Act of 1997 directs the Federal Communications Commission to complete the transition by 2006 but requires that licenses for the cleared spectrum be auctioned early enough to ensure that receipts from the auctions reach the Treasury by September 30, 2002. The Congressional Budget Office's (CBO's) baseline incorporates estimates of those future receipts. However, rather than focusing on that aspect of the shift to digital television, this paper explores issues related to completing the transition and does not specifically address how they and other factors would affect such estimates.

THE RADIO SPECTRUM AND THE FEDERAL GOVERNMENT

The federal government's role in the transition to digital television arises from its management of the radio spectrum, a conceptual tool that people use to organize and map a set of physical phenomena. Electric and magnetic fields generate waves that move through space at different frequencies (defined as the number of times a wave's peak passes a fixed point during a specific period); the set of all possible frequencies is called the electromagnetic spectrum. The subset of frequencies from 3,000 cycles

per second to 300 billion cycles per second—or 3 kilohertz to 300 gigahertz—is known as the radio spectrum.[1]

Since the 1920s, the rapid pace of scientific discoveries and technical innovations has made the radio spectrum a valuable communications resource. Over-the-air, or broadcast, television is one of many applications of radio technology that use the spectrum to transmit information; other broadcast services include AM and FM radio and direct broadcast satellite, or DBS, services. Nonbroadcast uses of the spectrum include wireless phones, pagers, private radio systems employed by businesses for internal communications, and amateur radio. Radar and radio astronomy are important nontelecommunications applications.

Over the years, the spectrum's many valuable uses have attracted a broad range of commercial interests, and the federal government stepped in early to resolve those competing demands. That initial action by the government is most often justified by certain of the spectrum's attributes that set it apart from other resources; for example, one person's reception of a radio signal does not prevent another person from receiving it. Some analysts, however, view early federal regulation of the spectrum as motivated by industry's attempt to restrict competition.[2] Both views are consistent with the government's decision to allocate blocks of frequencies for specific uses under restrictive terms and conditions—including whether the frequencies are to be shared or used exclusively and what technical standards should apply to equipment for transmitting and receiving signals. The federal government today continues to manage use of the spectrum, although a number of analysts question the need for the current level of federal involvement.[3] Portions of the spectrum are reserved for use by the federal government (for example, for military purposes); the National Telecommunications and Information Administration (NTIA) of the Department of Commerce is responsible for administering those frequencies. Since passage of the Communications Act of 1934, the Federal Communications Commission (FCC) has managed and regulated the nonfederal portion of the spectrum.[4]

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1. For more detailed information about spectrum management, see Congressional Budget Office, *Where Do We Go From Here? The FCC Auctions and the Future of Radio Spectrum Management* (April 1997), Chapters 1 and 5.

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

3. See, for example, Evan R. Kwerel and John R. Williams, "Moving Toward a Market for Spectrum," *Regulation*, no. 2 (1993), pp. 53-62; and Reed E. Hundt and Gregory L. Rosston, "Spectrum Flexibility Will Promote Competition and the Public Interest," *IEEE Communications Magazine* (December 1995), pp. 40-43.

4. The NTIA and the FCC work closely together to harmonize federal and nonfederal use of the spectrum within and between bands of frequencies. Because radio waves do not stop at international borders, allocations are coordinated worldwide through the International Telecommunications Union at periodic gatherings called World Administrative Radio Conferences.

Thus, for parties other than the federal government, the FCC determines how the spectrum can be used and grants licenses, typically for use of specific frequencies over a limited geographic area. The portion of the radio spectrum allocated to television broadcasting is licensed in that fashion. In choosing among competing applicants for the same license, the FCC has increasingly used auctions. Legally, all spectrum is owned by the public (auction receipts thus go into the public coffers), and licensees have only a limited right to use the band of spectrum assigned to them. Again, unlike most other resources, a licensee of a band of spectrum is not generally free to change how it uses those frequencies without the government's approval.

TELEVISION BROADCASTING

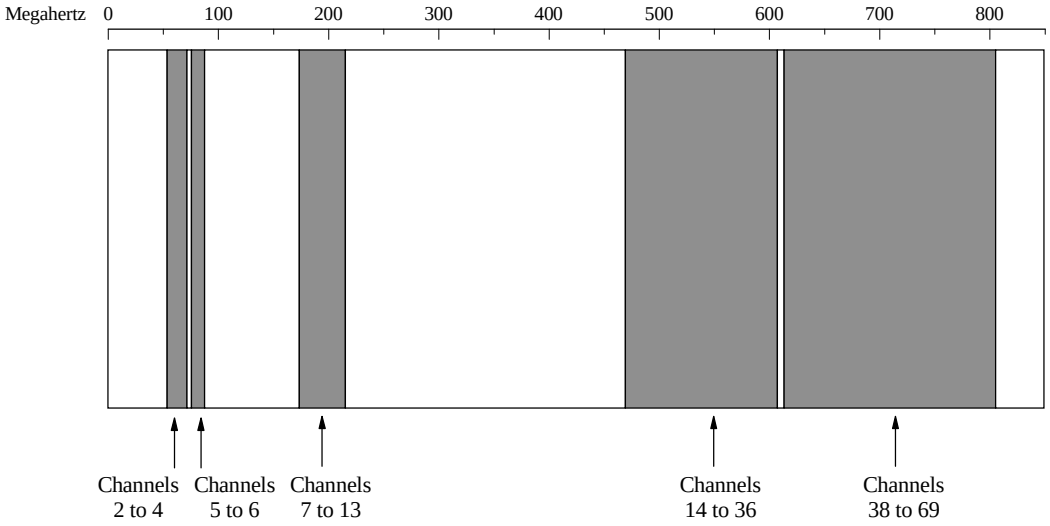
Currently, television signals are broadcast in an analog format. In analog TV—also called NTSC for the National Television System Committee, which developed the technical standard for it—the electrical pulses that make up the video and audio programming are converted directly to radio waves for transmission over the airways. Each analog television station is licensed to use a frequency band of 6 megahertz (MHz). The very high frequency (VHF) stations use three blocks of spectrum: 54 to 72 MHz (channels 2, 3, and 4), 76 to 88 MHz (channels 5 and 6), and 174 to 216 MHz (channels 7 to 13; see Figure 1). The ultrahigh frequency (UHF) stations occupy two blocks: 470 to 608 MHz (channels 14 to 36—channel 37 is reserved for radio astronomy) and 614 to 806 MHz (channels 38 to 69). To keep one station's signals from interfering with another's, the FCC requires stations using the same frequencies and stations on adjoining frequency bands to maintain a certain minimum geographic distance from one another.[5] In the UHF bands, the commission also controls the spacing of some combinations of channels whose signals would otherwise interfere with each other because of physical relationships between their frequencies.

As of October 1998, on the eve of the first commercial digital broadcasts (see below), analog televison was widespread: 1,215 advertiser-supported commercial stations and 368 public stations were broadcasting in the United States. In addition to those 1,583 full-power stations, 7,319 low-power and translator stations were operating.[6] (Low-power stations broadcast programming with a weaker signal and to smaller areas than the full-powered stations; translator stations retransmit the signals of other stations to unserved areas.) In 1997, the average home received just

5. As Figure 1 shows, sequentially numbered channels may not necessarily occupy adjoining frequencies and thus are not subject to the spacing requirements. For example, stations operate on both channels 4 and 5 in Washington, D.C.

6. "By the Numbers," *Broadcasting & Cable*, November 9, 1998, p. 72.

FIGURE 1. PORTION OF THE ELECTROMAGNETIC SPECTRUM ALLOCATED TO BROADCAST TELEVISION



SOURCE: Congressional Budget Office.

over 13 full-power, over-the-air channels, up from about nine in 1981.[7] Moreover, in 1998, 98 percent of U.S. households had color television sets. (By contrast, 94 percent of households had telephone service.)[8]

During the transition to DTV service, each analog station will broadcast a digital signal on a second 6-MHz channel simultaneously with its analog signal. In contrast to analog TV, digital TV first converts the information contained in programming to a digital format—a series of zeros and ones—and then translates the digital information into a radio wave for transmission. Thus, both analog and digital television signals are transmitted over the air by modulating a radio wave. However, converting a television broadcast to a digital format allows much more information—whether in the form of better picture and sound quality, multiple programs, or supplementary data—to be broadcast over a single channel. In addition, digital signals are more tolerant of interference, which allows stations to broadcast on adjacent channels. Those and other features are among the incentives that spurred the transition to digital television.

7. Nielsen Media Research, *1992-1993 Report on Television* (New York: Nielsen Media Research, 1993), p. 7; and personal communications to the Congressional Budget Office by Nielsen Media Research staff, December 9, 1998.

8. Data provided by the Consumer Electronics Manufacturers Association and Federal Communications Commission, "FCC Releases New Telephone Subscriber Report," *News Release*, February 18, 1999.

THE DTV TRANSITION

The FCC began investigating the potential of advanced TV technology in 1987. Its action came in response to a petition by broadcasters that was, in its turn, prompted by earlier research in Japan. (An additional motivation for the broadcasters' petition was their fear that the FCC would accept proposals to reallocate some UHF channels to mobile radio uses.)[9] In the wake of the FCC's interest, a number of research labs and manufacturers joined together in a consortium known as the Grand Alliance and developed a digital broadcast system for television, including high-definition television (HDTV). That system is now being used by broadcasters around the nation as they begin the transition (see Box 1).[10]

As the Grand Alliance's research proceeded in the early 1990s, the FCC laid out an initial plan for the transition to DTV broadcasting that took advantage of the technology's spectrum-conserving attribute and "shoehorned" new digital channels into the bands currently allocated to analog TV. The FCC also settled on what it termed the core spectrum—that is, the spectrum that will remain allocated to television broadcasting after the transition. Initially, the FCC reserved channels 7 to 51 (out of channels 2 to 69, the current TV broadcasting channels) as the core spectrum. That left channels 2 to 6 and 52 to 69, comprising 138 MHz of spectrum (of the 402 MHz currently dedicated to television broadcasting), for reallocation to other, nonbroadcast uses at the transition's end. The FCC later expanded the core (see the discussion of the Balanced Budget Act below); that action allows broadcasters' digital signals to more fully replicate their existing analog signals and in some cases permits stations to transmit at higher power and reach a larger audience without increasing the interference to existing analog stations. Making the DTV signals stronger could help speed the transition by making digital TV available to more households and eliminating the need for some viewers to use less convenient rooftop antennas. In addition, expansion of the core creates more room during the transition for low-power television stations (LPTVs) and translators. (Because LPTVs and translators are licensed on a secondary basis, they must yield to full-power broadcasters that need their spectrum—for example, for broadcasting a new

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

10. The members of the HDTV Grand Alliance were AT&T, General Instrument Corporation, Massachusetts Institute of Technology, Philips Electronics North America, Thomson Consumer Electronics, David Sarnoff Research Center, and Zenith Electronics Corporation.

BOX 1.
DIGITAL TELEVISION TECHNOLOGY

Digital high-definition television (HDTV) has roughly twice the horizontal and vertical resolution of current analog broadcasts, thus providing a much clearer, brighter picture as well as sound quality equal to that of compact disc technology.[1] The system is capable of delivering 19 million digital bits of data per second over a 6-megahertz (MHz) broadcast channel, enough for a picture with up to 1,080 lines and 1,920 pixels (picture elements) per line, compared with 483 lines and 440 pixels per line in today's analog TV.[2] The high-definition picture from such a system would have a width-to-height ratio of 16 to 9, which is wider than today's TV pictures and closer to the ratios used in movie theaters.

An alternative to HDTV is digital standard-definition television, or SDTV. SDTV provides a picture resolution and format roughly equal to today's television; nevertheless, it tends to be clearer than analog TV. A DTV broadcast uses the full channel of 6 MHz of spectrum regardless of the amount of programming that is transmitted. However, SDTV's properties mean that instead of broadcasting one HDTV channel, broadcasters could divide their channels into multiple subchannels of SDTV. Depending on the compressibility of the programs being shown at a given time—prerecorded programs and those with relatively static scenes allow more compression than fast-moving live programs—four to six SDTV subchannels, or more, could be accommodated with picture and sound quality comparable with or better than that of present analog channels.

The Grand Alliance, the consortium of research labs and manufacturers that developed the standard for digital TV, settled on 18 formats for the new technology that range from high definition to standard definition. The formats also vary along four dimensions: the number of pixels per screen (usually expressed as the number of vertical lines multiplied by the number of pixels per line); the aspect (width-to-height) ratio; the number of frames displayed per second; and whether the lines of the picture are displayed in a progressive format (used, for example, by computer monitors, in which the lines of the picture tube on the television set are illuminated sequentially from the top to the bottom of the screen) or in an interlaced format (used by current analog televisions, in which the display alternates between illuminating the even- and odd-numbered lines on the screen). For broadcasting advertiser-supported TV programming, broadcasters are free to choose among the 18 formats. If they use formats that take up only a portion of the 19 million digital bits, they can transmit multiple streams of video programming, audio signals, and data.

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1. Federal Communications Commission, *Fourth Report and Order*, MM Docket No. 87-268, FCC 96-493 (December 24, 1996), p. 4, footnote 11.

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

digital station or because their signal interferes with that of the full-power broadcasters.)[11]

A Generic Model

Although the details and timing of the transition to digital TV will continue to unfold over the next several years, policymakers, regulators, and industry experts have developed a consensus about the generic process of moving from a TV industry based on analog broadcasts to one based on digital technology. In the initial stages of such a transition, early adopters—like the initial consumers of first-generation color TV sets and personal computers—would purchase "high-end" digital products such as multifeature projection TV sets. (The first high-end models of a new technology are always the worst value—in price and quality—because they cost more to build than later models and because manufacturers try to recover some of their development outlays by charging higher prices to the least price-sensitive consumers.) At that point, early adopters would have only limited choices in the over-the-air DTV programming they could view, but as the transition proceeded, more stations would begin broadcasting in a digital format. At the same time, the availability of new, high-quality digital programming would increase, and more households would purchase digital TV sets. With time, the prices of sets would fall, and more consumers would join the DTV audience. As set prices began to decline, set-top converter boxes that allowed the digital signals to be viewed on analog sets (although with poorer-quality pictures) would become available at prices substantially below the cost of a DTV set, further expanding the audience for DTV programming.

Sometime during the transition, either through regulation or consumer demand, digital programming would become available over cable and other multichannel video delivery systems such as satellite services, which would further encourage consumers to buy DTV sets. Finally, once enough consumers were able to view the digital broadcasts, the older analog signals would cease, and a portion of the radio spectrum currently dedicated to over-the-air broadcasting would be reallocated to other valuable uses. In addition, the spectrum in the core that was previously occupied by analog broadcasters would become available to digital television licensees. Some of those licensees would be new, and some would be digital stations that had been operating outside of the core during the transition.

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11. Although expanding the core spectrum will help LPTVs and translators, squeezing will nevertheless occur—first, during the transition as they make room for digital broadcasters; second, as spectrum they previously used outside of the core is reallocated to nonbroadcast uses; and third, if new full-power DTV broadcast licenses for spectrum in the core are auctioned after the analog stations cease broadcasting. Proposals to give some LPTVs the same rights and protections that full-power broadcasters receive could lessen the third effect.

The process seems straightforward enough, but in reality, the transition to digital TV is a classic chicken-and-egg problem. Broadcasters do not have an immediate incentive to spend money upgrading their facilities for digital broadcasts if no viewers have TV sets capable of receiving the broadcasts. Likewise, viewers have no incentive to buy TV sets capable of receiving digital broadcasts or digital-to-analog set-top converter boxes until broadcasters start broadcasting a digital signal. The federal government, citing society's interest in a successful transition to DTV, is forcing the issue. The Congress and the FCC have taken a series of steps (detailed below) to ensure that broadcasters begin transmitting a digital signal. Those initial broadcasts, coupled with improved programming, give consumers an incentive to buy DTV sets and set-top converter boxes and start the process of price declines. Lower prices in turn should further encourage purchases of DTV sets and converter boxes and thus speed the transition.

The Legislative Framework

Like the FCC, the Congress's interest in the transition to digital television dates back to the 1980s, when it held a series of hearings on America's ability to compete in selected high-technology markets. At that point, the Congress saw high-definition television as a way to promote U.S. competitiveness in consumer electronics.[12] In recent years, its focus has been more on the potential monetary value of licenses for the radio spectrum associated with television broadcasting. For example, in 1995 and 1996, a wide-ranging coalition including then Senate Majority Leader Robert Dole and Congressman Barney Frank urged that licenses for the portions of spectrum set aside by the FCC for the new digital television stations be auctioned off to the highest bidder and then put to their best, market-determined uses. However, in the Telecommunications Act of 1996 (the Telcom Act), the Congress affirmed the FCC's plan not to charge current broadcasters for the use of the new digital TV channels during the transition. The act codified the FCC's intent to pair the new digital channels with existing analog channels and allow all current full-power TV license holders to use the digital channels during the transition. The act further specified that broadcasters would not be required to pay for the use of those channels if they provided free over-the-air services directly.

The Telcom Act also gave broadcasters a high degree of flexibility in how they used their digital channels. Stations were allowed to broadcast a DTV signal consisting of one channel of high-definition televison or, as discussed in Box 1, many channels of digital standard-definition television (SDTV). They were also permitted to use any portion of their digital channels for services that generated revenues

12. See Congressional Budget Office, *The Scope of the High-Definition Television Market and Its Implications for Competitiveness*, CBO Staff Working Paper (July 1989).

directly from consumers or from third parties wanting to transmit material other than advertisements. But if broadcasters chose to engage in such revenue-generating activity, they had to pay a fee equal to 5 percent of the gross revenues generated.[13] Thus, the Congress provided flexibility but expressed its preference that the digital TV channels be used for advertiser-supported video programming.

In the Balanced Budget Act of 1997 (BBA), the Congress then turned to the value of the licenses for spectrum that would be returned to the FCC once the transition had been completed. The BBA added three more areas of direction to the transition to digital TV and the uses of the TV spectrum bands.

Completing the Transition by 2006. The BBA's first new directive set a conditional deadline of December 31, 2006, for broadcasters to complete the transition to digital broadcasting. (As Box 2 makes clear, the law actually states that a broadcaster's analog license will not be renewed past that date.) Without such a directive, broadcasters would continue to use both their digital and analog channels as long as it was profitable to do so. An analog broadcaster may request an extension of the deadline if it can demonstrate one of the following:

- Less than 85 percent of households in the broadcaster's market are capable of receiving digital broadcasts. To be counted as receiving broadcasts, households must be able to receive any one digital broadcast over the air using a digital TV set or an analog set equipped with a digital-to-analog set-top converter box or be able to receive at least one digital programming channel of each broadcaster in the market from a multichannel video programming distributor (MVPD) such as a cable system.

- One or more of the four largest networks has an affiliate in the broadcaster's market that, despite the "due diligence" required by the law, is not broadcasting a digital signal.

- Digital-to-analog converter technology is not readily available in the broadcaster's market.

When couched broadly in the affirmative, the first point noted above—85 percent of the television households in a market are able to receive digital programming—is the linchpin that determines when the transition to digital TV is complete and a broadcaster's analog signal will be turned off. (The second and third points are unlikely to be an impediment to the transition's ending by 2006 and are not

13. See Congressional Budget Office, *Two Approaches for Increasing Spectrum Fees*, CBO Memorandum (November 1998); and Federal Communications Commission, *Report and Order*, MM Docket No. 97-247, FCC 98-303 (November 19, 1998).

BOX 2.
THE LAW AND THE END OF THE TRANSITION

The Balanced Budget Act of 1997 sets out the guidelines for determining the end of the transition to digital television in a given market:

SEC. 3003. AUCTION OF RECAPTURED BROADCAST TELEVISION SPECTRUM.
Section 309(j) of the Communications Act of 1934 (47) U.S.C. 309(j) is amended by adding at the end of the following new paragraph:

"(14) AUCTION OF RECAPTURED BROADCAST TELEVISION SPECTRUM.—

"(A) LIMITATIONS ON TERMS OF TERRESTRIAL TELEVISION BROADCAST LICENSES—A television broadcast license that authorizes analog television service may not be renewed to authorize such service for a period that extends beyond December 31, 2006.

"(B) EXTENSION—The Commission shall extend the date described in subparagraph (A) for any station that requests such extension in any television market if the Commission finds that—

"(i) one or more of the stations in such market that are licensed to or affiliated with one of the four largest national television networks are not broadcasting a digital television service signal, and the Commission finds that each such station has exercised due diligence and satisfies the conditions for an extension of the Commission's applicable construction deadlines for digital television service in that market;

"(ii) digital-to-analog converter technology is not generally available in such market; or

"(iii) in any market in which an extension is not available under clause (i) or (ii), 15 percent or more of the television households in such market—

"(I) do not subscribe to a multichannel video programming distributor (as defined in section 602) that carries one of the digital television service programming channels of each of the television stations broadcasting such a channel in such market; and

"(II) do not have either—

"(a) at least one television receiver capable of receiving the digital television service signals of the television stations licensed in such market; or

"(b) at least one television receiver of analog television signals equipped with digital-to-analog converter technology capable of receiving the digital television service signals of the television stations licensed in such market.

discussed further.) Policymakers settled on the "market penetration" rate of 85 percent in part because they considered the loss of analog broadcasting for the remaining 15 percent of television households to have relatively limited social costs. The law leaves most of the details of the market penetration test—for example, the definition of a television market —to the FCC's discretion (see Box 3). Thus, under current law, the FCC will ultimately define the relevant television market, which in turn will establish the pool of households that must be considered in determining whether digital TV is reaching 85 percent of a market's households and the transition is complete.

Yet the law contains further ambiguities besides those related to the definition of a TV market. One of the most significant involves subscribers to a cable service or to another MVPD and whether they should be counted as DTV households in calculating market penetration. For example, the law is clear that for a household subscribing to a cable service to be counted as a DTV adopter, the cable company must provide its customers with at least one programming channel from each digital broadcaster in its market.[14] Yet the law does not specify whether DTV signals included in a premium subscription package but not in a basic cable subscription package would count for purposes of the 85 percent test.

The law is also unclear about whether the cable subscriber must be able to view the digital programming (either on a digital TV set or by using a digital-to-analog set-top converter box with an analog set) to be counted as a DTV household. For instance, a household with a DTV set that received its DTV programming over a cable system that did not carry all local DTV broadcasters would not be counted as a DTV household unless it also used an antenna capable of receiving over-the-air digital broadcasts. By contrast, another household that subscribed to a cable system that provided programming from all local DTV broadcasters but did not have the technology necessary to watch that programming might nevertheless be counted as a DTV household.

Reallocating the Frequency Band Comprising Channels 60 to 69. The BBA's second direction instructed the FCC to allocate to public safety uses—for example, dispatch services for local police and firefighters—a portion of the spectrum in the noncore band occupied by channels 60 to 69 (the 60-to-69 band). In December 1997, the FCC allocated 24 MHz of spectrum associated with channels 63, 64, 68, and 69 for such uses. (Licenses for spectrum allocated to public safety will not be auctioned.) That left the remaining 36 MHz in the 60-to-69 band for reallocation to commercial

14. Other MVPDs available to some or all consumers include direct broadcast satellite, multichannel multipoint distribution systems (wireless cable), local multipoint distribution systems, satellite master antenna television, and open video systems.

BOX 3.
DEFINING THE TELEVISION MARKET

The key condition established by the Balanced Budget Act of 1997 (BBA) that must be met for the transition to digital television (DTV) broadcasting to end in 2006 is that 85 percent of viewers be able to receive DTV signals. As the BBA specifies, that so-called market penetration test is to be applied at the level of the television market. However, the law does not define a television market. Furthermore, the Federal Communications Commission (FCC), which is charged with carrying out that part of the law, does not have a standard definition—rather, it adopts an appropriate market definition on a case-by-case basis. For example, the FCC has defined the relevant market for the rule against duopolies (ownership of more than one TV station in a market) as the area inside the grade B contour of a television station.[1] (Grade A and grade B contours are discussed later.) But in establishing a schedule for stations to begin DTV broadcasting, the FCC defined the relevant television market as the "designated market area," part of a nationwide framework developed by Nielsen Media Research.

How the FCC defines the relevant television market can have important consequences for when the transition to digital TV ends. The legislation leaves the FCC to calculate the 85 percent market penetration level that constitutes the end point. Defining a television market that covers a broader rather than a narrower geographic area and includes more rather than fewer households requires more rather than fewer people to be able to view DTV programming before the BBA's specified level of 85 percent is reached. Moreover, broadening the definition of a television market tends to add viewers to the relevant pool of TV households who may be least able to adopt DTV technology—specifically, households in rural areas that are less likely than more urban viewers to be able to receive an over-the-air television signal and more likely to be part of the 5 percent of television households that are outside of cable service areas.

The FCC could create a new definition of a television market for the purpose of calculating DTV penetration levels. More probable, however, is that it will use an existing definition—for instance, one of those given below:[2]

- *Grade A Contour*—a measure of the approximate geographic coverage of a television signal based on the predicted strength of a high-quality broadcast signal in the absence of physical barriers. The most narrow definition of a television market presented here, its adoption would probably lead to a relatively faster transition.

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1. Recently, the FCC relaxed the prohibition against duopolies; see Federal Communications Commission, "FCC Revises Local Television Ownership Rules," *News Release*, August 5, 1999 (available at http://fcc.gov/Bureaus/Mass_Media/News_Releases/1999/nrmm9019.html).

2. For full definitions of the grade A and grade B contour measures, see 47 C.F.R. 73.683. Further discussion of Langley-Rice areas appears in Federal Communications Commission, *Report and Order*, CS Docket No. 98-201, FCC 99-14 (February 2, 1999). Definitions for the two Nielsen Media Research areas are from R.R. Bowher, *Broadcasting & Cable Yearbook, 1997*, vol. 1 (New Providence, N.J.: R.R. Bowher, 1997), p. C-146.

BOX 3.
CONTINUED

- *Grade B Contour*—a measure of the approximate geographic coverage of a television signal based on the predicted strength of a broadcast signal of minimum acceptable quality in the absence of physical barriers.

- *Langley-Rice Areas*—a measure of acceptable signal strength that accounts for terrain and physical barriers. Unlike the grade A or grade B contours, the Langley-Rice area may contain "holes" and not be continuous.

- *Nielsen Designated Market Areas*—a geographic designation developed by Nielsen Media Research. A designated market area (DMA) is made up of all the counties that get the preponderance of their broadcast programming from a given television market. (The counties do not necessarily form a contiguous area.) The Nielsen DMAs are both complete (all counties in the United States are in a DMA) and exclusive (DMAs do not overlap). The broadest definition of a television market presented here, its adoption would probably lead to a relatively slower transition.

- *Nielsen Metro Rating Areas*—the counties representing the metropolitan areas of a DMA. They usually correspond to the Census Bureau's standard metropolitan statistical areas.

These market definitions fall into two categories, and the use of either to determine DTV penetration rates could present problems. The first three definitions, which are based on the strength of a broadcast signal, are station oriented; they raise questions about how the FCC should treat the overlapping portions of each broadcaster's signals to keep viewers from losing analog broadcast signals in a piecemeal fashion when the transition ends in a market and stations go off the air. (For example, two stations in a city with signal coverage areas that overlap for the most part but not completely may reach the 85 percent threshold at different times because they have different "markets.") The second two definitions raise questions about individual stations that effectively broadcast to two distinct television markets.

The FCC is likely to use an open proceeding to establish the definition of a television market for meeting the 85 percent test. During the proceeding, the commission would take public comments on the proper definition of a television market and might also consider its own related precedents. For example, when the FCC prepared the schedule for DTV stations to begin broadcasting, it used the Nielsen DMA as the relevant television market. The recently upheld analog must-carry rules, which are discussed in Chapter II, also establish the precedent of using a geographic measure while allowing adjustments on a case-by-case basis.

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3. See Bill McConnell, "Court OKs FCC Carriage Criteria," *Broadcasting & Cable*, January 4, 1999, p. 23.

uses. (Licenses for that spectrum will be auctioned.)[15] However, during the transition, the 97 existing analog stations around the nation that are broadcasting over the frequencies in the 60-to-69 band (37 in the public safety bands and 60 in the bands to be auctioned) and 20 newly assigned digital broadcasters (five in the public safety bands and 15 in the auction bands) will be protected and will continue with their operations. As noted below, licenses for the 36 MHz of spectrum must be auctioned and the receipts deposited no later than September 30, 2002. But because of the protected incumbents, auction winners might not have full use of their frequencies until at least 2007, which could affect how much they were willing to pay initially for their licenses. All of the top 10 television markets have at least one protected incumbent broadcaster in the 60-to-69 band (see Table 1).

Auctioning Licenses for the Newly Available Spectrum. The third direction from the BBA specified that licenses for the spectrum freed by the transition to DTV should be auctioned in two stages. For the first stage, the Congress directed that licenses for the 36 MHz allocated to commercial uses in the lightly used 60-to-69 band not be auctioned before 2001 but that the auction receipts reach the Treasury by September 30, 2002.[16] It is likely that such spectrum will be covered by overlay licenses—that is, the new owners will be free to develop the spectrum as long as they protect incumbent users (in this case, the 60 analog and 15 digital television broadcasters noted above).[17] The FCC has not yet determined the uses to which those frequencies can be put or the size (in either megahertz or geographic area) of the blocks of spectrum that the new licenses will cover. However, there is no reason to believe that the blocks will correspond to the size of a television channel (6 MHz) or the area of a television market (however the FCC decides to define it), which makes broadcasting uses unlikely.

The BBA directed that the second stage of the auctions deal with the remaining spectrum to be reclaimed at the end of the transition. Originally, the FCC had planned to auction licenses for a total of 114 MHz of noncore spectrum in the bands for channels 2 to 6 and 52 to 69. (That total reflects subtraction of the 24 MHz to be reallocated to public safety uses.) But in December 1997, the FCC expanded the core spectrum to include channels 2 to 6, leaving 84 MHz available for auction.[18] In the second auction stage, then, the BBA directs the FCC to auction licenses for the

15. See Federal Communications Commission, *Report and Order*, ET Docket No. 97-157, FCC 97-421 (December 31, 1997), pp. 5-12.

16. The President's proposed budget for fiscal year 2000 would move up that auction by one year.

17. Because LPTVs and translators are licensed on a secondary basis, they may not be protected in the TV bands if overlay licenses are issued.

18. Federal Communications Commission, *Memorandum Opinion and Order on Reconsideration of the Sixth Report and Order*, MM Docket No. 87-268, FCC 98-24 (February 17, 1998), p. 21.

TABLE 1. DISTRIBUTION OF CHANNELS IN THE 60-TO-69 NONCORE SPECTRUM BAND IN THE TOP 10 TELEVISION MARKETS, 1996

Designated Market Area[a]	Commercial Bands[b]		Public Safety Bands[c]	
	Digital	Analog	Digital	Analog
New York	1	3	0	2
Los Angeles	4	0	0	2
Chicago	0	2	0	0
Philadelphia	3	3	1	2
San Francisco/Oakland/San Jose	0	3	1	1
Boston	0	3	0	1
Washington, D.C.	0	2	0	1
Dallas/Ft. Worth	0	0	0	1
Detroit	0	1	0	0
Atlanta	0	0	0	2
Total, Top 10 Market Areas	8	17	2	12
All Market Areas	15	60	5	37

SOURCE: Congressional Budget Office based on data from R.R. Bowher, *Broadcasting & Cable Yearbook, 1997*, vol. 1 (New Providence, N.J.: R.R. Bowher, 1997).

NOTE: The top 10 market areas are ranked by the number of television households.

a. Designated market areas, or DMAs, are the foundation of a geographic market design developed by Nielsen Media Research based on measured viewing patterns. The DMA consists of all counties in which the home market stations (in general, the stations located in that market) draw a preponderance of viewers. Each U.S. county is allocated to only one DMA with no overlap. The total of all DMAs represents all television households in the United States.

b. Subdivisions of the 60-to-69 band composed of channels 60, 61, 62, 65, 66, and 67.

c. Subdivisions of the 60-to-69 band composed of channels 63, 64, 68, and 69.

remaining 48 MHz of spectrum associated with channels 52 to 59—again, in time for the receipts to be deposited by September 30, 2002.

Like the winners in the first auction, bidders who are successful in the second may be able to use the unencumbered portions of the spectrum covered by their licenses immediately and the balance when the transition is over and the spectrum is clear of both analog and digital broadcasters. In contrast to the band with channels 60 to 69, however, the 52-to-59 band is more heavily laden with full-power stations (94 analog and 168 DTV broadcasters).[19]

19. Federal Communications Commission, *Second Memorandum Opinion and Order on Reconsideration of the Fifth and Sixth Report and Orders*, MM Docket No. 87-268, FCC 98-315 (November 24, 1998).

The Congress's choice of 2002 for deposit of the auction receipts was motivated partly by its desire to achieve an estimate of a balanced budget in that year and partly to maintain pressure on television broadcasters to make the transition quickly and produce the social benefits of improved quality and spectrum available for new, more highly valued services. (That pressure would come naturally from auction winners wanting to have full use of the license they had won.) The transition completion date of 2006 was necessary in part to make an auction in 2002 reasonable—a longer period between the auction and when winners could expect to take possession of their spectrum would reduce what bidders would be willing to pay. Nevertheless, the BBA's timetable for ending the transition by 2006 is conditional; it rests on digital TV's achieving an 85 percent market penetration level. In contrast, the requirement to conduct auctions by 2002 is absolute.

When the BBA was passed, CBO's estimate of the auction receipts from licenses for spectrum in the television bands—which assumed a successful end of the transition by 2006—was $6.1 billion.[20] The most important unresolved question about the scheduled auction in 2002 is when that spectrum will be available for new uses. Both current expectations that some or all of the returned TV spectrum will not be available at the end of 2006 and increasing uncertainty about the speed of digital TV's adoption and, consequently, the end of the transition decrease the value of the licenses to prospective bidders.

Factors Affecting the Transition's Completion

The discrepancy between the certain auction date and the uncertain end of the transition raises questions for all of the parties interested in the shift to DTV broadcasting. Those concerns can be grouped into four broad areas:

- Will the DTV technology work as promised?
- Will the new digital stations begin broadcasting in the near future?
- Will the programming on the new digital stations be available on cable systems?
- Will consumer adoption rates, fueled by consumer desire and equipment price declines, be sufficient to make digital TV pervasive?

20. CBO subsequently reduced that estimate for several reasons including a drop in the amount of spectrum expected to be available and evidence from ongoing FCC auctions that the value of a license for any piece of the spectrum offered for bid, not just that released by the transition to DTV, had fallen.

How those questions will be answered depends on the responses of many different players. The television industry, broadcasters, MVPDs such as cable and satellite system operators, and TV set manufacturers will have a major say in when and what kind of digital TV is available to consumers. The FCC and the Congress will continue to set the regulatory and legal environment for digital television, which will have a profound impact on how some of the remaining issues surrounding the transition are resolved. Finally, consumers will be the ultimate arbiters of the value of the new technology and the speed of its adoption.

Because the four areas of concern interact with each other, there is a simultaneity among the transition's many pieces—a circularity that makes it hard to say which step comes first. As an example, the question of DTV signals being carried on cable systems, which may be the most significant single determinant of when the transition is completed, becomes particularly relevant after stations are broadcasting. Yet the early creation of strong regulations requiring cable systems to carry DTV programming could encourage stations to begin broadcasting sooner than the law demands, which could lead to a quicker transition. Thus, for purposes of exposition, this paper discusses the above issues in a roughly sequential order, but that progression is likely to have little resemblance to actual events.

CHAPTER II
FACTORS AFFECTING THE SPEED OF THE TRANSITION TO DIGITAL TELEVISION

In order for the transition to digital television broadcasting to end by 2006, the DTV technology must work as promised, DTV stations must initiate broadcasts soon, cable systems must retransmit the programming of digital broadcasters, and consumers must adopt the new technology quickly. Meeting each of those milestones is crucial to achieving the market penetration level of 85 percent specified in the Balanced Budget Act that allows analog signals to be turned off and the spectrum that carried them to become fully available for new uses or users.

THE DTV BROADCAST TECHNOLOGY

The first area of concern as well as the most basic hurdle to the introduction of digital TV is that the broadcast technology work as promised. A successful transition requires that the technical standards for the video and audio formats and the compression (removal of redundant data), transmission, and reception of the digital signal be robust enough to work in the marketplace. The Grand Alliance's technical standard for high-definition television has successfully passed laboratory trials and initial field testing. Thus, it seems unlikely that remaining questions about DTV technology will significantly delay its introduction. However, issues related to technology—in particular, the ease with which consumers will be able to receive digital signals in their homes—could have a strong effect on the speed of adoption by the last viewers needed to meet the BBA's 85 percent market penetration test.

Background

The Grand Alliance's DTV system cannot send signals that are intelligible to the television sets currently found in virtually every U.S. household. To watch digital TV, viewers will need at least a set-top converter box (with a substantial amount of computer processing capability) to restore the compressed digital picture and sound data and translate them into a format that viewers can watch on their current sets. Moreover, some DTV products may not have enough features to take full advantage of the technology; thus, some DTV sets will display programming only in a standard-definition TV format. To enjoy the full benefit of high-definition TV programs, viewers will need a wide-screen TV receiver capable of displaying the finer resolution characterizing such programming.

Another question regarding the transition to digital broadcasting involves the quality, or strength, of the DTV signal. Digital TV's superior sound and pictures depend on a strong signal that can provide enough compressed data. At a threshold signal level, however, a small decrease in signal strength can cause a DTV receiver to go from displaying a perfect picture to displaying nothing—a phenomenon known as the "cliff effect." As a DTV signal goes "over the cliff," a brief transition occurs that could be described as blocking, or digital static. Even a small amount of digital static renders a picture unviewable, with part or all of it frozen in various-sized blocks on the screen. In contrast, a weakening analog signal increases the static in the picture, whose quality slowly degrades. That phenomenon is referred to as "graceful degradation."

Early testing of DTV technology by broadcasters has produced mixed results in signal quality. WRAL-TV of Raleigh, North Carolina, found that the strength of its digital signal matched its analog signal's strength at most test locations. Results from indoor tests showed a perfect DTV signal between 64 percent and 81 percent of the time, depending on the type of antenna used.[1] In contrast, WHD-TV—the experimental DTV station in Washington, D.C.—achieved acceptable indoor reception between 27 percent and 39 percent of the time, again depending on the type of antenna.[2] WHD-TV's relatively poor results can be attributed in part to a lower transmitter tower (see the later discussion) and a more urban landscape. The tests are an early indication that many households will need a rooftop antenna to receive an acceptable DTV picture over the air.

Unresolved Questions

The remaining technology-related issues most relevant to reaching an 85 percent market penetration rate involve consumers' ability to receive DTV signals over the air without effort and expense above what they now pay to receive broadcast analog signals. (Currently, one-third of TV households receive signals over the air, but that proportion could shrink to 30 percent or less by 2006.) The Federal Communications Commission intended the new DTV signal to reach a broadcaster's existing analog audience, referred to as those households in the area outlined by the television station's grade B contour.[3] (As discussed in Box 3 on page 12, the grade B contour

1. See Andrew Bowser, "Testing 1, 2, 3, . . . 166," *Broadcasting & Cable*, July 20, 1998, p. 30.

2. Memorandum from Lynn Claudy, Senior Vice President, Science and Technology, National Association of Broadcasters, to the association's Television Board, April 24, 1998.

3. See Federal Communications Commission, *Memorandum Opinion & Order on Reconsideration of Sixth Report and Order*, MM Docket No. 87-286, FCC 98-24 (February 17, 1998), paragraph 28, and 47 C.F.R. 73.683 for more discussion of the grade B contour. However, CBO calculated that overall DTV coverage per channel increased by 8 percent when measured by area and by 5 percent when measured by population, compared with the same channels' analog coverage.

is a measure of the approximate geographic coverage of a television signal based on the predicted strength of a broadcast signal of minimum acceptable quality in the absence of physical barriers. It has also been defined as a half-strength signal half of the time.)[4] The FCC has stated that with a TV signal of grade B intensity, households should receive an acceptable picture at least 90 percent of the time.[5] Nevertheless, some households within those areas have relatively poor reception of analog TV signals. As a result, they would probably not be able to receive a viewable DTV signal without a new antenna. Still uncertain is how many of the households that would have to upgrade their antennas would actually go to the trouble and expense of doing so.

One cause of poor TV reception for those households could be a weak signal. Some viewers may have accepted an over-the-air analog signal of relatively poor quality rather than pay for a better antenna or a subscription to a cable service. Yet that same poor-quality signal from a digital broadcaster may be over the cliff and completely unviewable.

For households that receive a signal of adequate strength for over-the-air broadcasts but still have poor reception, the problem may be multipath interference—the phenomenon of radio signals reflecting off of solid surfaces, with the same signal arriving at a receiver at different times.[6] (The "ghosting" that sometimes occurs on an analog television set when the set's receiver tunes to a signal and one or more of its reflections at the same time is an example of multipath interference.) The problem is potentially more severe in the digital world. Unlike analog television, the interference caused by the reflected signal can prevent a receiver from getting enough digital information from the primary signal, thus causing the cliff effect and total loss of the picture. However, in some cases, the reflected signal may be stronger, and the receiver can successfully tune to that signal.

Antenna strength and multipath problems can be addressed in several ways. On the broadcast side, a higher transmitter tower increases the likelihood of a line-of-sight path from the transmitter to the receiver and consequently provides both a stronger signal and less opportunity for the signal to be reflected off of other surfaces. On the reception side, a rooftop antenna can provide many of the same benefits. In addition, receivers that have higher-quality—though more expensive—filters can better tune to one signal and ignore other, interfering signals.

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4. Paige Albiniak, "EchoStar Takes Big 4 to Court," *Broadcasting & Cable*, October 26, 1998, p. 19.

5. Federal Communications Commission, *Report and Order*, CS Docket No. 98-201, FCC 99-14 (February 1, 1999), paragraph 13.

6. Recent demonstrations by the Sinclair Broadcast Group indicate that the early DTV receivers do not perform well in environments with a great deal of multipath interference. See Glen Dickson, "Back to the Future," *Broadcasting & Cable*, August 2, 1999, pp. 22-24.

Neither the prospect of antenna upgrades nor the problem of multipath interference suggests that technology issues will be a significant impediment to a large majority of DTV viewers. Nevertheless, they could affect adoption by the marginal viewers needed to reach an 85 percent market penetration level, some of whom may not be willing to expend the resources necessary to ensure that they can view DTV programming. That group is likely to be relatively small and might only affect the transition in markets that rely heavily on over-the-air reception of television signals.

DEADLINES FOR BROADCASTING DTV PROGRAMMING

A second area of concern is whether digital broadcasts will begin relatively early in the transition. A strong start is necessary to trigger the mutually reinforcing cycle of consumer purchases of DTV sets and increased DTV programming by broadcasters. To that end, the FCC established a timetable for stations to begin broadcasting: large commercial stations in urban markets would start broadcasting first, followed by stations in smaller markets, rural stations, and finally public broadcasters. All stations would be broadcasting DTV signals by 2003. The largest obstacle broadcasters face in meeting the proposed deadlines is the availability of tower space to locate broadcast antennas for their new digital signals. Progress to date indicates that most stations will meet the FCC deadlines, and the few that do not will not be significantly delayed.

Getting DTV Stations on the Air

Stations face some urgency in upgrading their broadcasting facilities to meet the FCC's deadlines. The commission specified that the affiliates of the four major networks—ABC, CBS, FOX, and NBC—in the top 10 markets were to be broadcasting a digital signal by May 1, 1999. (Those markets are New York; Los Angeles; Chicago; Philadelphia; San Francisco/Oakland/San Jose; Boston; Washington, D.C.; Dallas/Ft. Worth; Detroit; and Atlanta. Together, they take in 30 percent of all television households.) The networks' affiliates in the top 30 markets are scheduled to be airing digital programming by November 1, 1999. The remaining commercial stations must be broadcasting DTV signals by May 1, 2002; noncommercial stations must be broadcasting them by May 1, 2003.

In many cases, the timetable has been met, and in some cases, exceeded. By mid-November 1998, 44 stations—28 in the top 10 markets—were on the air

voluntarily with digital signals.[7] As of July 2, 1999, 69 broadcasters were transmitting a digital signal, 39 in the top 10 markets. In those markets, 33 of 45 of the "Big Four" network affiliates required to be on the air by May 1, 1999, were broadcasting. Of the 132 Big Four affiliates in the top 30 markets (not required to be on the air until November 1, 1999), 48 were broadcasting.[8] If the early success of such stations continues, by the end of 1999, over half of the U.S. population will have the option of receiving multiple DTV channels over the air.

Before broadcasting a digital signal, a television station must upgrade its facilities. The work can be done in stages, somewhat easing the stations' financial burdens and the demand on manufacturers for new digital broadcasting equipment. Station upgrades begin, at a minimum, with the ability to "pass through," or retransmit, a digital signal from a network or other program provider and end with the ability to produce original programming in a digital format. Estimates of the cost to get on the air during the early part of the transition range from $1.7 million to $6.5 million per station.[9] A full-fledged conversion to digital facilities including production capability is estimated to cost as much as $20 million.[10] Smaller stations that are the last to begin broadcasting may pay less because by the time they purchase equipment, prices may have fallen and used equipment may be available.

Resolving Tower Problems

Broadcasters' most significant concern about the FCC's deadlines is getting their broadcast towers ready for DTV transmitters. For many stations, a key feature of upgrading their facilities is construction of a new broadcast tower or retrofitting of an existing one to hold the extra weight of a second antenna for DTV broadcasting. In addition, many broadcasters may attempt to replicate their current audiences as well as resolve some of the signal strength and multipath problems discussed earlier by broadcasting their DTV signal from an antenna higher than the corresponding one for analog signals.

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7. Glen Dickson, "The High Cost of Pioneering DTV," in *The Dawn of Digital Television*, special insert to *Broadcasting & Cable*, November 11, 1998, p. S39.

8. These figures are based on National Association of Broadcasters, "DTV Stations in Operation" (press release, Washington, D.C., July 2, 1999, available at http://www.nab.org/pressrel/ dtvstations.asp); and R.R. Bowher, *Broadcasting & Cable Yearbook, 1997*, vol. 1 (New Providence, N.J.: R.R. Bowher, 1997).

9. Dickson, "The High Cost of Pioneering DTV."

10. Diane Mermigas, "New Study Has Some Good News for DTV," *Electronic Media*, November 23, 1998, p. 28.

When a new tower needs to be built, a broadcaster's first problem—the solution of which may generate some controversy—is finding an appropriate location with the proper zoning.[11] (Even retrofitting an existing tower can be controversial, as shown in the case of the shared tower serving the San Francisco Bay area.)[12] New construction, however, may offer opportunities for collocating the transmitters of different broadcasters, a practice that can greatly reduce potential interference between stations. One analyst has estimated that 1,000 of the roughly 1,600 existing full-power TV broadcasters may need significant modifications or new towers to upgrade their facilities for digital broadcasts; as many as 350 may need to construct new towers at least 1,000 feet high.[13] New towers for DTV broadcasting can be as high as 2,000 feet and construction can cost $1,000 per foot, making a new tower a major expense for some broadcasters.[14] Retrofitting an existing tower can also be costly.

A second problem broadcasters may face is the limited availability of crews to carry out the required tower construction and modification. One industry expert estimates that across the nation, there are currently 18 crews erecting broadcast towers and that the number of such crews may increase only slowly because it takes time for them to learn to work together effectively.[15] Moreover, greater demand for more tower construction crews is likely to lead to higher prices for the increased supply.

Tower construction problems may prevent some stations from meeting the FCC-imposed deadlines, but the overall effect of those delays on the transition is likely to be small. In most markets, problems related to towers may delay one or two but not all stations in a market—the exception being the few markets that use a community or shared broadcast tower and experience delays in modifying it. Even without all stations broadcasting, consumers would still have some reason to

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11. Concerns in 1998 over delays in tower construction resulted in the FCC's creating a DTV Tower Strike Force headed by FCC Commissioner Susan Ness. The group's purpose is to provide broadcasters and local authorities with expedited access to commission staff for information about tower construction and modification. See Federal Communications Commission, "Commission Creates DTV Tower Strike Force to Target Potential Problems in Implementing Digital Television," Report No. MM 98-6 (news release, May 29, 1998).

12. In San Francisco, residents living in the area downhill from the tower worried that in a severe earthquake the tower could collapse on their homes. See Glen Dickson, "DTV Tower Hits Snag in San Francisco," *Broadcasting & Cable*, August 17, 1998, p. 71.

13. Thomas A. Fogarty, "Laws, Labor May Delay Digital TV," Tech Report, *USA Today*, January 26, 1999 (available at http://www.usatoday.com/life/cyber/tech/ctb634.htm).

14. Ibid.

15. Ibid.

purchase digital TV sets, which helps strengthen the incentives that will further the adoption of DTV.

AVAILABILITY OF DIGITAL PROGRAMMING FROM CABLE TV PROVIDERS

A third area of concern for the timely introduction of digital TV, and the most important in terms of the raw number of households receiving DTV signals by 2006, is regulatory requirements for carriage of DTV signals by cable TV providers. The availability of digital programming on cable systems is a necessary, though not sufficient, condition for a timely transition. Without it, reaching the 85 percent penetration rate needed to end analog broadcasts in a market will take much longer because whenever the transition is completed, the largest number of households will probably be receiving DTV programming from cable providers. Growing uncertainty about cable carriage of DTV signals is a major factor leading CBO to conclude that the transition from analog to digital programming is likely to stretch beyond 2006.

Cable television is available to about 95 percent of the nation's roughly 100 million television households, and approximately 67 percent of such households currently subscribe to a cable service.[16] That percentage may increase modestly in coming years, possibly reaching 70 percent by 2006.[17] (The percentages reported here are slightly lower than commonly reported cable penetration rates because they are calculated against a base of *all* television households rather than against the number of households that have cable TV available.)

The national averages for households subscribing to a cable service over-simplify the picture for projecting the length of the transition because the BBA's 85 percent test is applied market by market rather than nationally.[18] In 1996, cable penetration rates (that is, the percentage of households with cable available that actually subscribe) in the top 10 markets varied from under 52 percent in the Dallas/Ft. Worth market to almost 77 percent in the Boston market (see Table 2). Only four markets (Palm Springs, Honolulu, Hartford/New Haven, and Santa Barbara/

16. CBO calculation based on "By the Numbers," *Broadcasting & Cable*, July 5, 1999, p. 40; and Federal Communications Commission, *Fifth Annual Report*, CS Docket No. 98-102, FCC 98-335 (December 23, 1998).

17. See Paul Kagan Associates, Inc., *Cable TV Financial Factbook* (Carmel, Calif.: Paul Kagan Associates, Inc., June 1998).

18. The current discussion and Table 2 use the designated market area, or DMA, developed by Nielsen Media Research as the definition of a market. The DMA may or may not be the market definition that the FCC will use to calculate the DTV penetration rates (see Box 3 on page 12).

TABLE 2. HOUSEHOLDS WITH CABLE TV SERVICE IN THE TOP 10 TELEVISION MARKETS, 1996

Designated Market Area[a]	Television Households (Thousands)	Households with Cable TV Service	
		In Thousands	As a Percentage of Television Households
New York	6,711	4,663	69
Los Angeles	4,942	3,049	62
Chicago	3,124	1,869	60
Philadelphia	2,654	2,015	76
San Francisco/Oakland/San Jose	2,278	1,620	71
Boston	2,150	1,665	77
Washington, D.C.	1,908	1,301	68
Dallas/Ft. Worth	1,849	954	52
Detroit	1,772	1,174	66
Atlanta	1,625	1,089	67
Total, Top 10 Market Areas	29,015	19,400	67
All Market Areas[b]	96,916	64,404	66

SOURCE: Congressional Budget Office based on data from R.R. Bowher, *Broadcasting & Cable Yearbook, 1997*, vol. 1 (New Providence, N.J.: R.R. Bowher, 1997).

NOTE: The top 10 market areas are ranked by the number of television households.

a. Designated market areas, or DMAs, are the foundation of a geographic market design developed by Nielsen Media Research based on measured viewing patterns. The DMA consists of all counties in which the home market stations (in general, the stations located in that market) draw a preponderance of viewers. Each U.S. county is allocated to only one DMA with no overlap. The total of all DMAs represents all television households in the United States.

b. Data were unavailable for areas 212 through 225, which cover Alaska, Hawaii, Guam, Puerto Rico, the Virgin Islands, and the Northern Mariana Islands.

Santa Maria/San Luis Obispo), which are all outside of the top 25, had cable penetration rates of 85 percent or more.

Regulatory and technical obstacles must be overcome before the digital programming that is now being broadcast over DTV channels is available to viewers who receive their programming by cable. On the regulatory side, the most important issue is how, or if, must-carry rules—which require cable systems to carry the analog signals of broadcasters in designated market areas—apply to a broadcaster's second, digital channel during the transition. The FCC is currently deciding what rights and obligations cable operators and digital broadcasters have regarding carriage of digital

signals.[19] The technical question yet to be resolved involves the interface between the cable system and the digital TV set. At some point, the DTV programming delivered by a cable service must be translated into a format that can be displayed by a digital TV set or converted for display on an analog TV set.

Must-Carry Rules for Cable Carriage of Digital Programming

In setting the DTV penetration test at 85 percent, the BBA raises a high bar through its strict requirements for counting the households subscribing to a multichannel video programming distributor such as a cable system. As noted earlier, the law requires an MVPD to carry at least one programming channel of every DTV station broadcasting in its market before the provider's subscribers can be considered part of the DTV audience for purposes of meeting the 85 percent goal. Cable operators may carry the required programming because consumers demand it. If they do not, must-carry rules may be needed before cable subscribers will be considered part of the DTV audience.

Must-carry rules for analog TV are already in place as part of the legal framework that defines the relationship of TV broadcasters and cable operators. An analog broadcast signal may be legally retransmitted on a cable system by one of two avenues. First, a cable operator may negotiate for the broadcaster's permission—known as retransmission consent—which may include compensation from the cable operator. Second, under what is known as the must-carry option, a local broadcaster from the market that a cable operator serves may demand that its signal be carried on a cable system. (Must-carry is the only option for noncommercial broadcasters.) However, broadcasters invoking the must-carry rule receive no compensation from the cable operator. Must-carry rules apply primarily to traditional cable systems that use public rights-of-way for their cables. Every three years, broadcasters must elect whether to negotiate a retransmission consent, exercise the must-carry option, or decline to have their signals retransmitted by the cable service.[20]

Whether to apply must-carry rules to cable systems during the transition has produced some controversy—as well as something of a catch-22. Without digital must-carry rules for cable systems during the transition, a move that most cable operators oppose, the likelihood of reaching the 85 percent penetration rate that marks the transition's end in a market appears small. Yet once the transition has ended, the underlying law related to must-carry rules for analog broadcasting would

19. See Federal Communications Commission, *Notice of Proposed Rule Making*, CS Docket No. 98-120, FCC 98-153 (July 9, 1998).

20. See Federal Communications Commission, Cable Bureau, *Fact Sheet on Cable Carriage of Broadcast Stations* (September 1997, available at http://fcc.gov/Bureaus/Cable/WWW/facts/cblbdcst.html).

generally apply to digital signals. Thus, even if ending the transition and applying the current must-carry rules for cable systems to DTV signals would create an audience of 85 percent of households in a market, that achievement would not satisfy the BBA's requirement that the 85 percent goal be reached before the transition ends.

A strong guarantee of cable carriage of DTV programming through an extension of the analog must-carry rules could affect the transition in several ways. First and foremost, it would ensure that by 2006, DTV signals reached, on average, a projected 70 percent of the nation's TV households. Second, depending on the form of the rules, those signals could be available to cable subscribers relatively early in the transition, thereby boosting the early demand for DTV sets. Third, the guarantee of cable carriage would be an incentive for nonnetwork and smaller market stations to begin broadcasting their digital signals earlier than required by the FCC-mandated deadlines.

Yet the help in speeding the transition that strong must-carry rules would bring must be balanced against their cost to cable operators and subscribers. The rules would require cable providers to restrict a number of channels to broadcast DTV programming at the possible expense of other, more profitable or more desirable material. Those restrictions would lessen subscribers' viewing choices as well. In fact, the perceived need for must-carry rules exists because cable companies and their subscribers value some nonbroadcast programming more than some broadcast channels. If every broadcast station was voluntarily carried by a cable operator, then the must-carry rules would not affect anyone's choices or pose any costs.

Cable operators argue that must-carry rules are not only an unconstitutional "taking" of their property by the government but unnecessary as well.[21] The industry contends that if consumers genuinely desire DTV programming, marketplace agreements between cable operators and broadcasters will get DTV channels onto cable systems, making must-carry rules unnecessary. The industry cites a recent agreement between TimeWarner Cable and CBS as an example of why digital must-carry rules are unnecessary—under the agreement, TimeWarner will carry stations owned and operated by CBS in markets in which the two overlap.[22] The Supreme Court has held that analog must-carry rules are constitutional but has not ruled on the constitutionality of digital must-carry rules. Although no deadline has been set for the FCC to decide whether to implement digital must-carry rules, a decision can reasonably be expected before the scheduled auctions of licenses for use of spectrum reclaimed from the television bands.

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21. For more on the issue of takings, see Congressional Budget Office, *Regulatory Takings and Proposals for Change* (December 1998).

22. Don Petrozzello and Glen Dickson, "TW to CBS: Will Carry," *Broadcasting & Cable*, December 14, 1998, pp. 6-7.

The FCC is considering seven alternative rules for cable carriage of DTV signals during the transition. (After the transition is completed, must-carry rules in a digital world should not impose significantly greater burdens than in the analog world, although they would have to be amended to address multiple channels of programming and auxiliary services.) The proposals noted below are ranked from those most likely to speed the transition to digital TV—by enabling cable households to be counted toward the 85 percent market penetration goal—to those least likely to help it.

- *Immediate Carriage*—would require cable systems to carry DTV station programming constituting no more than one-third of their available channel capacity.

- *System Upgrade*—would impose the digital must-carry obligation only on systems with a minimum channel capacity, perhaps 120 channels.[23]

- *Phase-In*—would phase in the must-carry obligation, initially suggested at a rate of three to five channels a year, until all digital channels had been added to the system.

- *Either/Or*—would allow broadcasters to opt for mandatory carriage of either their analog or digital broadcast signal until 2005, when the programming carried by both signals would have to be the same and the must-carry requirement would apply only to the digital transmission.

- *Equipment Penetration*—would establish a threshold for the start of the must-carry obligation (for example, when 5 percent or 10 percent of households were able to view the digital signal).

- *Deferral*—would delay implementing must-carry rules until a later date, such as May 1, 2002, when all commercial stations would be broadcasting digital signals.

- *No Must-Carry*—would not impose any must-carry obligation for digital broadcasts during the transition.

The burden on cable operators of any proposed must-carry requirement could be lessened if the rule required cable operators to carry only one digital programming channel of standard-definition TV quality from each broadcaster. (In that case, the

23. This proposal is actually based on how much bandwidth the cable system uses, but with older cable technology, that translates roughly to channel capacity. Once cable systems have converted to digital technology—which is distinct from carrying digital programming on their systems—the number of channels in a system of given capacity becomes less precise.

SDTV-quality criterion would apply even if the programming was originally of high-definition quality.) Such a rule would also help speed the transition. The BBA requires that only one programming channel of each broadcaster be carried in order to meet the 85 percent test. The legislation is silent on whether cable operators could exploit the capability of DTV technology to transmit multiple streams of SDTV programming (and so retransmit several broadcasters' programming at an SDTV-quality level) on one 6-MHz channel. The major benefit of the strategy for cable systems is that it could greatly reduce the amount of transmission capacity they would have to dedicate to digital must-carry requirements. However, broadcasters might object to retransmission of their signals at a lesser level of quality to meet a must-carry requirement.[24]

Beyond the question of carriage, a second issue affecting the speed of the transition is whether cable operators will provide digital-to-analog conversion capability. Under the BBA, households subscribing to a cable service that provides all of the digital channels in a given market may be counted toward the 85 percent target even if the households cannot actually view the signals. Nonetheless, if cable operators provided conversion technology (for example, embedded in a set-top cable box), they could ensure that subscribers were able to view the DTV signals on their analog TV and might indirectly speed the transition by creating increased consumer demand. Current must-carry rules for analog TV require that the signal delivered to the home by the cable system be viewable on all properly connected television receivers.[25] However, any future digital must-carry rules could conceivably give individual households the choice of acquiring either digital TVs or converter boxes.

The Cable/DTV Interface

How the cable and DTV sets interface will affect the costs to consumers of viewing DTV programming and determine how integrated the digital broadcasts will be with the rest of the cable system's programming and other, value-added services (such as interactive on-screen programming guides) that cable operators plan to provide. Trade-offs between cost, ease and convenience of use, security, and the availability of enhanced features will have to be made. Those decisions may have some impact on the speed of the transition because they affect the ability to view digital programming provided by cable systems on the new DTV sets. Of primary importance for the transition, however, is that the issues be resolved in the near term so that cable systems can begin retransmitting digital broadcasts.

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24. That objection might not stand in a voluntary context. In fact, AT&T's cable systems recently announced that they will retransmit NBC's high-definition programming at a standard-definition quality level. See John Higgins, "AT&T-NBC's Digital Dance," *Broadcasting & Cable*, June 14, 1999, p. 9.

25. 47 U.S.C. 534(b)(7).

A DTV signal passes through several technical formats between the time it is created by a broadcaster and the time a picture is produced on a television set in a cable subscriber's home. A central technical question is, What piece or pieces of equipment will convert the signal from a cable operator to a form that will deliver a viewable picture on a television screen? The answer will involve trade-offs between cable companies and manufacturers of TV sets and cable set-top boxes. The less processing or translating of the signal that the cable box does, the cheaper that device is likely to be. The disadvantage of using a less expensive, less sophisticated device, however, is that the cable company cannot then provide as many value-added services. A further question is whether cable set-top boxes will convert the digital signal delivered by a cable system to a format that can be viewed on an analog TV set. If they do not, consumers will need to purchase—at their own expense—a separate digital-to-analog set-top converter box in order to view digital programming on their existing sets. Using a separate box will cost more than converting signals with a cable set-top box.

These pending technical issues could affect the DTV transition in two ways. First, any hold-up in determining the cable/DTV interface would delay the availability of digital programming to cable subscribers who did not or could not receive broadcast signals over the air. In addition to denying programming to some subscribers, delay in establishing a cable/DTV interface standard would discourage some consumers from purchasing DTV sets, which could prolong the period before the prices of sets declined sufficiently for digital TV to be financially viable for large numbers of consumers. Second, how the interface issues are resolved could affect the integration of broadcast digital television with the host of value-added products that cable systems are expected to provide in the near future. Although the interface question is not likely to have a large effect on the transition, it could make broadcast digital TV less integrated and consequently a less valuable component of cable subscribers' video choices.

CONSUMER ADOPTION OF DIGITAL TV: GETTING TO 85 PERCENT

The fourth area of concern about the transition to digital TV involves consumer demand for the new technology. Although demand is likely to grow over time, expecting it to be great enough to hit the 85 percent adoption target needed to complete the transition by 2006 appears overly optimistic. Assuming that most of the supply-side issues are resolved—DTV programming is abundant, easily received in the home, and available on cable—the question of consumers' taste for the new product remains. Certainly, consumer desire for digital TV will not translate into widespread adoption of the technology until the price of the new equipment declines. Of particular importance in meeting the transition target of 85 percent adoption is the acceptance of digital TV (through purchases of DTV sets or set-top converter boxes

or by cable subscriptions) by the roughly 33 percent of households that currently receive their broadcast television programming over the air.[26]

Questions about what the DTV marketplace will eventually look like and how to use the new technology profitably fuel the uncertainty about when the transition to digital TV will be completed. Broadcasters seek to maximize their profits. Currently, they do that by selling commercial time to advertisers, who pay for it on the basis of the size and demographics of the viewing audience for the broadcasters' programming. Some industry experts, especially those in the consumer electronics area, argue for broadcasting HDTV rather than any lesser-quality digital signal as a way to distinguish the new technology from current TV and create consumer demand for it. Other industry participants—in particular, a subset of broadcasters—argue for broadcasting multiple streams of the slightly improved SDTV as the most profitable strategy. Still others contend that the new possibilities of greater interaction with the viewer are what will make digital TV profitable.[27]

Ironically, viewers who value television the least—the 10 percent to 15 percent of households that are not expected to subscribe to a multichannel video programming distributor by 2006—may be the key to reaching the 85 percent adoption level and triggering the cessation of stations' analog broadcasting. Reaching the last households needed for the transition to end may be difficult and time-consuming under the process's current rules.

Adoption Rates for Consumer Electronics Products

The rate at which consumers adopt new electronics products derives from the interaction of the quality and price of the new product on the supply side and the general desirability of the new product on the demand side. All consumer electronics products are unique, and their adoption rates differ. Considering the rates of adoption of other such products highlights the ambitiousness of the goal of completing the DTV transition by 2006.

As discussed earlier, cable TV—a technology, infrastructure, and service combined in one product—had reached an adoption rate of 67 percent, on average, by 1998 but only after its introduction a half century before and following 20 years

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26. Throughout this section, CBO's calculations of the percentage shares of categories of television households are based on Federal Communications Commission, *Fifth Annual Report*; Paul Kagan Associates, Inc., *Cable TV Financial Factbook* and *Marketing New Media* (Carmel, Calif.: Paul Kagan Associates, Inc., August 17, 1998); and C.E. Unterberg, Towbin, *The Satellite Book, First Quarter 1999* (New York: C.E. Unterberg, Towbin, 1999).

27. For example, NBC is planning to broadcast SDTV pictures with text and graphic enhancements. See Glen Dickson, "Must-See Interactive TV," *Broadcasting & Cable*, April 19, 1999, p. 4.

of rapid growth. That rate is not unusual for the consumer electronics field. It took 22 years for color TV and 15 years for videocassette recorders (VCRs) to reach adoption rates of 85 percent, whereas compact disc players have yet to reach such levels nationally after 11 years on the market (see Figure 2). In comparison, a DTV transition that was completed by the end of 2006 would mean reaching an adoption rate of 85 percent within eight years.

Although the history of the introduction of other products seems to bode poorly for the adoption of digital TV, such comparisons should not be given too much weight. For example, comparing digital TV with color TV is complicated by the fact that when color broadcasts were first introduced, they could be viewed, at a lesser quality but without additional expense, on existing black-and-white sets—which reduced the incentive to buy a new color one. Perhaps the largest difference between the introduction of digital TV and other consumer electronics devices is that digital TV is being introduced into the marketplace as a public policy, enjoying government mandates such as technology standards (absent in the introduction of VCRs) and required broadcasting (absent in the introduction of color TV). Those mandates should help speed the new technology's adoption compared with a product whose introduction is completely driven by the market.

Declines in the Price of DTV Equipment

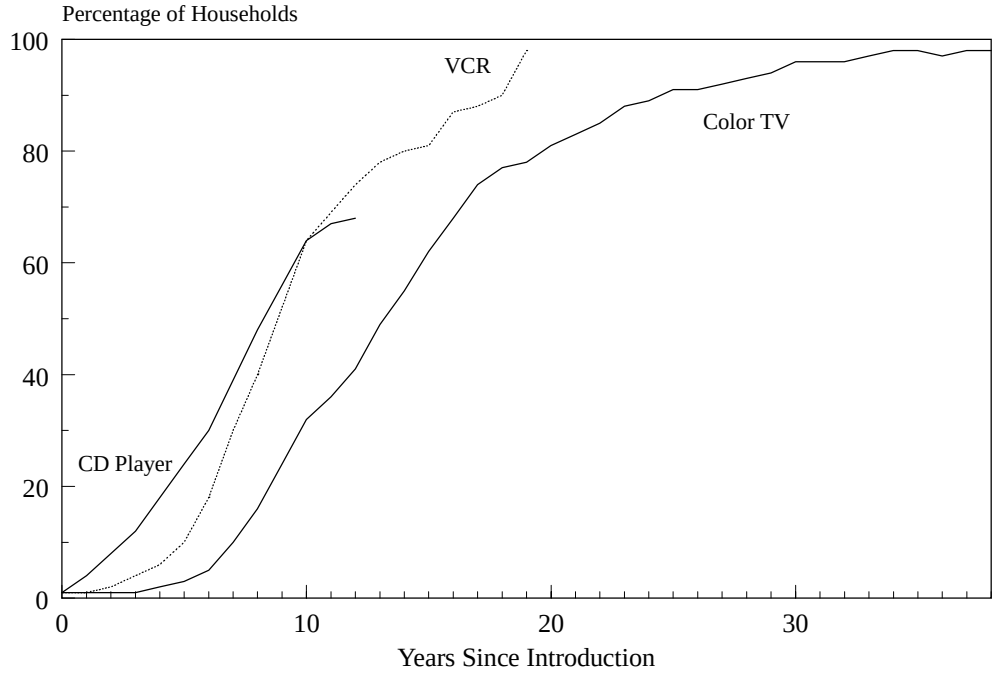
The first TV sets capable of decoding and displaying the new digital broadcasts went on sale in November 1998 for about $7,000.[28] Those sets are geared toward the "high end" of the retail television market and are consequently unaffordable for most consumers. As noted earlier, an alternative to a DTV set is a set-top converter box that translates digital signals into an analog format so that they can be viewed on existing television sets—albeit in a lower-quality picture than on a digital set. The set-top boxes should be available in 1999; they are expected to cost $1,700 initially but less than half that in the near future.[29] (However, there is no indication that prices of set-top converter boxes will fall as low as $50, the figure cited by an Administration official in early 1996.)[30] For digital programming to become widely viewed,

28. See Greg Tarr, "Consumer Electronics Manufacturers Take Different Routes to DTV," *The Dawn of Digital Television*, special insert to *Broadcasting & Cable*, November 11, 1998, pp. S47 and S49; and Paul Farhi, "A Defining Moment for TV?" *Washington Post*, November 1, 1998, pp. H1 and H15.

29. See Joel Brinkley, "HDTV: High in Definition, High in Price," *New York Times*, August 20, 1998, pp. G1 and G8. Evan Ramstead, "Second Generation Digital TV Demonstrated," *Wall Street Journal*, January 7, 1999, p. A17, mentions a $649 digital-to-analog box that Thomson Consumer Electronics plans to introduce.

30. Statement of Larry Irving, Assistant Secretary for Communications and Information, Department of Commerce, in U.S. House of Representatives, *Federal Management of the Radio Spectrum: Advanced Television Services*, hearings before the Subcommittee on Telecommunications and Finance of the House

FIGURE 2. RATES OF ADOPTION BY HOUSEHOLDS OF VCRs, COLOR TELEVISION SETS, AND CD PLAYERS



SOURCE: Congressional Budget Office based on data from the Electronic Industries Alliance.

NOTE: VCR = video cassette recorder; CD = compact disc.

the prices of DTV sets and set-top converter boxes will have to decrease significantly. No one knows how far the prices of sets must decline before they become a mass market item, but one analyst believes that $500 is the price point that elevates a consumer electronics product to mass market status.[31]

The cost of DTV equipment is likely to drop dramatically over time, but whether it does so within a transition that ends in 2006 is very much an open question. Expectations are that the prices of DTV sets and converter boxes will follow the precedent of other consumer electronics equipment and decline fairly rapidly in the years after their introduction. The initial prices of DTV sets are high

Committee on Commerce, Serial No. 104-75 (March 21, 1996), pp. 47, 52, and 57. Digital video disc players might provide the functions of a set-top box, just as some VCRs made homes "cable ready," at a marginal cost below that of a stand-alone box.

31. Todd Thibodeaux, Consumer Electronics Manufacturers Association, quoted in Brinkley, “HDTV: High in Definition, High in Price.”

but not significantly out of line with the introduction of other consumer electronics devices. A DTV set consists of a display and a receiver, which are sometimes sold separately. As with other consumer electronics devices, the costs of producing displays should come down as manufacturing techniques advance. Receivers and digital-to-analog converter boxes rely heavily on computer chips, whose price declines have spurred the fall in computer prices over the past decade. As a result, the price of DTV devices should decline rapidly as well.

Examining the history of other consumer electronics products reveals a range for price declines in the years following a product's introduction (see Figure 3). In 1954, the retail price of a color TV set was about $1,000, or 24 percent of the median family's annual income. In today's dollars, that set would cost roughly $6,000—very close to the $7,000 that the first digital sets cost but only 15 percent of today's median family's annual income.[32] One estimate of general trends in consumer electronics prices is that it takes about 10 years for a new product's inflation-adjusted price to fall by half.[33] In the case of color TV, the wholesale price had fallen to 43 percent of its first-year price to retailers within 20 years of its introduction.

Adoption by Households That Receive TV Programming from Noncable Multichannel Video Programming Distributors

Like households that subscribe to a cable service, households that subscribe to noncable MVPDs have demonstrated their desire for television and a willingness to pay for it. However, in contrast to cable systems, most other MVPDs such as direct broadcast satellite, C-band satellite, satellite master antenna television, wireless cable systems, and local multichannel distribution services do not use public rights-of-way. (Satellite systems, for example, deliver video and audio programming over radio waves but use much higher frequencies and different technology than over-the-air broadcast television.) Therefore, noncable MVPDs have not been subject to traditional analog must-carry rules, and the FCC is not considering applying digital must-carry restrictions to them. In a further contrast to cable subscribers, noncable MVPD households will probably have to purchase some kind of DTV equipment if they wish to view DTV programming. In sum, those households, which have a high demonstrated demand for TV, are likely to experience additional trouble and incur additional expense in order to receive DTV television programming and be counted as DTV households for purposes of the 85 percent market penetration test.

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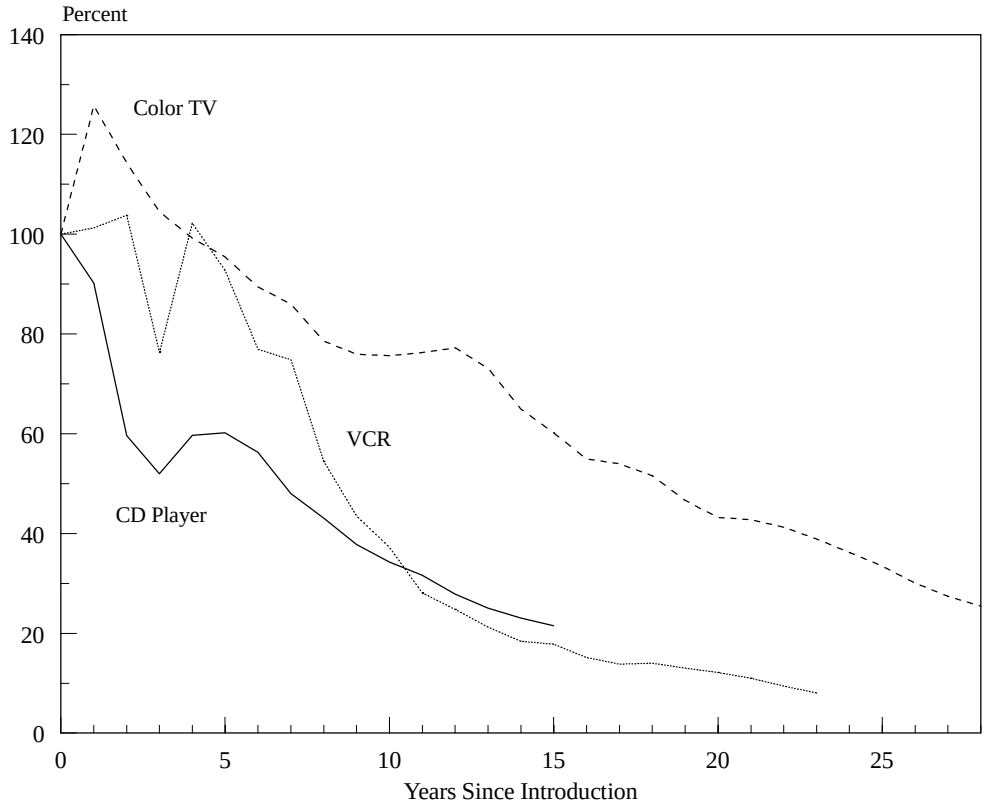
32. See Paul Fahri, "Seeing Parallels in Color TV's Start," *Washington Post*, November 1, 1998, p. H15. CBO's calculation of the median family's annual income is based on income data from Bureau of the Census, "Historical Income Tables— Families: Table F-5, Race and Hispanic Origin of Householder—Families by Median and Mean Income, 1947 to 1997" (available at http://www.census.gov/hhes/income/histinc/f05.html).

33. Brinkley, "HDTV: High in Definition, High in Price."

FIGURE 3. AVERAGE WHOLESALE PRICES FOR VCRs, COLOR TELEVISION SETS, AND CD PLAYERS



SOURCE: Congressional Budget Office based on data from the Consumer Electronics Manufacturers Association.

NOTE: VCR = video cassette recorder; CD = compact disc.

Carriage of DTV programming by noncable MVPDs could help expand the base of DTV viewers needed for a timely end to the transition. Indeed, any source of programming that created an incentive for consumers to purchase DTV sets would probably help speed the overall transition. For example, the satellite programming provider United States Satellite Broadcasting (USSB) is planning to carry Home Box Office's premium high-definition move channel.[34] That kind of programming delivered on MVPD systems would give consumers a reason to purchase new DTV sets and hasten declines in their prices. The same analysis may apply to digital video disc players if they provide better-quality movies that can take advantage of the new DTV set technology.

34. Donna Petrozzello, "USSB Takes HBO HDTV," *Broadcasting & Cable*, November 2, 1998, p. 42. USSB was recently acquired by DirecTV, another DBS company.

Although the percentage of cable subscribers is projected to grow only modestly (perhaps to as much as 70 percent of all television households), other MVPDs—in particular, DBS services—may see subscriber growth that in some cases could be significant. (Box 4 treats the prospects for such growth.) At the end of 1998, over 8 million households, or approximately 8 percent of all television households, subscribed to DBS services, and one-quarter of them, or 2 percent, also subscribed to a cable service. DBS subscriber growth is expected to remain robust, with the DBS share of all television households reaching 15 percent to 20 percent or more by 2006. Some of that growth will come from households that already subscribe to a cable service or to another MVPD. Perhaps as many as one-half of those new DBS subscribers will wish to add to their viewing choices, although many will substitute DBS for another MVPD. The rest of the expected growth will come from households that currently do not pay for programming. As a result, DBS-only subscribers are likely to represent an estimated 11 percent to 15 percent of all television households by 2006. The share of other MVPDs may be as much as 5 percent to 6 percent.

DBS subscribers are an important factor in achieving 85 percent DTV penetration of a market and thus ending the transition. But satellite television broadcasters are hemmed in by laws that could pose problems for delivering DTV broadcast programming to their customers. Current copyright law effectively prevents satellite video providers from retransmitting network programming to households that can receive it over the air.[35] Those restrictions ensure that a network affiliate in a market has no competition from an out-of-market network affiliate delivered by satellite. Although individual broadcasters do not object to their signals being retransmitted to viewers in their own market, the broadcaster community wants satellite services to retransmit all local signals. Yet today the capacity of satellite programming providers is so constrained that it would not be economical for them to carry all local analog stations in most markets. The Congress is currently considering the issue of retransmission of an analog television signal into its own local market.[36] It has not begun to address retransmission of digital signals by a satellite carrier, in part because carriage of broadcast DTV programming in addition to analog channels would exacerbate the existing capacity problems of DBS services.

Although DBS companies in the future might be able to carry programming from every broadcaster in a given local market—and thus meet the requirements for a subscriber to be counted toward the 85 percent goal—CBO does not believe such

35. Satellite providers can carry some out-of-market, nonnetwork broadcast signals—such as superstation WGN from Chicago.

36. See "Congress Starts Work on Satellite TV Bills," *Telecommunications Reports*, January 18, 1999, pp. 27-28.

BOX 4.
GROWTH IN HOUSEHOLDS RECEIVING TV PROGRAMMING FROM NONCABLE, NON-DBS MULTICHANNEL VIDEO PROGRAMMING DISTRIBUTORS

The Congressional Budget Office (CBO) reviewed projections of growth for noncable multichannel video programming distributors (MVPDs) other than direct broadcast satellite (DBS) services to gauge the potential effects of such growth on the speed of the transition to digital television (DTV):[1]

- *C-Band Satellite*. Subscribers to large-dish satellite services currently account for roughly 2 percent of television households. This portion of the MVPD market has shrunk over the past several years, and that trend is expected to continue into the future.

- *Satellite Master Antenna Television*. Subscribers to these services—essentially cable systems for apartment buildings in which signals are delivered to the building by satellite instead of cable—account for approximately 1 percent of television households. That percentage is not expected to increase and may decline.

- *Multichannel Multipoint Distribution Systems*. These traditional wireless cable services account for approximately 1 percent of television households. Growth in such services is likely to be based on providing two-way data communications rather than on an expanded core of video subscribers.

1. CBO's calculations of the percentage shares of categories of television households are based on Federal Communications Commission, *Fifth Annual Report*, CS Docket No. 98-102, FCC 98-335 (December 23, 1998); Paul Kagan Associates, Inc., *Cable TV Financial Factbook* (Carmel, Calif.: Paul Kagan Associates, Inc., June 1998); Paul Kagan Associates, Inc., *Marketing New Media* (August 17, 1998); and C.E. Unterberg, Towbin, *The Satellite Book, First Quarter 1999* (New York: C.E. Unterberg, Towbin, 1999).

a development would greatly affect the speed of the transition. By 2005, the FCC requires stations to deliver the same programming on both their digital and analog signals—although the DTV version could simply be broadcast at a higher resolution or as only one of several streams of programming. If a DBS video provider is retransmitting local analog signals to a market, it may be able to substitute DTV versions of that programming. However, that option may only be viable if the DBS company provides its subscribers with conversion capability to allow the DTV signals to be viewed on an analog set, a function that is not included in the current base of DTV hardware in subscribers' homes.

Adoption by Households That Do Not Pay for TV Programmimg

Persuading TV households that are not MVPD subscribers to adopt the new digital technologies could be an important element of the transition to digital TV. If cable

BOX 4.
CONTINUED

- *Local Multipoint Distribution Services.* This newer form of wireless cable is now in its infancy. Such services, which are characterized by much higher capacity than traditional wireless cable systems, are likely to move in the direction of high-speed data and voice communications instead of more traditional video programming.

- *Open Video Systems*. These video delivery systems are provided by telephone companies and currently represent a negligible share of television households. In the future, however, such systems could experience the largest growth in subscribers of any of the noncable, non-DBS MVPDs. Unlike other noncable MVPDs, open video systems are subject to analog must-carry rules; depending on the FCC's decision on digital must-carry, they may be subject to those rules as well.

In total, CBO believes these other MVPDs may account for 5 percent to 6 percent of television households by 2006 and thus are unlikely to play a major role in a market's reaching the 85 percent DTV penetration that triggers termination of analog station broadcasting. Subscribers to noncable MVPDs demonstrate a desire for video programming by paying for it. However, except for the nascent open video systems, such MVPDs currently do not operate under must-carry rules, and whether the FCC will apply them in the future is uncertain. The lack of a strong must-carry requirement coupled with capacity constraints makes it unlikely that noncable, non-DBS MVPDs will carry programming from all local broadcasters in a market. Consequently, if this group is counted as part of the DTV audience, it will probably be because subscribers choose to go to the expense and effort of buying DTV equipment to view digital signals transmitted over the air. (For example, a household may have to put up a new antenna to receive terrestrial broadcast signals and install a digital-to-analog set-top converter box to view those signals on its existing television set.)

systems carried all DTV broadcast signals, currently two-thirds of all TV households, on average, would be considered to be receiving DTV signals for the purpose of meeting the 85 percent adoption goal. The other MVPDs now account for approximately 10 percent of television households; however, those households would not count toward the 85 percent goal because those MVPDs do not carry local broadcasters. The household shares of both cable services and noncable MVPDs are expected to grow over the next several years. Whether the remaining TV households that do not now pay for programming will either buy DTV equipment or subscribe to an MVPD that meets the DTV requirement—in all likelihood, a cable service—is an open question.

Data on households that do not pay for TV programming are limited to cable nonsubscribers, and even there, little is known other than that such households apparently have little desire for the enhanced or expanded television programming available through a cable service Their low demand for television does not seem to

TABLE 3. HOUSEHOLDS WITH AND WITHOUT CABLE TV SERVICE, BY INCOME, 1997

Household Income	Households with Cable TV Service as a Percentage of All Television Households	Households Without Cable TV Service	
		In Thousands	As a Percentage of All Households Without Cable TV Service
Under $10,000	48	6,397	18
$10,000 - $14,999	56	3,857	11
$15,000 - $24,999	60	6,305	18
$25,000 - $34,999	64	5,093	15
$35,000 - $49,999	68	5,388	15
$50,000 - $74,999	72	4,753	14
$75,000 and Over	82	2,625	8
All Income Groups	65	34,869	100

SOURCE: Congressional Budget Office based on data from Robert Kieschnick and B.D. McCullough, "Why Do People Not Subscribe to Cable Television? A Review of the Evidence" (paper presented at the Telecommunications Policy Research Conference, October 1998), Tables 2 and 3.

be driven solely by low income—cable nonsubscribers are spread over all income groups (see Table 3). Thus, even at the highest income levels, a significant number of households do not subscribe. (Many of those households may subscribe to other noncable MVPDs, but some do not.) For households at lower income levels, expense may indeed be a factor, and as a result, the cost of DTV equipment could be a significant barrier to the technology's adoption by those households.

To sum up, the speed of consumer adoption of the new DTV technology is the so-called wild card in the transition. On the one hand, all of the elements of the transition could mesh smoothly with a high level of consumer desire for digital TV, thus creating the conditions for its rapid adoption. On the other hand, problems with the transition—delays in getting stations on the air, lack of cable carriage, or less of a decline than expected in equipment prices, to name a few—could cause the transition to be prolonged. Ultimately, the transition will take place only if consumers decide that the benefits offered by the new service outweigh the costs of adopting the new technology.

CHAPTER III
CONCLUSIONS AND IMPLICATIONS

The Congressional Budget Office concludes from its analysis that the transition to digital television is likely to continue beyond the tentative ending date of 2006 set out in the Balanced Budget Act. Thus, the benefits that the transition is expected to bring—better-quality television pictures, a significant increase in the amount and types of television programming, an array of new services provided by broadcasters, and spectrum freed for new, possibly nonbroadcast uses and users—are likely to be deferred. A further implication of that conclusion is that under current law, receipts from the auctioned licenses for use of that spectrum will be lower than initially estimated. Yet the likelihood of delay also leaves room for positive policy actions that could increase the benefits from the transition to both society and the federal budget.

CONCLUSIONS

CBO's assessment that the transition to DTV is likely to extend beyond 2006 is based on two main observations. First, uncertainty about whether cable systems will carry the digital programming required to allow their subscribers to be counted toward the 85 percent test throws the timing of the entire transition into question. Second, the last TV households that need to adopt DTV technology for the transition to be completed may be the group of consumers who will be the least interested in adopting it voluntarily.

A number of factors play a role in whether households will adopt digital TV and the transition will end as planned. If DTV technology is available in all markets and the vast majority of television stations have begun broadcasting DTV programming in a timely manner, the remaining hurdle in a successful transition as defined in the Balanced Budget Act is the requirement for 85 percent market penetration. The base of households for meeting that requirement is likely to be the roughly 70 percent (on average) of all television households that projections indicate will be subscribing to a cable service by 2006 (see Table 4). For those households to be legally included in the DTV audience, their cable operator must provide at least one programming channel from each broadcaster in its market. Meeting that condition is likely to require a strong must-carry rule from the Federal Communications Commission.

TABLE 4. CATEGORIES OF TELEVISION HOUSEHOLDS AND FACTORS AFFECTING THEIR BEING CONSIDERED A DTV HOUSEHOLD

	Percentage of TV Households in 1998	Percentage of TV Households in 2006	Factors Affecting Their Being Counted as a DTV Household[a]		
			Must-Carry Rules[b]	Ease of Reception	"Affordable" Equipment
Households with Cable TV Service	67	70	Yes	n.a.	Maybe
Households with Noncable MVPD Service[c]	10	15 - 20	n.a.	Yes	Yes
Households Without Cable or Other MVPD Service	23	10 - 15	n.a.	Yes	Yes

SOURCE: Congressional Budget Office based on Federal Communications Commission, *Fifth Annual Report*, CS Docket No. 98-102, FCC 98-335 (December 23, 1998); Paul Kagan Associates, Inc., *Cable TV Financial Factbook* (Carmel, Calif.: Paul Kagan Associates, Inc., June 1998); Paul Kagan Associates, Inc., *Marketing New Media* (August 17, 1998); and C.E. Unterberg, Towbin, *The Satellite Book, First Quarter 1999* (New York: C.E. Unterberg, Towbin, 1999).

NOTE: DTV = digital television; MVPD = multichannel video programming distributor; n.a. = not applicable.

a. The Balanced Budget Act of 1997 calls for broadcasters to stop broadcasting analog signals in a given market when DTV market penetration reaches 85 percent—that is, when 85 percent of households meet specified conditions to be counted as DTV households capable of receiving digital signals. The cessation of analog signals in a market marks the end of the transition to digital TV—in broad terms, the period during which a TV station broadcasts both a digital and analog signal.

b. Rules that require cable systems to carry the analog signals of broadcasters in designated market areas. The Federal Communications Commission is considering whether to apply such rules to broadcasters' digital signals during the DTV transition.

c. Percentages do not include households that subscribe to both a cable service and another MVPD. Noncable MVPDs include direct broadcast satellite, multichannel multipoint distribution systems (wireless cable), local multipoint distribution systems, satellite master antenna television, and open video systems.

Yet even if all cable subscribers could be counted toward the 85 percent test, the law would still require adoption by another 15 percent of television households. Those additional adopters will come from the remaining 30 percent of television households that analysts project will receive their broadcast digital TV over the air. To be able to view DTV programming, those viewers—unlike cable subscribers—will probably have to invest additional time and money by purchasing set-top converter boxes or antennas. Are there any categories of viewers among that 30 percent who might be more likely than others to adopt digital TV?

CBO expects that by 2006, between one-half and two-thirds of that group—or as much as 20 percent of all television households—will demonstrate a demand for television by subscribing to a noncable MVPD. That willingness to pay for programming could indicate that many, though not all, of those households will adopt digital TV relatively quickly, despite the need to purchase additional equipment. The remaining 10 percent to 15 percent of television households that are not expected to pay for programming by 2006 make up the group that apparently values television the least. Getting enough of those households to adopt digital TV and so raise the market penetration rate to 85 percent is likely to pose the greatest challenge to completing the transition.

IMPLICATIONS

The overall effect of the transition's lasting beyond 2006 is that some of the anticipated benefits from the move to digital TV may not be available as originally planned. Of particular significance for policymakers is that receipts from the scheduled auctions of licenses for the use of spectrum formerly available for analog broadcasting are likely to be lower. Each year of delay expected in freeing up those frequencies in a given market reduces a potential bidder's valuation of the license by the bidder's annual cost of funds. For example, if bidders desired a 10 percent rate of return on their investment, a one-year delay in receiving use of the spectrum would reduce what they were willing to pay for their license by about 10 percent (although the correspondence is not always exact).

In general, market conditions affecting the value of spectrum can be expected to change—as more licenses come to market, the value of additional offerings may well decline. And the delay only affects the portion of value associated with the spectrum that incumbent broadcasters are using and that will not be available until the transition ends. Furthermore, the effect on auction receipts of delays in ending the transition must be evaluated market by market. Licenses for broadcasting frequencies in the top 10 markets are always considered to be more valuable than those for frequencies reaching less populated areas. As an example, roughly half the receipts from the various auctions held since 1994 of licenses for spectrum allocated to personal communications services came from the top 10 markets.

As events unfold over the next few years, observers will develop a better idea of how the transition is proceeding. Unexpected problems with the new technology or significant delays in when stations begin digital broadcasting would imply a longer transition. As noted earlier, a relatively strong digital must-carry rule for cable services could speed the transition, but a weaker rule requiring operators to carry fewer than all stations in a market would be likely to prolong it. Strong sales of DTV sets and digital-to-analog set-top converter boxes accompanied by rapid and significant price declines for both products would bode well for a timely shift.

Further complicating the picture, however, are nascent services such as video programming delivered over the Internet, which could radically change the marketplace in which over-the-air broadcasting competes. What such changes might imply for the speed of the transition is unclear at this time.

An additional factor besides the developments in DTV technology and the marketplace is the possibility of changes in the set of policies affecting the transition. For example, the President's budget for fiscal year 2000 proposes an annual fee of $200 million to be collected from broadcasters that continue to use analog technology. (A broadcaster transmitting only a DTV signal would be exempt from the fee.)[1] The fee could affect the transition in different ways. On the one hand, it could slow the transition by taking resources that might have been used to develop new digital programming away from broadcasters. On the other hand, it could help quicken the transition because the sooner the transition was over in a market and the sooner a broadcaster could turn off its analog signal, the sooner that broadcaster could cease paying the fee tied to the analog channel.

Although time will resolve many of the questions surrounding the transition, a variety of affirmative policy actions carried out now could dispel some of that uncertainty and improve the overall benefits the transition is expected to create. One such action would be to strengthen some of the government mandates related to digital TV; another would be to relax some of the legal requirements that must be met before analog stations can be taken off the air. Delaying the spectrum auctions might also be considered. As 2002 approaches—the year mandated for depositing receipts from auctions of licenses to use spectrum freed by the transition—policymakers will almost certainly reevaluate whether to allow those auctions to proceed, in part because delaying them would be likely to increase the expected receipts to the Treasury. Future research could explore the effects of that option and others on the speed of the transition, on spectrum auctions, and on the benefits to society of freeing bands of spectrum for new uses and users.

1. *Budget of the United States Government, Fiscal Year 2000*, pp. 1144-1145.