United States Government Accountability Office

GAO

Report to Congressional Committees

May 2006

TELECOMMUNICATIONS

Broadband Deployment Is Extensive throughout the United States, but It Is Difficult to Assess the Extent of Deployment Gaps in Rural Areas

GAO Accountability * Integrity * Reliability

GAO-06-426

May 2006

TELECOMMUNICATIONS

Broadband Deployment Is Extensive throughout the United States, but It Is Difficult to Assess the Extent of Deployment Gaps in Rural Areas

GAO Accountability·Integrity·Reliability

Highlights

Highlights of GAO-06-426, a report to congressional committees

Why GAO Did This Study

Both Congress and the President have indicated that access to broadband for all Americans is critically important. Broadband is seen as a critical economic engine, a vehicle for enhanced learning and medicine, and a central component of 21st century news and entertainment. As part of our response to a mandate included in the Internet Tax Nondiscrimination Act of 2004, this report examines the factors that affect the deployment and the adoption of broadband services. In particular, this report provides information on (1) the current status of broadband deployment and adoption; (2) the factors that influence the deployment of broadband networks; (3) the factors that influence the adoption, or purchase, of broadband service by households; and (4) the options that have been suggested to spur greater broadband deployment and adoption.

What GAO Recommends

GAO recommends that FCC develop information regarding the cost and burden that would be associated with various options for improving the information available on broadband deployment and report this information to the relevant Senate and House committees to help them determine what actions, if any, are necessary. FCC provided technical comments on this report, but did not comment on this recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-06-426.

To view the full product, including the scope and methodology, click on the link above. For more information, contact JayEtta Z. Hecker at (202) 512-2834 or heckerj@gao.gov.

What GAO Found

About 30 million American households have adopted broadband service, but the Federal Communications Commission's (FCC) data indicating the availability of broadband networks has some weaknesses. FCC conducts an extensive data collection effort using its Form 477 to assess the status of advanced telecommunications service in the United States. For its zip-code level data, FCC collects data based on where *subscribers* are served, not where providers have deployed broadband infrastructure. Although it is clear that the deployment of broadband networks is extensive, the data may not provide a highly accurate depiction of local deployment of broadband infrastructures for residential service, especially in rural areas.

A variety of market and technical factors, government efforts, and access to resources at the local level have influenced the deployment of broadband infrastructure. Areas with low population density and rugged terrain, as well as areas removed from cities, are generally more costly to serve than are densely populated areas and areas with flat terrain. As such, deployment tends to be less developed in more rural parts of the country. Technical factors can also affect deployment. GAO also found that a variety of federal and state efforts, and access to resources at the local level, have influenced the deployment of broadband infrastructure.

A variety of characteristics related to households and services influence whether consumers adopt broadband service. GAO found that consumers with high incomes and college degrees are significantly more likely to adopt broadband. The price of broadband service remains a barrier to adoption for some consumers, although prices have been declining recently. The availability of applications and services that function much more effectively with broadband, such as computer gaming and file sharing, also influences whether consumers purchase broadband service.

Stakeholders identified several options to address the lack of broadband in certain areas. Although the deployment of broadband is widespread, some areas are not served, and it can be costly to serve highly rural areas. Targeted assistance might help facilitate broadband deployment in these areas. GAO found that stakeholders have some concerns about the structure of the Rural Utilities Service's broadband loan program. GAO was also told that modifications to spectrum management might address the lack of broadband infrastructure in rural areas. Also, because the cost of building land-based infrastructure is so high in some rural areas, satellite industry stakeholders noted that satellite broadband technology may be the best for addressing a lack of broadband in those regions. While several options such as these were suggested to GAO, each has some challenges to implementation. Also, a key difficulty for analyzing and targeting federal aid for broadband is a lack of reliable data on the deployment of networks.

Contents

Figures

Abbreviations

3G	third generation
ADSL	asymmetric digital subscriber line
BPL	broadband over power lines
CTIA	Cellular Telecommunications and Internet Association
DBS	direct broadcast satellite
DSL	digital subscriber line
FCC	Federal Communications Commission
FTTH	fiber to the home
HFC	hybrid-fiber coaxial
IEEE	Institute of Electrical and Electronics Engineers
IG	inspector general
ILEC	incumbent local exchange carrier
Kbps	kilobits per second
Mbps	megabits per second
MSA	metropolitan statistical area
NARUC	National Association of Regulatory Utility Commissioners
NATOA	National Association of Telecommunications Officers and Advisors
NCTA	National Cable and Telecommunications Association
NTCA	National Telecommunications Cooperative Association
NTIA	National Telecommunications and Information Administration
RUS	Rural Utilities Service
SIA	Satellite Industry Association
UNE	unbundled network element
USF	Universal Service Fund
USIIA	US Internet Industry Association
USTA	United States Telecom Association
VoIP	voice over Internet protocol
Wi-Fi	wireless fidelity
WiMAX	Worldwide Interoperability for Microwave Access

WISP	wireless Internet service provider
WISPA	Wireless Internet Service Providers Association

GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, D.C. 20548

May 5, 2006

The Honorable Ted Stevens
Chairman
The Honorable Daniel K. Inouye
Co-Chairman
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Joe L. Barton
Chairman
The Honorable John D. Dingell
Ranking Minority Member
Committee on Energy and Commerce
House of Representatives

The universal availability of high speed Internet access over broadband technologies—commonly referred to as broadband Internet access—has become a national goal.[1] The Telecommunications Act of 1996 directed the Federal Communications Commission (FCC) and state commissions to encourage the deployment of advanced telecommunications capability. Similarly, in 2004, the President stated that there should be a national goal for universal, affordable access to broadband technology by 2007. The importance placed on access to broadband correlates to its many benefits for individuals and society. Broadband is seen as a critical economic engine, a vehicle for enhanced learning and medicine, and a central component of 21st century news and entertainment.

As part of our response to a mandate included in the Internet Tax Nondiscrimination Act of 2004, this report examines the factors that affect the deployment—that is, the building of infrastructure over which broadband services can be provided—and the adoption of broadband services. We focus particularly on the deployment and adoption of broadband to households, as opposed to businesses or institutions. In particular, this report provides information on (1) the current status of broadband deployment and adoption; (2) the factors that influence the deployment of broadband networks; (3) the factors that influence the adoption, or purchase, of broadband service by households; and (4) the

[1]Throughout this report, we refer to high speed Internet access over broadband technologies as broadband Internet access.

options that have been suggested to spur greater broadband deployment and adoption. In January 2006, we released a report that examined the impact of the Internet tax moratorium on state and local tax revenues, as also mandated by the law.[2]

To respond to the objectives of this report, we selected eight states and conducted case studies on the status of broadband deployment and adoption. For each of the states—Alaska, California, Kentucky, Massachusetts, North Dakota, Ohio, Texas, and Virginia—we interviewed state and local officials, including local franchising authorities, state public utility regulators, and representatives from governors' offices; state industry and government associations; private cable and telephone providers; wireless Internet service providers; and municipal and cooperative telecommunications providers. We also spoke with a variety of individuals and organizations knowledgeable about broadband services, such as national industry associations and experts. We spoke with representatives from FCC, the National Telecommunications and Information Administration of the Department of Commerce, and the Rural Utilities Service (RUS) of the Department of Agriculture. To assess the status of broadband deployment and to understand the factors affecting the deployment and adoption of broadband, we used survey data from Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report*. Knowledge Networks/SRI interviewed approximately 1,500 randomly sampled households, asking questions about each household's purchase of Internet services and the availability of cable television service. Using these data, we estimated two econometric models: One model examined the factors affecting broadband deployment and the second examined the factors affecting households' adoption of broadband services. We combined the household survey data with information from FCC's Form 477 filings, which contain information on companies' provision of broadband services by zip codes. This enabled us to develop information about what options for broadband a particular household would have. To assess the impact of Internet taxes on broadband deployment and adoption, we contacted officials in 48 states and the District of Columbia to determine whether the state, or local governments in the state, imposed taxes on Internet access in 2005; we did not evaluate the level of taxation. We concluded that information from Knowledge Networks/SRI and FCC (with modifications discussed later in this report) was sufficiently reliable

[2]See GAO, *Internet Access Tax Moratorium: Revenue Impacts Will Vary by State*, GAO-06-273 (Washington, D.C.: Jan. 23, 2006).

for the purpose of this report. All percentage estimates from the Knowledge Networks/SRI survey have margins of error of plus or minus 7 percentage points or less, unless otherwise noted. See appendix I for a more detailed discussion of the overall scope and methodology for this report, including a discussion of how we selected the case-study states; appendix II for an assessment of the data reliability of the Knowledge Networks/SRI survey; and appendix III for a more detailed explanation of, and results from, our deployment and adoption models.

We conducted our work from April 2005 through February 2006 in accordance with generally accepted government auditing standards.

Results in Brief

About 30 million American households purchase, or have adopted, broadband service, but it is difficult to assess the extent of gaps in the availability of broadband in local markets. Using a survey of American households, we found that 28 percent—or about 30 million—subscribed to broadband service in 2005. In addition, 30 percent of surveyed households subscribed to a dial-up Internet service, and 41 percent did not access the Internet from their home. Among households subscribing to broadband service, we found roughly an equal share taking cable modem and digital subscriber line (DSL) service, the two primary broadband services at this time. Households in rural areas were less likely to subscribe to broadband service, compared with households in urban and suburban areas. On a semiannual basis, FCC conducts an extensive data collection effort using its Form 477 to assess the availability of advanced telecommunications service in the United States. As of July 2005, FCC has found that 99 percent of Americans live in the 95 percent of zip codes that have at least one broadband provider reporting to be serving at least one subscriber. These data clearly indicate that deployment of broadband networks has been extensive. However, for its zip-code level data, FCC collects data based on where *subscribers* are served, not where providers have deployed broadband infrastructure. Based on our analysis is appears that these data may not provide a highly accurate depiction of deployment of broadband infrastructures for residential service in some areas.[3]

[3]While FCC states that its zip-code information is not meant to be a measure of broadband deployment, some parties have used it in this manner because there are no other official data on deployment of broadband across the country.

A variety of market and technical factors, as well as federal and state government efforts and access to resources at the local level have influenced the deployment of broadband infrastructure. Most importantly, companies contemplating the deployment of broadband infrastructure consider both the cost to deploy and operate a broadband network and the expected demand for broadband service. We found it is more costly to serve areas with low population density and rugged terrain with terrestrial facilities than it is to serve areas that are densely populated and have flat terrain. It also may be more costly to serve locations that are a significant distance from a major city. As such, these important factors have caused deployment to be less developed in more rural parts of the country. Firms also consider the extent of existing competition in the broadband market when making deployment decisions: New entrants are more likely to enter markets with no competitors, but at the same time, we found that incumbent cable and telephone companies may respond to entry by new companies by rolling out broadband in markets where they had not yet provided service. Even when cost and demand factors are favorable, technical factors can limit the deployment of broadband service in certain contexts. For example, DSL—the primary broadband service provided by telephone companies—can generally extend only 3 miles[4] from the central office with copper plant, which precludes many households from obtaining DSL service.[5] Finally, we found that a variety of federal and state government efforts as well as access to resources at the local level have influenced the deployment of broadband infrastructure. At the federal level, one of the programs of the Universal Service Fund (USF)—known as the High Cost Fund—has indirectly facilitated broadband service in more rural areas. Similarly, the Department of Agriculture's Rural Utilities Service (RUS) provides grants and loans to promote broadband service in rural areas. At the local level, access to rights-of-way, pole attachments, wireless-tower sites as well as the video franchising process can influence the pace of deployment. We also found that strong leadership within a community can help promote broadband deployment by, for example, enhancing the likely market success of companies' entry into rural markets. Finally, using our econometric model, we found that the imposition of taxes was not a statistically significant factor influencing the deployment of broadband.

[4]The 3-mile limit applies to the path taken by the telephone wire, not necessarily a straight line between the central office and the customer's residence.

[5]With fiber feeders, DSL service can be extended beyond three miles from the central office.

A variety of characteristics related to households and services influence whether consumers purchase (or adopt) broadband service. Based on our econometric model, we found that several characteristics of households influence the adoption decision. Our model showed that households with high incomes were 39 percentage points more likely to adopt broadband than lower-income households, and those with a college-educated head of household were 12 percentage points more likely to purchase broadband than households headed by someone who did not graduate from college. While rural households are less likely to adopt broadband, our findings indicate that this difference may be related in part to the lower availability of broadband in rural areas. In addition, based on discussions with stakeholders, we identified several characteristics of broadband service that influence whether a consumer purchases the service. The price of broadband service remains a barrier to adoption of broadband service for some consumers, although prices have been declining recently. The availability of applications and services that either require or function much more effectively with broadband—such as computer gaming and file sharing—also influences whether a particular consumer purchases broadband service. Using our model, we found that the imposition of the tax was not a statistically significant factor influencing the adoption of broadband service at the 5 percent level. It was statistically significant at the 10 percent level, perhaps suggesting that it is a weakly significant factor. However, giving the nature of our model, it is unclear whether this finding is related to the tax or other characteristics of the states in which the households resided.

Targeted government assistance might help facilitate the deployment of broadband service, and stakeholders we spoke with identified several options to spur greater deployment of broadband service in rural America. However, each of the policy options that stakeholders discussed with us had challenges to their implementation. For example, a few of the stakeholders we spoke with expressed concerns about the structure of the Rural Utilities Service's broadband loan program. Also, several of the stakeholders suggested that modifications to spectrum management might address the lack of broadband infrastructure in rural areas. Finally, because the cost of building land-based infrastructure is so high in some rural areas, satellite industry stakeholders noted that satellite broadband technology may be the best option for addressing a lack of broadband in those regions. Ultimately, we found that a key difficulty for analyzing and targeting any federal aid for broadband is a lack of reliable data on the deployment of networks.

We provided a draft of this report to the Department of Agriculture, the Department of Commerce, and FCC for their review and comment. The Department of Agriculture had no comments on the draft. The Department of Commerce and FCC provided technical comments that we incorporated, as appropriate.

In the draft, GAO recommended that FCC identify and evaluate strategies for improving the 477 data such that the data provide a more accurate depiction of residential broadband deployment throughout the country. In oral comments regarding this recommendation, FCC staff noted that the commission had recently determined that it would be costly and could impose large burdens on filers—particularly small entities—to require any more detailed filings on broadband deployment. As such, we recommend that FCC develop information regarding the degree of cost and burden that would be associated with various options for improving the information available on broadband deployment and should provide that information to the Senate Committee on Commerce, Science, and Transportation and the House Energy and Commerce Committee in order to help them determine what actions, if any, are necessary going forward. FCC did not comment on our final recommendation.

We also provided a draft of this report to several associations representing industry trade groups and state and local government entities for their review and comment. Specifically, the following associations came to GAO headquarters to review the draft: Cellular Telecommunications and Internet Association (CTIA), National Association of Regulatory Utility Commissioners (NARUC), National Association of Telecommunications Officers and Advisors (NATOA), National Cable and Telecommunications Association (NCTA), National Telecommunications Cooperative Association (NTCA), Satellite Industry Association (SIA), US Internet Industry Association (USIIA), United States Telecom Association (USTA), and Wireless Internet Service Providers Association (WISPA). Officials from CTIA, NARUC, and NTCA did not provide comments. Officials from NATOA, NCTA, SIA, and USIIA provided technical comments that were incorporated, as appropriate. USTA and WISPA provided comments that are discussed in appendix V.

Background

Internet access became widely available to residential users by the mid 1990s. For a few years, the primary mechanism to access the Internet was a dial-up connection, in which a standard telephone line is used to make an Internet connection. A dial-up connection offers data transmission speeds up to 56 kilobits per second (Kbps). Broadband, or high-speed, Internet access became available by the late 1990s. Broadband differs from a dial-up connection in certain important ways. First, broadband connections offer a higher-speed Internet connection than dial-up—for example, some broadband connections offer speeds exceeding 1 million bits per second (Mbps) both upstream (data transferred from the consumer to the Internet service provider) and downstream (data transferred from the Internet service provider to the consumer).[6] These higher speeds enable consumers to receive information much faster and thus enable certain applications to be used and content to be accessed that might not be possible with a dial-up connection. Second, broadband provides an "always on" connection to the Internet, so users do not need to establish a connection to the Internet service provider each time they want to go online.

Consumers can receive a broadband connection to the Internet through a variety of technologies. These technologies include, but are not limited to, the following:

- **Cable modem.** Cable television companies first began providing broadband service in the late 1990s over their hybrid-fiber coaxial networks. When provided by a cable company, broadband service is referred to as cable modem service. Cable providers were upgrading their infrastructure at that time to increase their capacity to provide video channels in response to competition from direct broadcast satellite (DBS) providers such as DirecTV® and Dish Network. By also redesigning their networks to provide for two-way data transmission, cable providers were able to use their systems to provide cable modem service. Cable modem service is primarily available in residential areas, and although the speed of service varies with many factors, download speeds of up to 6 Mbps are typical. Cable providers are developing even higher speed services.

- **DSL.** Local telephone companies provide digital subscriber line (DSL) service, another form of broadband service, over their telephone networks on capacity unused by traditional voice service. Local telephone companies began to deploy DSL service in the late 1990s—

[6] FCC defined "advanced service" as exceeding 200 Kbps both upstream and downstream and "high-speed" service as exceeding 200 Kbps in at least one direction, in order to distinguish these from existing data services based on widely available analog telephony and ISDN technology.

some believe, in part, as a response to the rollout of cable modem service. To provide DSL service, telephone companies must install equipment in their facilities and remove devices on phone lines that may cause interference. While most residential customers receive asymmetric DSL (ADSL) service with download speeds of 1.5 to 3 Mbps, ADSL technology can achieve speeds of up to 8 Mbps over short distances. Newer DSL technologies can support services with much higher download speeds.

- **Satellite**. Currently, three providers of satellite service can offer nearly ubiquitous broadband service in the United States. These providers use geosynchronous satellites that orbit in a fixed position above the equator and transmit and receive data directly to and from subscribers. Signals from satellites providing broadband service can be accessed as long as the user's reception dish has a clear view of the southern sky. Therefore, while the footprint of the providers' transmission covers most of the country, a person living in an apartment with windows only facing north, or a person living in house in a heavily wooded area might not be able to receive Internet access via satellite. Earlier Internet services via satellite could only receive Internet traffic downstream—that is, from the satellite to the subscriber—and upstream Internet traffic was transmitted through a standard telephone line connection. Currently, however, satellite companies provide both upstream and downstream connections via satellite, eliminating the need for a telephone line connection and speeding the overall rate of service. Transmission of data via satellite typically adds one-half to three-fourths of a second, causing a slight lag in transmission and rendering this service less well-suited for certain applications over the Internet. While satellite broadband service may be available throughout the country, the price for this service is generally higher than most other broadband modes; both the equipment necessary for service and recurring monthly fees are generally higher for satellite broadband service, compared with most other broadband transmission modes.

- **Wireless.** Land-based, or terrestrial, wireless networks can offer a broadband connection to the Internet from a wide variety of locations and in a variety of ways. Some services are provided over unlicensed spectrum and others over spectrum that has been licensed to particular companies.[7] In licensed bands, some companies are offering fixed wireless broadband throughout cities. Also, mobile telephone carriers—such as the large companies that provide traditional cell phone service—have begun offering broadband mobile wireless Internet service over licensed spectrum—a service that allows subscribers to access the Internet with their mobile phones or laptops as they travel across cities where their provider supports the service. Such services are becoming widely deployed and are increasingly able to offer high-speed services. A variety of broadband access technologies and services are also provided on unlicensed spectrum—that is, spectrum that is not specifically under license for a particular provider's network. For example, wireless Internet service providers generally offer broadband access in particular areas by placing a network of antennae that relay signals throughout the network. Subscribers place necessary reception equipment outside their homes that will transmit and receive signals from the nearest antenna. Also, wireless fidelity (Wi-Fi) networks—which provide broadband service in so-called "hot spots," or areas up to 300 feet—can be found in cafes, hotels, airports, and offices. Some technologies, such as Worldwide Interoperability for Microwave Access (WiMAX), can operate on either licensed or unlicensed bands, and can provide broadband service up to approximately 30 miles in a line-of-sight environment.

Under section 706 of the Telecommunications Act of 1996, Congress directs FCC to encourage deployment of advanced telecommunications capability, which includes broadband, to all Americans. In implementing the act, FCC has treated the two most widely available broadband services—cable modem and DSL service—as information services having a telecommunications component. FCC's approach of not treating such services as telecommunications services has important legal implications because a service defined as a telecommunications service could be subject to regulation under Title II of the Communications Act, which imposes substantial common carrier regulations unless the commission choose to forebear from their enforcement. As part of its responsibilities, FCC periodically issues a report to Congress on the status of advanced telecommunication capability in the United States. To prepare this report,

[7]Spectrum is a natural resource used to provide an array of wireless communication services. FCC regulates commercial entities' use of spectrum. With unlicensed spectrum, a number of users without licenses share a portion of the spectrum, adhering to certain technological specifications. In contrast, with licensed spectrum, FCC provides entities with a license to use a specific portion of the spectrum.

FCC developed a periodic reporting requirement using Form 477. In November 2004, FCC modified its rules regarding the filing of the 477 form, which went into effect for the companies' second filing in 2005. Specifically, FCC removed existing reporting thresholds,[8] and companies are now required to report their total state subscribership by technology.[9]

About 30 Million American Households Purchase Broadband Service; Despite Evidence of Substantial Broadband Deployment throughout the United States, It Is Difficult to Assess Deployment Gaps in Some Areas

We found that in 2005, about 30 million American households—or 28 percent—subscribed to broadband, although households in rural areas were less likely to subscribe to broadband service than were households in urban and suburban areas. Households appear to subscribe to cable modem and DSL services—the two primary broadband services—in approximately equal numbers. FCC requires providers of broadband service to report on the geographic areas in which they serve *subscribers*, but these data are sometimes used to infer the status of *deployment* of companies' Internet infrastructure. Some stakeholders find FCC data collection efforts useful for comparison of adoption of broadband across states, but we found that the data may not be as useful for understanding the status of broadband deployment across the country.

About 30 Million American Households Purchase Broadband Service

Based on survey data from 2005,[10] we found that 28 percent of American households subscribe to broadband service. Figure 1 illustrates how American households access the Internet, by various technologies, and also shows the percentage of households that do not own a computer. As

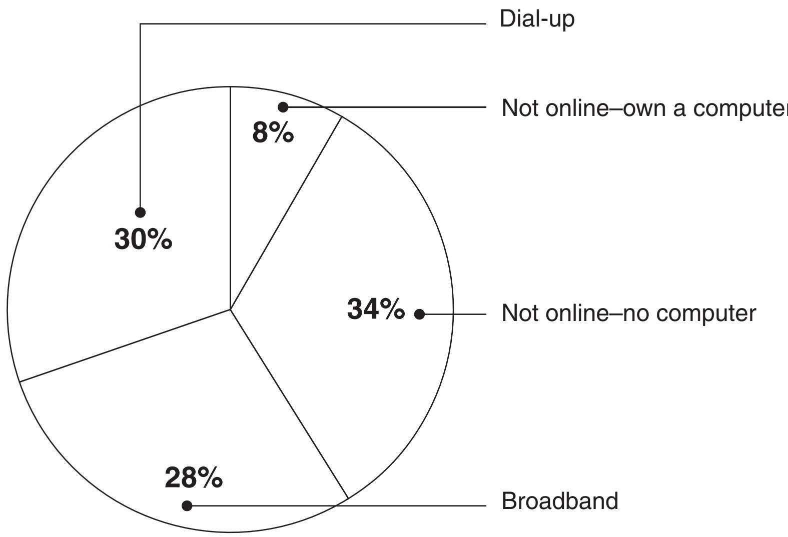
[8]In the past, companies with less than 250 broadband connections were not required to submit information to FCC through Form 477. FCC officials told us that many of the companies that are now required to report are very small and in rural areas. These officials stated that many of these companies are not reporting and that therefore the data may not fully represent broadband deployment.

[9]FCC requires providers to report on their broadband lines or wireless channels. While this may not exactly equate to subscribers, the number of lines and subscribers is related, and we use the word subscribers throughout this report as we refer to the 477 filings of companies.

[10]We used survey data from Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report.*

shown, 30 percent of American households subscribe to dial-up access, and about 41 percent of American households do not have an Internet connection from home. Of those households that do not access the Internet, more than 75 percent do not have a computer in the home, while the remaining households own a computer but do not have online access.

Figure 1: Status of Household Computer Ownership and Internet Connection

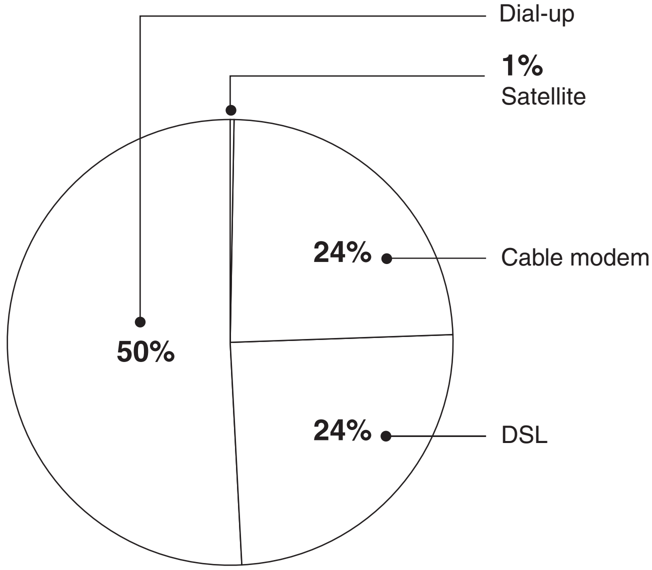


Source: GAO analysis of Knowledge Networks/SRI's *The Home Technology Monitor*TM: *Spring 2005 Ownership and Trend Report.*

Among online households, we found 50 percent subscribe to dial-up service, and 48 percent subscribe to a broadband service.[11] Additionally, we found that of those households subscribing to a broadband service, roughly half purchase DSL service and half purchase cable modem service. (See fig. 2 for the types of connections purchased by online households.)

[11]A very small number of respondents to the survey accessed the Internet over a satellite connection, but none of the respondents reported any other means of wireless access.

Figure 2: Household Online Connection



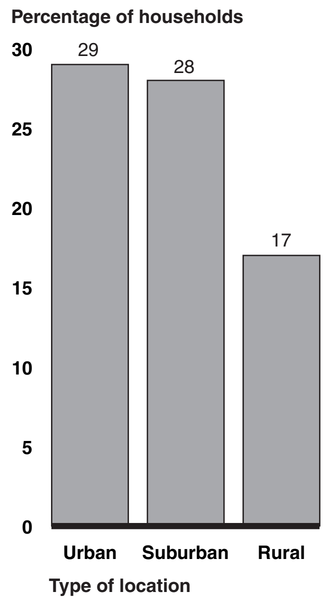
Source: GAO analysis of Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report.*

Finally, we found that households residing in rural areas were less likely to subscribe to broadband service than were households residing in suburban and urban areas.[12] Seventeen percent of rural households subscribe to broadband service, while 28 percent of suburban and 29 percent of urban households subscribe to broadband service. (See fig. 3 for the percentage of urban, suburban, and rural households purchasing broadband service.)

[12]We refer to rural areas as areas outside metropolitan statistical areas (MSA); suburban areas as areas within an MSA but not a central city; and urban areas as a central city of an MSA.

We also found that rural households were slightly less likely to connect to the Internet, compared with their counterparts in suburban areas.[13]

Figure 3: Percentage of Households Subscribing to Broadband, by Type of Location



Source: GAO analysis of Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report.*

[13]Our findings are not substantially different from those of other organizations. Based on 2003 data, the Census Bureau reported that 62 percent of American households had a computer—see U.S. Census Bureau, *Computer and Internet Use in the United States: 2003* (Washington, D.C., 2005). Additionally, the Department of Commerce reported that 20 percent of households—or 37 percent of online households—had broadband service, with DSL becoming increasingly popular. This study also found that broadband service was less commonly purchased in rural areas—see U.S. Department of Commerce, *A Nation Online: Entering the Broadband Age* (Washington, D.C., September 2004). Similarly, using survey data from 2005, the Pew Internet and American Life Project reported that 53 percent of Internet users subscribed to broadband service, that much of the growth in broadband service in recent years arose from DSL subscriptions, and that broadband service was less prevalent in rural areas when compared with broadband subscribership in suburban and urban areas.

Deployment of Broadband Appears to Be Extensive, but FCC's Form 477 Data May Not Provide an Accurate Depiction of Gaps in Broadband Deployment

In order to fulfill its responsibility under section 706 of the Telecommunications Act, FCC collects data on companies' broadband operations. In early 2004, FCC initiated a proceeding to examine whether it should collect more detailed information for its broadband data gathering program than had previously been collected. Specifically, FCC asked whether it should do several things to enhance the broadband data including (1) requiring providers to report the speeds of their broadband services, (2) eliminating the reporting threshold such that all providers of broadband—no matter how small—must report to FCC on its services, and (3) requiring that providers report the number of connections by zip code. In late 2004, FCC released an order in which it decided to require all providers—no matter how small—of broadband to report in the 477 data collection effort on broadband and also required providers to report information about their services within speed tier categories. The commission decided not to require providers to report the number of connections (or subscribers) that they serve within each zip code or the number of connections in speed tiers or by technology within each zip code, finding that finding that such a requirement would impose a large burden on filers (particularly smaller entities), and would require significant time to implement. In particular, several providers commented in the 2004 proceeding that it would be costly and burdensome to develop the software and systems to generate the detailed zip code-level data and that the cost and burden of further reporting requirements would likely outweigh the benefits of more substantial information on broadband deployment in the United States. On the other hand, 3 state utility commissions asked FCC to gather more information within zip codes or by some other Census boundary because such information is, in their view, important for tracking broadband availability.

Based on the modifications to the filing requirements FCC implemented, FCC collects, through its Form 477 filings, information on several aspects of each company's provision of broadband at the state level, such as the total number of subscribers served, the breakdown of how those subscribers are served by technology, and estimates within each technology of the percentage of subscribers that are residential. For each technology identified in the state reporting, providers also submit a list of the zip codes in which they serve at least one customer. As discussed above, companies do not report the number of subscribers served or whether subscribers are business or residential within each zip code; they also do not report information on the locations within the zip code that they *can* serve.

In July 2005, FCC found that 99 percent of the country's population lives in the 95 percent of zip codes where at least one provider reported to FCC that it serves at least one high-speed subscriber as of December 31, 2004. In 83 percent of the nation's zip codes, FCC noted that subscribers are served by more than one provider, and the commission noted that for roughly 40 percent of zip codes in the United States, there are five or more providers reporting high-speed lines in service. Although these data indicate that broadband availability is extensive, we found that FCC's 477 data may not be useful for assessing broadband deployment at the local level.[14] While FCC, in general, notes that the 477 zip-code data are not meant to measure deployment of broadband, in its July 2005 report,[15] the commission states that in order to be able to evaluate *deployment*, the commission "instituted a formal data collection program to gather standardized information about *subscribership to high speed services*. . . ." (Emphasis added.) Based on our analysis, we found that collecting data about where companies have *subscribers* may not provide a clear depiction of their *deployment*, particularly in the context of understanding the availability of broadband for *residential* users.[16]

One quandary in analyzing broadband deployment is how to consider the availability of satellite broadband services. Even though broadband over satellite may not be seen by some as highly substitutable for other broadband technologies because of certain technical characteristics or because of its higher cost, satellite broadband service is *deployed*: Three companies have infrastructure in place to provide service to most of the country.[17] The actual *purchase* of satellite broadband is scattered

[14]In a recent report, we also noted that the 477 data do not provide a full description of broadband services for certain segments of the population, such as Native Americans residing on tribal lands. See GAO, *Telecommunications: Challenges to Assessing and Improving Telecommunications for Native Americans on Tribal Lands*, GAO-06-189 (Washington, D.C.: Jan. 11, 2006).

[15]See FCC, *High-Speed Services for Internet Access: Status as of December 31, 2004* (Washington, D.C., July 2005).

[16]The problems related to tracking data on subscribership versus deployment/availability in Form 477 is not an issue with mobile wireless operators. Because mobile wireless broadband services are designed to be used while subscribers are mobile, those operators are directed to report the zip codes covered by their mobile wireless broadband networks, rather than the zip codes of the billing addresses of their subscribers.

[17]As noted earlier, some households might not be able to actually receive broadband over satellite if they do not have a clear view of the southern sky.

throughout the country and shows up in FCC's 477 zip-code data only where someone actually purchases the service. It is not clear how satellite service should be judged in terms of deployment. Since it is available throughout the entire country, one view could be that broadband is near fully deployed. Alternatively, it could be viewed that satellite broadband—while available in most areas—does not reflect *localized* deployment of broadband infrastructure and should therefore not be counted as a deployed broadband option at all. In either case, FCC's zip-code data on satellite broadband—which is based on the pattern of scattered subscribership to this service—does not seem to be an appropriate indicator of its availability.

Aside from the question of how to view satellite deployment, other issues arise in using subscribership indicators for wire or wireless land-based providers at the zip-code level as an indicator of deployment. These issues include the following:

- Because a company will report service in a zip code if it serves just one person or one institution in that zip code, stakeholders told us that this method may overstate deployment in the sense that it can be taken to imply that there is deployment throughout the zip code even if deployment is very localized. We were told this issue might particularly occur in rural areas where zip codes generally cover a large geographic area. Based on our own analysis, we found, for example, that in some zip codes more than one of the large established cable companies reported service. Because such providers rarely have overlapping service territories, this likely indicates that their deployment was not zip-code-wide and that the number of providers reported in the zip code overstates the level of competition to individual households. We also found that a nontrivial percentage of households lie beyond the 3-mile radius of their telephone central office, indicating that DSL service was unlikely to be available to these homes.

- Companies report service in a zip code even if they only serve businesses. One academic expert we interviewed expressed a concern about this issue. Based on our own analysis, we found that many of the companies filing 477 data indicating service in particular zip codes only served business customers. As such, the number of providers reported as serving many zip codes is likely overstated in terms of the availability of broadband to residences.

- FCC requires that companies providing broadband using unbundled network elements (UNE)[18] report their broadband service in the zip code data. When a provider serves customers using UNEs, they purchase or lease underlying telecommunications facilities from other providers—usually incumbent telephone companies—to serve their customers. Having these providers report their subscribers at the state level is important to ensure that correct numbers on the total subscribers of broadband service is obtained. However, while UNE providers may make investments in infrastructure, such as in collocation equipment, they do not generally own or provide last-mile connectivity for Internet access. Thus, counting these providers in the zip-code-level data may overstate the extent of local infrastructure deployment in the sense that several reporting providers could be relying on the same infrastructure, owned by the incumbent telephone company, to provide broadband access.

ConnectKentucky

Source: ConnectKentucky.

The purpose of ConnectKentucky's Geographic Information Systems (GIS) mapping project is to produce an inventory of existing broadband infrastructure and service availability. The tool can produce maps at the state and census block level. Some of the items mapped include water towers, wireless towers, proposed sewer lines, roads, and population density. The maps also plot which areas are served by municipal, local exchange carrier, cable, and wireless broadband providers.

Based on our analysis, we believe that the use of subscriber indicators at the zip-code level to imply availability, or deployment, may overstate terrestrially based deployment. We were able to check these findings for one state—Kentucky—where ConnectKentucky, a state alliance on broadband, had done an extensive analysis of its broadband deployment. ConnectKentucky officials shared data with us indicating that approximately 77 percent of households in the state had broadband access available as of mid-2005. In contrast, we used population data within all zip codes in Kentucky, along with FCC's 477 zip-code data for that state, and determined that, according to FCC's data, 96 percent of households in Kentucky live in zip codes with broadband service at the end of 2004. Thus, based on the experience in Kentucky, it appears that FCC's data may overstate the availability and competitive deployment of nonsatellite broadband.

Additionally, to prepare our econometric models, we relied on FCC's 477 data to assess the number of providers serving the households responding to Knowledge Networks/SRI's survey. Based on FCC's data, we found that the median number of providers reporting that they serve zip codes where the households were located was 8; in 30 percent of these zip codes, 10 or more providers report that they provide service. Only 1 percent of

[18]UNEs are physical and functional elements of the telephone network, such as the telephone line, or loop, which, under the Telecommunications Act of 1996, incumbent telephone companies must make available to competitors for lease or purchase.

respondents lived in zip codes for which no broadband providers reported serving at least one subscriber, according to FCC's data. To better reflect the actual number of providers that each of the survey respondents had available at their residence, we made a number of adjustments to FCC's provider count based on our analysis of the providers, certain geographic considerations, and information provided by the survey respondents.[19] After making these adjustments, the median number of providers for the respondents fell to just 2, and we found that 9 percent of respondents likely had no providers of broadband at all.

Despite these concerns about FCC's 477 data, several stakeholders, including a state regulatory office and a state industry association, said they found FCC's data useful. An official at a state governor's office also noted that analysis of FCC data allowed them to make conclusions about the extent of deployment in their state. Similarly, an official in another governor's office said that they use FCC's data to benchmark the accessibility of broadband in their state because it is the only data available. A few academic experts also told us that they use FCC's data.

A Variety of Market and Technical Factors, in Addition to Government Involvement and Access to Resources at the Local Level, Have Influenced the Deployment of Broadband

Several market characteristics appear to influence providers' broadband deployment decisions. In particular, factors related to the cost of deploying and providing broadband services, as well as factors related to consumer demand, were critical to companies' decisions about whether to deploy broadband infrastructure. At the same time, certain technical factors related to specific modes of providing broadband service influence how and where this service can be provided. Finally, a variety of federal and state government activities, as well as access to resources at the local level, have influenced the deployment of broadband infrastructure.

[19] In particular, we removed satellite providers, removed any companies we determined only provide service to business customers, removed a cable provider if we found that more than 1 of the largest 10 cable providers served the zip code, removed a cable provider if the respondent said that cable does not pass their residence, and removed telephone-based providers if the residence was further than 2.5 miles from the central office that served the respondent's home.

Several Key Market Factors Related to the Cost of Service and Demand Influence Deployment Decisions

As companies weigh investment decisions, they consider the likely profitability of their investments. In particular, because broadband deployment requires substantial investment, potential providers evaluate the cost to build and operate the infrastructure, as well as the likely demand—that is, the expected number of customers who will purchase broadband service at a given price—for their service. Based on our interviews, we found that several cost and demand factors influence providers' deployment decisions.

Cost Factors

The most frequently cited cost factor affecting broadband deployment was the population density of a market. Many stakeholders, including broadband providers, state regulators, and state legislators, said population density—which is the population per square mile—was a critical determinant of companies' deployment decisions. In particular, we were told that the cost of building a broadband infrastructure in areas where people live farther apart is much higher than building infrastructure to serve the same number of people in a more urban setting. As such, some stakeholders noted that highly rural areas—which generally have low population density—can be costly to serve. Results from our econometric model confirm the views of these stakeholders. We found that densely populated and more urbanized locations were more likely to receive broadband service than were less densely populated and rural locations. For example, we found that urban areas were 9 percentage points more likely to have broadband service available than were rural areas.

Terrain was also frequently cited as a factor affecting broadband deployment decisions. In particular, we were told that infrastructure build-out can be difficult in mountainous and forested areas because these areas may be difficult to reach or difficult on which to deploy the required equipment. Conversely, we were told that flat terrain constitutes good geography for telecommunications deployment. For wireless providers, we were told that terrain concerns can present particular challenges because some wireless technologies require "line-of-sight," meaning that radio signals transmitted from towers or antennas need an unobstructed pathway—with no mountains, trees, or buildings—from the transmission site to the reception devices at users' premises. Terrain can also affect satellite broadband availability in rural areas that have rolling hills or many trees that can obstruct a satellite's signal.

Backhaul

Source: GAO.

In Alaska, backhaul from rural villages requires the use of satellites. This type of backhaul is costly because of the need for terrestrial infrastructure to send and receive signals from satellites as well as the need to either own or lease satellite transmitters. The high cost can affect whether providers deploy broadband service in a village. To help defray this cost, providers often look to serve an "anchor tenant" in a village, such as schools or health clinics that receive federal funding.

Some stakeholders also said costs for what is known as "backhaul" are higher for rural areas and can affect the deployment of broadband networks in these areas. Backhaul refers to the transmission of information—or data—from any of a company's aggregation points to an Internet backbone provider that will then transmit that data to any point on the Internet. This is also sometimes referred to as the "middle mile." Internet traffic originating from rural areas may need to travel a long distance to a larger city to connect to a major Internet backbone provider. Because the cost of transmitting over this distance—that is, the backhaul—can be high, one stakeholder noted that backhaul costs are another barrier to deployment in rural areas. However, using our econometric model, we did not find that the distance to a metropolitan area with a population of 250,000 or more—our proxy for backhaul—was associated with a lower likelihood of broadband deployment.

Demand Factors

Based on our interviews with stakeholders, we found that certain demand factors influence providers' deployment decisions. In particular, because stakeholders noted that potential providers seek to deploy in markets where demand for their service will be sufficient to yield substantial revenues, certain elements of markets were identified as affecting the demand for broadband:

- **Ability to aggregate demand**. For rural locations, officials we spoke with stressed the importance of aggregating sufficient demand. For example, officials in one state told us that to justify the cost of deployment in rural areas where population density is low, telecommunications providers need to be able to aggregate all of the possible demand to make a business case. We were also told that aggregation is furthered by ensuring that a large "anchor tenant" will subscribe to the service. Possible anchor-tenant customers described to us included large businesses, government agencies, health-care facilities, and schools. Because the revenues from such customers will be significant, two stakeholders noted that the anchor tenant alone will help to cover a significant portion of the providers' expenses.

- **Degree of competition**. We found that the degree of existing broadband competition in a local market can inhibit or encourage deployment, depending on the circumstances. Some new entrants—

companies not already providing a telecommunications service in an area—reported that they avoid entering markets with several existing providers and seek out markets where incumbent telephone and cable companies do not provide broadband service. The lack of existing service enables the entrant company to have the potential to capture many customers. At the same time, stakeholders told us that deployment by a new entrant often spurred incumbent telephone or cable providers to upgrade their infrastructures so as to compete with the entrant in the broadband market.

- **Technological expertise**. A few stakeholders noted that demand will be greater in areas where potential customers are familiar with computers and broadband, as these individuals are more likely to purchase broadband service.

Stakeholders we spoke with rarely mentioned the per-capita income of a service area as a factor determining deployment. In fact, a few stakeholders credited cable franchising requirements with ensuring deployment to low-income areas; in some cases, cable franchise agreements require cable providers to build out to all parts of the service territory. However, a 2004 study did find that areas with higher median incomes were more likely to have competitive broadband systems.[20] Similarly, results from our econometric analysis indicate that areas with higher per-capita income are more likely to receive broadband service than are areas with lower per-capita income.

Taxation of Internet Access

Using our econometric model, we did not find that taxation of Internet access by state governments influenced the deployment of broadband service. Taxes can raise consumer prices and reduce revenues and impose costs on providers, and thereby possibly reduce the incentive for companies to deliver a product or service. To assess the impact of Internet taxes on broadband deployment, we contacted officials in 48 states and the District of Columbia[21] to determine whether the state, or local governments in the state, imposed taxes on Internet access. To incorporate this analysis into our model, we used a binary variable to indicate the presence of the

[20]See Tony H. Grubesic and Alan T. Murray, "Waiting for Broadband: Local Competition and the Spatial Distribution of Advanced Telecommunication Services in the United States," *Growth and Change* (2004), 139-165.

[21]We did not contact officials in Alaska and Hawaii, since the survey data from Knowledge Networks/SRI did not include households from these two states.

tax; that is, each state was placed into one of two groups, states with a tax and states without a tax. As such, this binary variable could potentially capture the influence of other characteristics of the states, in addition to the influence of the tax. While the parameter estimate in our model had the expected sign—indicating that the imposition of taxes may reduce the likelihood of broadband deployment—it was not statistically significant.

Certain Critical Technical Factors Affect Broadband Deployment

Many stakeholders we spoke with commented on issues related to technical characteristics of networks that provide broadband. In particular, many noted that certain technical characteristics of methods used to deliver broadband influence the extent of its availability. In terms of issues discussed for established modes of broadband delivery, we were told the following:

- DSL service can generally be provided over telephone companies' copper plant to residences and businesses that are within approximately 3 miles from the telephone company's facility, known as a central office. However, if the quality of the telephone line is not good, the distance limit can be reduced—that is, it may only be possible to provide DSL for locations within some lesser distance—perhaps 2 miles—from a central office. We were told, for example, that in some rural areas, DSL is more limited by distance because the telephone lines may be older. While the distance limit of DSL can be addressed by deploying certain additional equipment that extends fiber further into the network, this process can be expensive and time consuming.

- Across spectrum bands used to provide terrestrial wireless broadband service, technical characteristics vary: In some cases, signals may travel only a short distance, and in other cases, they may travel across an entire city; in some cases there may be a need for line-of-sight from the transmission tower to the user, but in other cases, the signals may be able to travel through walls and trees. Some stakeholders mentioned that wireless methods hold great promise for supporting broadband service.

- Satellite technology can provide a high-speed Internet service throughout most of the United States. However, the most economical package of satellite broadband service generally offers, at this time, upstream speeds of less than 200 kilobits per second, and therefore this service does not necessarily meet FCC's definition of *advanced telecommunications services*, while it does meet FCC's definition of high-speed service. Despite the near universal coverage of satellite service, consumers need a clear view of the southern sky to be able to receive transmissions from the satellites. Additionally, transmission via satellite introduces a slight delay, which causes certain applications, such as VoIP (i.e., telephone service over the Internet), and certain computer gaming to be ill-suited for use over satellite broadband.

Some emerging or expanding broadband technologies do not currently have significant subscribership, but have the potential to be important means of broadband service in the coming years. These technologies include deep fiber deployment (e.g., fiber to the home), WiMAX, broadband over power lines (BPL), and third-generation (3G) cellular. Each of these technologies has technical considerations that are influencing the nature of deployment. See appendix IV for a discussion of these technologies.

Federal and State Government Efforts, and Access to Resources at the Local Level, Have Impacted the Deployment of Broadband

We found that government involvement in several venues, and access to resources at the local level, have affected the deployment of broadband networks throughout the nation. In particular, we found that (1) certain federal programs have provided funding for broadband networks; (2) some state programs have assisted deployment; (3) state and local government policies, as well as access to resources at the local level, can influence broadband deployment; and (4) broadband deployment—particularly in more rural settings—is often influenced by the extent of involvement and leadership exercised by local government and community officials.

Federal Programs Have Funded Broadband Infrastructure

We found that several federal programs have provided significant financial assistance for broadband infrastructure.

- The Universal Service Fund (USF) has programs to support improved telecommunications services. The high-cost program of the USF provides eligible local telephone companies with funds to serve customers in remote or rural areas where the cost of providing service is higher than the cost of service in more urbanized areas. The high-cost funds are distributed to providers according to formulas based on several factors, such as the cost of providing service, with funds distributed to small rural incumbent local exchange carriers (ILEC) and larger ILECs serving rural areas based on different formulas. Competitive local exchange carriers can also qualify to receive high-cost funds. While high-cost funds are not specifically targeted to support the deployment of broadband infrastructure, these funds do support *telecommunications* infrastructure that is also used to provide

Universal Service Fund

Source: GAO.

The Universal Service Fund facilitates education and health care in rural Alaska by providing broadband Internet connections. Access to broadband connections provides learning opportunities for children, such as higher-level curriculum, and teacher certification programs. Additionally, it facilitates health care by allowing more immediate care in local villages rather than requiring long trips to a larger clinic or hospital.

broadband services. We were told by some stakeholders in certain states that high-cost support has been very important for the upgrade of telecommunications networks and the provision of broadband services. In particular, some stakeholders in Alaska, Ohio, and North Dakota told us that high-cost support has been critical to small telephone companies' ability to upgrade networks and provide broadband services. Additionally, the e-rate program of the USF has provided billions of dollars in support of Internet connectivity for schools and libraries. Another USF program, the Rural Health Care Program, provides assistance for rural health facilities' telecommunications services.

- Some programs of the U.S. Department of Agriculture's Rural Utilities Service (RUS) provide grants to improve rural infrastructures providing broadband service. The Community Connect Program provides grants to deploy transmission infrastructures to provide broadband service in communities where no broadband services exist, and requires grantees to wire specific community facilities and provide free access to broadband services in those facilities for at least 2 years. Grants can be awarded to entities that want to serve a rural area of fewer than 20,000 residents. Approximately $9 million was appropriated in 2004 as well as in 2005 for this purpose.

- RUS's Rural Broadband Access Loan and Loan Guarantee program provides loans[22] to eligible applicants to deploy infrastructures that provide broadband service in rural communities that meet the program's eligibility requirements. A wide variety of entities are eligible to obtain loans to serve small rural communities. To obtain a 4 percent loan, the applicant must plan on serving a community with no previously available broadband service, but loans at the Treasury interest rate do not have such a requirement.

- The Appalachian Regional Commission's Information Age Appalachia program focuses on assisting in the development and use of telecommunications infrastructure. The program also provides funding to assist in education and training, e-commerce readiness, and technology-sector job creation. We were told that in Kentucky, funding from the commission assisted the development and operations of

[22]This program also can provide loan guarantees, but to date, no loan guarantees have been requested.

ConnectKentucky, a state alliance that focuses on broadband deployment and adoption. The Appalachian Regional Commission also provided some funding for projects in Ohio and Virginia.

Various State Programs Assist the Deployment of Broadband Services

A number of states we visited have had programs to assist the deployment of broadband services, including the following:

- The Texas Telecommunications Infrastructure Fund began in 1996 and according to an official of the Texas Public Utility Commission committed to spend $1 billion on telecommunications infrastructure in Texas. Public libraries, schools, nonprofit medical facilities, and higher education institutions received grants for infrastructure and connectivity to advanced communications technology. The program is no longer operational.

- ConnectKentucky is an alliance of technology-focused businesses, government entities, and universities that work together to accelerate broadband deployment in the state. ConnectKentucky focuses on three goals: (1) raising public awareness of broadband services, (2) creating market-driven strategies to increase demand—particularly in rural areas, and (3) initiating policy to reduce regulatory barriers to broadband deployment.

- The Virginia Tobacco Indemnification and Community Revitalization Commission partially funded Virginia's Regional Backbone Initiative. The backbone initiative is designed to stimulate economic development opportunities by encouraging the creation of new technology-based business and industry in southern Virginia, which has historically relied heavily on tobacco production.

Local Issues and Access to Resources Impact the Deployment of Broadband Services

The ability of a company to access local rights-of-way, telephone and electric poles, and wireless-tower sites can influence the deployment of broadband service. In particular, a few stakeholders we spoke with said difficulty in gaining access to these resources can serve as a barrier to the rapid deployment of broadband service because accessing these resources was a time-consuming and expensive process. Companies often require access to rights-of-way—such as areas along public roads—in order to install infrastructure for broadband service. In some instances, companies can face challenges gaining access to rights-of-way, which can hinder broadband deployment. For example, we were told that in one California community, providers had difficulty bringing wires across a highway, which limited their ability to provide service in all areas of the community. Some companies also require access to telephone and electric poles to install their broadband infrastructure. Depending on the entity owning the pole, we were told that acquiring access to poles could be costly and time consuming. For example, one BPL provider told us that it encountered difficulty accessing poles owned by the telephone company. Finally, wireless companies need access to towers or sites on which they can install facilities for their broadband infrastructure. A few stakeholders we spoke with told us that gaining this access can be a difficult process. For example, one company said providers are often challenged by the need to learn each town's tower-siting rules. While some stakeholders identified problems gaining access to these resources, other stakeholders did not identify access to rights-of-way, poles, and other resources as issues in deploying broadband services.

We found that the video-franchising process can also influence the deployment of broadband service because companies may be building infrastructure to simultaneously provide both video and broadband services. To provide video service, such as cable television, companies usually must obtain a franchise agreement from a local government. Some stakeholders assert that the video-franchising process can delay the deployment of broadband service because providers must negotiate with a large number of local jurisdictions. Further, these negotiations can be time consuming and costly. As a result, these stakeholders believe that local franchising can hinder their ability to deploy broadband infrastructures. Alternatively, some stakeholders believe that the video-franchising process is important because it helps promote deployment of broadband service to all areas of a community. For example, some jurisdictions have ubiquity requirements mandating deployment to all areas of a community, including those that are less affluent. These stakeholders argue that without the local ubiquity requirement, service providers could "cherry pick" and exclusively provide broadband services to more economically desirable areas.

In some instances, municipal governments provide broadband infrastructure and service. For example, we spoke with officials in five municipal governments that provide wire-based broadband service, often in conjunction with the government's electric utility. We also spoke with one municipal government that provided wireless broadband service. A few of these municipal government officials told us that their municipality had undertaken this deployment because they believe that their communities either do not have, or do not have adequate, private broadband service. A significant number of stakeholders we interviewed support a municipality's right to provide broadband services and believe that broadband service is a public utility, such as water and sewer. Some support municipal deployment of broadband, regardless of whether other providers are available in that area, while other stakeholders support a municipality's right to deploy broadband service only if there are no other broadband providers serving the area. However, other stakeholders we spoke with oppose municipal government deployment of broadband service. These stakeholders believe that municipal governments are not prepared to be in the business of providing broadband and that municipal deployment can hinder private-sector deployment.

Community Leadership Encourages the Deployment of Broadband Services

We found that the cost of serving rural areas presents a challenge to the nationwide goal of universal access to broadband. One of the ways that some communities have addressed the lack of market entry into rural areas has been through initiatives wherein community leaders have worked to enhance the likely market success of private providers' entry into rural broadband markets. For example, some community leaders have worked to aggregate demand—that is, to coordinate the Internet needs of various users so that a potential entrant would be able to support a business plan. We were told that this leadership—sometimes by key government officials, sometimes through partnerships—was seen as critical in helping to spur the market in some unserved areas.[23] The following examples illustrate this point:

Berkshire Connect Attracts Deployment to Western Massachusetts

BERKSHIRE CONNECT, INC.

Source: Berkshire Connect, Inc.

Berkshire Connect, Inc. was founded to respond to the lack of reliable and affordable T-1 service for businesses in the Berkshire region of Massachusetts. The organization aggregates demand for broadband service among users in the region, such as hospitals, schools, large and small businesses, and nonprofit organizations. Through a request for proposal process, the organization selected "preferred providers" that offer members of Berkshire Connect an array of advanced telecommunications services at competitive prices. Berkshire Connect's primary goals are to provide and ensure competitive pricing, equal pricing throughout Berkshire County, sustained competition, and a community focus regarding the provision of telecommunications services.

- In Massachusetts, several regional coalitions that have been called "connect" projects focus on demand aggregation as a tool to encourage further deployment of telecommunications backbone and broadband networks in more rural parts of the state that were not well served by broadband providers. In particular, three such regional groups said their demand aggregation model is designed to maximize the purchase of broadband services in their region by working with local hospitals, schools, home businesses, small business, and residents to demonstrate the full extent of the demand for broadband and thus encourage private investment in infrastructure. For the one project that was the most developed, a few stakeholders told us that the group had been critical in helping to spur infrastructure development in the area, and that

[23] A recent GAO report, *Telecommunications: Challenges to Assessing and Improving Telecommunications for Native Americans on Tribal Lands*, GAO-06-189 (Washington, D.C.: Jan. 11, 2006) discusses how leadership in a community can help to improve telecommunications services on tribal lands. The report provides several examples of tribes addressing the barriers to deployment of telecommunications networks by partnering with private entities, providing technical training, and taking initiative to access federal grants.

leadership by State government was important to the development of the initiative.

- ConnectKentucky, as discussed earlier, is an example of a state coalition taking a leadership role to develop information on state deployment levels, educate citizens about the benefits of broadband service, and advocate broadband-friendly policies with the state legislature. Throughout our meetings in Kentucky, the work of ConnectKentucky was stated to have been instrumental in the development of a common understanding of the state of broadband deployment and adoption as well as in instigating new initiatives to advance the market. The key element of ConnectKentucky that was cited as crucial to its success was leadership from state government, in particular from the governor's office.

- In Alaska, we found that in one remote area—Kotzebue, a community 26 miles above the Arctic Circle—strong local leadership was important to the development of a public-private partnership that provides improved medical care to the region. The local leadership from the health cooperative brought together parties in the community and worked with them to develop a plan to provide enhanced health service throughout the community's villages. The Maniilaq Health Center uses a wireless "telecart" with a video camera that can send high-quality, real-time sound and video between the center and Anchorage. The center's physicians are able to perform procedures under the guidance of experts in Anchorage who can "remotely" look over the physicians' shoulders. In addition, there are village clinics staffed by trained village health aides. These village clinics are connected to the main health center via a broadband link that allows them to share records and diagnoses via the telecart.

A Variety of Household and Service Characteristics Influence the Adoption of Broadband

We developed an econometric model to assess the many factors that might influence whether a household purchases broadband service. The model examined two types of factors: the tax status of states in which respondents live, and the characteristics of households. We also discussed these issues, as well as the influence of characteristics and uses of broadband service, with stakeholders.

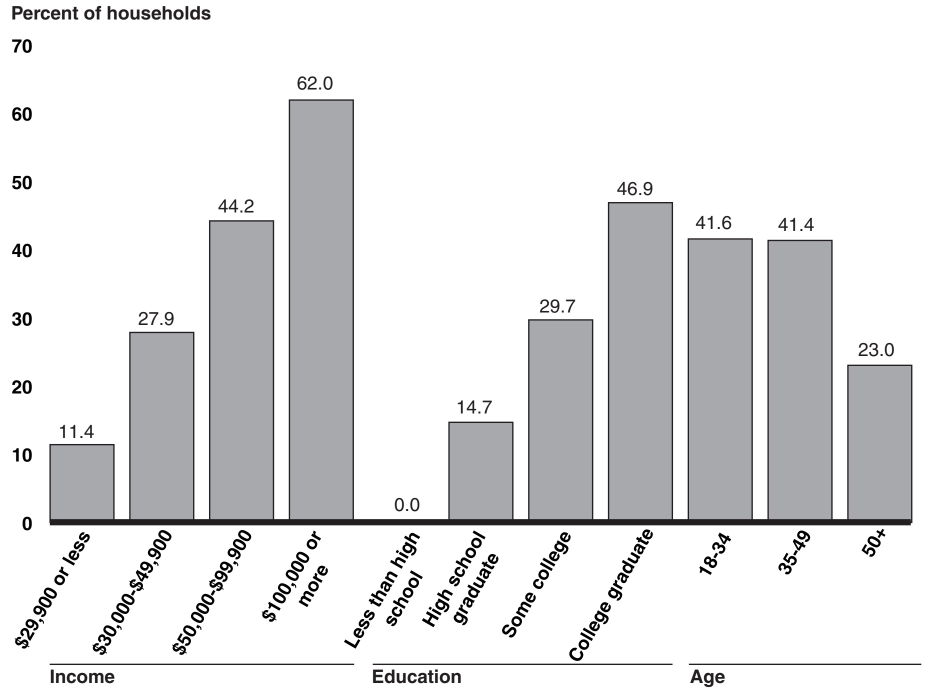
Based on our model and interviews with stakeholders, we identified several characteristics of households that influence broadband adoption.

First, our model indicated that high-income households are 39 percentage points more likely to purchase broadband service than are low-income households.[24] Similarly, some stakeholders we spoke with stated that adoption of broadband service is more widespread in communities with high income levels. A key underlying factor may be that computer ownership is substantially higher among higher-income households, according to a survey conducted by the Census Bureau. Second, our model results showed that households with a college graduate are 12 percentage points more likely to subscribe to broadband services compared with households without a college graduate. In fact, when discussing the effects of education on the demand for broadband, we were told that some college graduates see broadband as a necessity and would be less likely to choose to live in a rural area that did not have adequate broadband facilities. Third, we found that households headed by young adults are more likely to purchase broadband than are households headed by a person 50 or older.[25] Similarly, a few stakeholders we spoke with said that older adults are less likely to purchase broadband. This may be the case because older Americans generally have lower levels of computer ownership and computer familiarity. We also were told that households with children in school are more likely to have broadband service. Figure 4 provides some descriptive statistics to illustrate the relationship between several demographic characteristics and the adoption of broadband.

[24]"High-income households" were defined as those having incomes in top 25 percent of all households, while "low-income households" were defined as those having incomes in the bottom 25 percent of all households.

[25]We define "young adults" as people between the ages of 18 and 33.

Figure 4: Factors Influencing Subscription to Broadband



Source: GAO analysis of Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report.*

We also examined whether households residing in rural areas were less likely to purchase broadband service than those living in urban areas. As noted earlier, we found that only 17 percent of rural households subscribe to broadband service. Our model indicated, however, that when the availability of broadband to households, as well as demographic characteristics, are taken into account, rural households no longer appear less likely than urban households to subscribe to broadband. That is, the difference in the subscribership to broadband among urban and rural households appears to be related to the difference in availability of the service across these areas, and not to a lower disposition of rural households to purchase the service.

In addition to household characteristics, we also found that characteristics and uses of broadband service available to consumers can also influence the extent to which households purchase broadband service.

- Some stakeholders we spoke with mentioned that the price of broadband service is an important factor affecting a household's decision to purchase this service. Some stakeholders mentioned, for example, that one of the key reasons for the recent surge in DSL subscribership is due to recent price declines for the service: Some providers are now offering DSL for less than $15 per month. Conversely, because satellite broadband service is expensive and also requires the upfront purchase of expensive equipment needed to receive the satellite signal, several of those we spoke with said that the expense of satellite broadband deters its purchase. In fact, a recent study suggests that areas served by multiple providers, where prices may tend to be lower, may have higher rates of broadband adoption.[26] However, because we lacked data on the price of broadband service, we were unable to include this variable in our econometric model.[27] We did not find that the number of companies providing broadband service affected the likelihood that a household would purchase broadband service.

- Some stakeholders also told us that the availability of applications and content not easily accessible through dial-up, as well as the degree to which consumers are aware of and value this availability, contribute to a household's decision to adopt broadband. For example, some functions, applications, and content—such as gaming, VoIP, and music and video downloads—either need or function much more effectively with broadband service than with dial-up service and, as such, make broadband a major attraction for households that value these types of services and content. Alternatively, some applications, such as e-mail, function adequately with dial-up service, and for households that primarily use the Internet for e-mail, there may be little need to upgrade to broadband service. Several of those we spoke with noted that a "killer application"—one that nearly everyone would view as essential and might entice more American households to adopt broadband—has not yet emerged.

- We also examined whether the tax status of the state in which each survey respondent lived influenced their likelihood to adopt broadband service. As mentioned earlier, we used a binary variable to represent the

[26]See Debra J. Aron and David E. Burnstein, "Broadband Adoption in the United States: An Empirical Analysis" (paper presented at the 31st Annual Telecommunications Policy Research Conference, Arlington, Va., 2003).

[27]We recognize that our model does not fully include all the variables that would influence the adoption decision. As such, the parameter estimates will be biased. We are unable to assess the possible extent of this bias.

presence of Internet taxation. As such, the variable may capture the influence of other characteristics of the states in which the households resided, in addition to the influence of the tax. Further, lacking a variable for the price of broadband service, we cannot assess how the imposition of the tax influenced the price of the service. Using our model, we found that the parameter estimate had the expected sign—indicating that the imposition of the tax may have reduced the likelihood that a household would purchase broadband service. While the estimate was not statistically significant at the 5 percent level, it was statistically significant at the 10 percent level, perhaps suggesting that it is a weakly significant factor. However, given the nature of our model, it is unclear whether this finding is related to the tax or other characteristics of the states in which households resided.

Stakeholders Identified Several Options to Address the Lack of Broadband in Certain Areas, but Challenges Exist with Implementation

Stakeholders we spoke with identified several options to facilitate greater broadband service in unserved areas; however, each option poses special challenges. RUS broadband programs provide a possible means for targeted assistance to unserved areas, but stakeholders raised concerns about the effectiveness of the loan program and its eligibility criteria. USF programs have indirectly facilitated broadband deployment in rural areas, but it is unclear whether the program should be expanded to directly support broadband service. Finally, wireless technologies could help overcome some of the cost and technological limitations to providing service in remote locations, but congestion and the management of the spectrum remain possible barriers.

RUS Broadband Programs Could Provide a Source of Targeted Assistance, but Stakeholders Identified Several Concerns with the Programs

As mentioned earlier, RUS provides support through grants and loans to improve rural infrastructures providing broadband service. The Community Connect Broadband grant program provides funding for communities where no broadband service currently exists. One loan program, which provides loans at 4 percent, also requires that no existing broadband providers be present in a community, but loans at the Treasury interest rate are available to entities that plan to serve communities with existing broadband service. Several stakeholders with whom we spoke, as well as the findings of a recent report by the Inspector General (IG) of the Department of Agriculture, raised concerns about these programs:[28]

- **Effectiveness of loans**. It is not clear whether a loan program—such as the RUS loan program—is effective for helping rural areas gain access to broadband services. RUS requires applicants to submit an economically viable business plan—that is, applicants must show that their business will be sufficiently successful such that the applicant will be capable of repaying the loan. But developing a viable broadband business plan can be difficult in rural areas, which have a limited number of potential subscribers. As a result, RUS has rejected many applications because the applicant could not show that the business plan demonstrated a commercially viable and sustainable business. In fact, the agency has been unable to spend all of its loan program funds. Since the inception of the program in 2002, the agency has fallen far short of obligating the available funding in this program. For example, RUS officials told us that in 2004, they estimated that the appropriations for the broadband loan program could support approximately $2.1 billion in loans, but only 28 percent of this amount—or $603 million—was awarded for broadband projects. RUS officials also told us that its 2005 appropriations could support just over $2 billion in loans, but only 5 percent—or $112 million—was awarded to broadband projects. One stakeholder we spoke with suggested that a greater portion of RUS funds should be shifted from loans to grants in order to provide a more significant level of assistance for rural broadband deployment. RUS officials noted that they are currently evaluating the program and recognize that the program criteria limit the ability of the agency to utilize their full loan funding.

- **Competitive environment requirements**. During our interviews, some stakeholders expressed concerns about how the presence of existing broadband deployment was considered in evaluating RUS grant and loan applications. In the case of the grant program, RUS approves applications only for communities that have no existing broadband service. Some local government officials and a company we spoke with noted that this "unserved" requirement for RUS grants can disqualify certain rural communities that have very limited Internet access—

[28]U.S. Department of Agriculture, Office of Inspector General, *Audit Report: Rural Utilities Service Broadband Grant and Loan Programs*, Audit Report 09601-4-Te (Washington, D.C., Sept. 30, 2005).

perhaps in only one small part of a community.[29] Alternatively, regarding the Treasury rate loan program, a few providers and the IG's report criticized the program for supporting the building of new infrastructure where infrastructure already existed. In particular, we learned that loans were being let for deployment in areas that already had at least one provider and in some cases had several providers. As such, it is not clear whether these funds are being provided to communities most in need. RUS officials noted, however, that the statute specifically allows such loans. Additionally, the issue of how the status of existing service is gauged was a concern for one provider we spoke with. RUS obtains information about existing providers from applicants, and agency officials told us that agency field representatives review the veracity of information provided by applicants during field visits. However, RUS officials told us that FCC zip-code data is not granular enough for their needs in evaluating the extent of broadband deployment in rural areas.

- **Community eligibility**. A few local officials we spoke with criticized the community size and income eligibility requirements for the grant and loan programs. In Massachusetts, one stakeholder said that most small towns in part of that state exceed RUS's population requirements and thus do not qualify for grants or loans. The grant and loan programs also have per-capita personal income requirements. One service provider in Alaska said that the grant program income eligibility requirements can exclude Alaskan communities, while failing to take into account the high cost of living in rural Alaska.

- **Technological neutrality.** Satellite companies we spoke with said RUS's broadband loan program requirements are not readily compatible with their business model or technology. Once a company launches a satellite, the equipment that individual consumers must purchase is the remaining infrastructure expense. Because the agency requires collateral for loans, the program is more suited for situations where the *providers*, rather than individual consumers, own the equipment being purchased through the loan. Yet, when consumers purchase satellite broadband, it is common for them to purchase the equipment needed to receive the satellite signal, such as the reception dish. Additionally, broadband service must be provided at a speed of at least 200 kilobits *in both directions*—which is not necessarily the case for satellite

[29]According to RUS officials, demand for the grant program exceeds available funding under the current program requirements.

broadband—for it to qualify for RUS loans. Moreover, RUS officials noted that for satellite broadband providers to be able to access RUS loans, they would have to demonstrate that each customer lives in a community that meets the community size eligibility requirement. As such, this program may not be easily utilized by satellite broadband providers. Yet for some places, satellite could be a cost-effective mechanism to provide broadband infrastructure into rural areas. For example, in 2005, the RUS Community Connect program provided grants to 19 communities that average 554 residents and 194 households. The total cost of these grants was roughly $9 million. Thus, RUS spent an average of $2,443 per covered household,[30] but the cost per household that adopted broadband would be even higher since only a subset of these households would choose to subscribe to broadband service. By contrast, two satellite providers we spoke with estimate that their consumer equipment and installation costs are roughly $600 per subscribing household. These figures might not fully represent the full nature of the services provided through the grant program and those available via satellite; for example, grantees of the RUS program are required to provide free Internet service to community centers.

USF Programs Indirectly Support Broadband Service, but Several Stakeholders Expressed Concerns

While the USF program does not directly fund broadband service, the funding provided to support telecommunications networks indirectly supports the development of infrastructure that can provide many communications services, including broadband. USF's high-cost program helps maintain and upgrade telecommunications networks in rural areas. Three stakeholders we spoke with in Alaska, Ohio, and North Dakota attributed the relative success of broadband deployment in rural areas to the USF program. Additionally, the Schools and Libraries Program and the Rural Health Care Program help facilitate broadband service to specific locations; according to two providers in Alaska, these programs have been very beneficial in bringing some form of broadband service to rural Alaskan villages that might have received no service without these government programs.

However, stakeholders we spoke with identified several concerns about the USF program:

[30]RUS officials noted that many different technologies were used in these 19 communities, so that the cost per household varied considerably across the grant recipients.

- Large ILECs serving rural areas and rural ILECs receive high-cost fund support under different formulas. The two types of ILECs have different eligibility criteria under which they can qualify to receive high-cost support and more support is provided to rural companies than to nonrural companies serving rural areas.[31] Two stakeholders we spoke with suggested that the eligibility criteria should be modified, such that the criteria better reflect the cost to provide service in particular areas, rather than the type of company providing the service. Alternatively, two stakeholders we spoke with favor the current eligibility criteria and funding mechanism.

- Two stakeholders we spoke with expressed concerns about a lack of coordination across USF funding sources, which could lead to inefficient use of funds and inadequate leveraging of funds. For example, in Alaska, two stakeholders noted that governments and providers receive "silos" of funding for schools, libraries, and rural health centers. Because the programs are narrowly defined, multiple entities might be the recipient of funding for broadband service, which could lead to multiple broadband connections in relatively small rural communities. One stakeholder noted that since each entity might use only a fraction of its available broadband capacity, there can be capacity for Internet traffic available for other uses or users, but funding recipients are sometimes not allowed to share this capacity, either with other entities or with residents in the community. Thus, communities may be unable to leverage the available funding for other uses.

- While two stakeholders we spoke with suggested expanding the USF program to include broadband service, we found little support for this overall. Some stakeholders we spoke with expressed concern about funding the USF program at current levels of support. These stakeholders fear that expanding the USF program to include broadband service, which would increase program expenditures and thus require additional funding, could undermine support for the entire USF program.

[31] For rural ILECs, the cost of service is based on "embedded costs"—or the historical costs of infrastructure, which is used to provide a variety of communications services. For nonrural ILECs, the cost of service is based on the forward-looking costs of providing only certain telecommunications services.

Resolving Spectrum Congestion and Management Concerns Could Facilitate Greater Wireless Broadband Service

As mentioned previously, certain wireless technologies hold the potential for supporting broadband service in difficult-to-serve rural areas. In less densely populated areas, installing wire-based facilities for cable modem and DSL service represents a significant cost factor. Therefore, certain wireless technologies may be a lower-cost way to serve rural areas than wireline technologies.

While wireless technologies hold the promise of expanding the availability of broadband, some stakeholders we spoke with expressed concern about the degree of congestion in certain bands as well as the management of spectrum. For example, in some geographic areas, we heard that congestion in certain unlicensed spectrum bands makes providing wireless broadband Internet access more difficult, and a few stakeholders said that with more unlicensed spectrum, wireless providers could support greater broadband deployment. Additionally, wireless providers we spoke with also expressed concern about the management of spectrum, particularly the quality of certain bands and quantity of spectrum available for wireless broadband service. Two stakeholders mentioned that spectrum allocated to wireless broadband service is susceptible to having communications obstructed by interference from trees and buildings. In a 2005 report, we noted that experts agreed that the government should evaluate its allocation of spectrum between licensed and unlicensed uses.[32] But we also noted that these experts failed to agree on whether FCC should dedicate more or less spectrum to unlicensed uses. In June 2006, FCC will conduct an auction of spectrum dedicated to advanced wireless services, which will make available 90 MHz of spectrum for wireless broadband services. FCC staff also noted that the commission has other efforts underway to increase available spectrum for wireless broadband services.

Conclusion

In the past several years, the importance of broadband for Americans and for the American economy has been articulated by interested stakeholders, as well as by the President, Congress, and the last several FCC chairmen. Universal availability of broadband has been set forth as a policy goal for the near term—2007. And progress toward this goal has been substantial. The availability of broadband to residential consumers has grown from its

[32]See GAO, *Telecommunications: Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*, GAO-06-236 (Washington, D.C.: Dec. 20, 2005).

nascent beginnings in the latter part of the 1990s to broad coverage throughout the country. In the last 10 years, providers in traditional communications industry segments—telephone and cable—have upgraded and redesigned miles of their networks in order to offer broadband services. The provision of broadband through various wireless means, as well as over the existing electricity infrastructure, have also been developed, and for many, if not most Americans, the burgeoning broadband marketplace is characterized by competitive choice in broadband access and creative and ever-expanding applications and content. Many would consider the rollout of broadband infrastructure as a success story of entrepreneurial initiative.

But not all places or people have experienced the full benefits of this rapid rollout of broadband services. As with many other technologies, the costs of bringing broadband infrastructure to rural America can be high. For private providers who must weigh the costs and returns of their investments, the feasibility of serving the most rural parts of our country may not work within a reasonable business model. While there are federal support mechanisms for rural broadband, it is not clear how much impact these programs are having or whether their design suggests a broad consideration of the most effective means of addressing the problem. And one of the difficulties of assessing the gaps in deployment and where to target any federal support is that it is hard to know exactly where broadband infrastructure has not been deployed. FCC does collect data on the geographic extent of providers' service, but these data are not structured in a way that accurately illustrates the extent of deployment to residential users. Without accurate, reliable data to aid in analysis of the existing deployment gaps, it will be difficult to develop policy responses toward gaps in broadband availability. This could hinder our country's attainment of universally available broadband. And as the industry moves quickly to even higher bandwidth broadband technologies, we risk leaving some of the most rural places in America behind.

Recommendation for Executive Action

In a draft of this report provided to FCC for review and comment, GAO recommended that FCC identify and evaluate strategies for improving the 477 data such that the data provide a more accurate depiction of residential broadband deployment throughout the country. In oral comments regarding this recommendation, FCC staff acknowledged that the 477 data have some limitations in detailing broadband deployment, but also noted that there had recently been a proceeding examining its broadband data collection efforts and that some changes to the data collection had been implemented. In that proceeding, the commission also determined that it would be costly and could impose large burdens on filers—particularly small entities—to require any more detailed filings on broadband deployment. Although FCC staff told us that analysis of potential costs had been conducted, exact estimates of these costs and burdens have not yet been determined. Moreover, many have expressed concern about ensuring that all Americans—especially those in rural areas—have access to broadband technologies. Policymakers concerned about full deployment of broadband throughout the country will have difficulty targeting any assistance to that end without accurate and reliable data on localized deployment. As such, we recommend that FCC develop information regarding the degree of cost and burden that would be associated with various options for improving the information available on broadband deployment and should provide that information to the Senate Committee on Commerce, Science, and Transportation and the House Energy and Commerce Committee in order to help them determine what actions, if any, are necessary to employ going forward.

Agency Comments and Our Evaluation

We provided a draft of this report to the Department of Agriculture, the Department of Commerce, and the Federal Communications Commission for their review and comment. The Department of Agriculture provided no comments. The Department of Commerce and FCC provided technical comments that we incorporated, as appropriate. FCC did not comment on the final recommendation contained in this report.

We also provided a draft of this report to several associations representing industry trade groups and state and local government entities for their review and comment. Specifically, the following associations came to GAO headquarters to review the draft: Cellular Telecommunications and Internet Association (CTIA), National Association of Regulatory Utility Commissioners (NARUC), National Association of Telecommunications Officers and Advisors (NATOA), National Cable and Telecommunications Association (NCTA), National Telecommunications Cooperative Association (NTCA), Satellite Industry Association (SIA), US Internet Industry Association (USIIA), United States Telecom Association (USTA), and Wireless Internet Service Providers Association (WISPA). Officials from CTIA, NARUC, and NTCA did not provide comments. Officials from NATOA, NCTA, SIA, and USIIA provided technical comments that were incorporated, as appropriate. USTA and WISPA provided comments that are discussed in appendix V.

We are sending copies of this report to the appropriate congressional committees and to the Secretary of Agriculture, the Secretary of Commerce, and the Chairman of the Federal Communications Commission. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you have any questions about this report, please contact me at (202) 512-2834 or heckerj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Contact information and major contributors to this report are listed in appendix VI.

JayEtta Z. Hecker
Director, Physical Infrastructure Issues

Scope and Methodology

The objectives of the report were to provide information on (1) the current status of broadband deployment and adoption, (2) the factors that influence the deployment of broadband networks, (3) the factors that influence the adoption of broadband service by households, and (4) the options that have been suggested to spur greater broadband deployment and adoption. To respond to the four objectives, we used a variety of approaches.

To gather opinions for all four objectives, we employed a case-study approach. This approach allowed us to identify issues at the state and local level that would not be apparent in nationwide data. We selected eight states for our case studies: Alaska, California, Kentucky, Massachusetts, North Dakota, Ohio, Texas, and Virginia. We selected these states based on Census Bureau data on statewide income, urbanization, population density, and percentage of households using the Internet. We also considered whether each state taxed Internet access. We sought to include states in diverse categories of each of our selection criteria. In each state, we interviewed state and local officials, including local franchising authorities, state public utility regulators, representatives from state governor's offices; associations; private cable and telephone providers; wireless Internet service providers; and municipal and cooperative telecommunications providers.

We also spoke with a variety of individuals and organizations knowledgeable about broadband services. In particular, we spoke with industry providers, trade associations, and academic experts. We also spoke with representatives from the Federal Communications Commission (FCC), the National Telecommunications and Information Administration of the Department of Commerce, and the Rural Utilities Service of the Department of Agriculture.

To assess the factors influencing the deployment and adoption of broadband, we used survey data from Knowledge Networks/SRI's *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report.* Knowledge Networks/SRI is a survey research firm that conducted a survey on household ownership and use of consumer electronics and media. Knowledge Networks/SRI interviewed approximately 1,500 randomly sampled telephone households, asking questions about the household's purchase of computers and Internet access. All percentage estimates from the Knowledge Networks/SRI survey have margins of error of plus or minus 7 percentage points or less, unless otherwise noted. See appendix II for a discussion of the steps we took to evaluate the reliability of Knowledge

Networks/SRI's data. Using the data from Knowledge Networks/SRI, we estimated two econometric models. One model examined the factors affecting broadband deployment. We also developed a model to examine the factors affecting a household's adoption of broadband services. See appendix III for a more detailed explanation of, and results from, our deployment and adoption models.

To assess the status of broadband deployment, we used FCC's Form 477 data that identified companies providing broadband service by zip code. We used FCC's data to identify the companies reporting to provide broadband service in the zip codes where respondents to Knowledge Networks/SRI's survey resided. To assess the reliability of FCC's Form 477 data, we reviewed documentation, interviewed knowledgeable officials, and performed electronic testing of the data elements used in our analyses. We made several adjustments to these data, such as excluding satellite companies and companies only providing service to businesses. See appendix III for more on our methodology concerning adjustment to FCC's 477 data. With these adjustments to the data, we determined that they were sufficiently reliable for the purposes of this report.

We conducted our work from April 2005 through February 2006 in accordance with generally accepted government auditing standards.

Data Reliability

To obtain information on the types of Internet access purchased, or adopted, by U.S. households, we purchased existing survey data from Knowledge Networks Statistical Research (Knowledge Networks/SRI). Their survey was completed with 1,501 of the estimated 3,127 eligible sampled households for a response rate of 48 percent. The survey was conducted between February 22 and April 15, 2005.

The study procedures yielded a sample of members of telephone households in the continental United States using a national random-digit dialing method. Survey Sampling Inc. (SSI) provided the sample of telephone numbers, which included both listed and unlisted numbers and excluded blocks of telephone numbers determined to be nonworking or business-only. At least five calls were made to each telephone number in the sample to attempt to interview a responsible person in the household. Special attempts were made to contact refusals and convert them into interviews; refusals were sent a letter explaining the purpose of the study and an incentive. Data were obtained from telephone households and are weighted to the total number of households in the 2005 Current Population Survey adjusted for multiple phone lines.

As with all sample surveys, this survey is subject to both sampling and nonsampling errors. The effect of sampling errors due to the selection of a sample from a larger population can be expressed as a confidence interval based on statistical theory. The effects of nonsampling errors, such as nonresponse and errors in measurement, may be of greater or lesser significance but cannot be quantified on the basis of available data.

Sampling errors arise because of the use of a sample of individuals to draw conclusions about a much larger population. The study's sample of telephone numbers is based on a probability selection procedure. As a result, the sample was only one of a large number of samples that might have been drawn from the total telephone exchanges from throughout the country. If a different sample had been taken, the results might have been different. To recognize the possibility that other samples might have yielded other results, we express our confidence in the precision of our particular sample's results as a 95 percent confidence interval. We are 95 percent confident that when only sampling errors are considered each of the confidence intervals in this report will include the true values in the study population. All percentage estimates from the survey have margins of error of plus or minus 7 percentage points or less, unless otherwise noted. The 95 percent confidence interval for the estimate of the total number of

U.S. households that subscribed to broadband service in 2005 is 28.5 million to 33.7 million households.

In addition to the reported sampling errors, the practical difficulties of conducting any survey introduce other types of errors, commonly referred to as nonsampling errors. For example, questions may be misinterpreted, some types of people may be more likely to be excluded from the study, errors could be made in recording the questionnaire responses into the computer-assisted telephone interview software, and the respondents' answers may differ from those who did not respond. Knowledge Networks/SRI has been fielding versions of this survey for over 20 years. In addition, to reduce measurement error, Knowledge Networks/SRI employs interviewer training, supervision, and monitoring, as well as computer-assisted interviewing to reduce error in following skip patterns.

For this survey, the 48 percent response rate is a potential source of nonsampling error; we do not know if the respondents' answers are different from the 52 percent who did not respond. Knowledge Networks/SRI took steps to maximize the response rate—the questionnaire was carefully designed and tested through deployments over many years, at least five telephone calls were made at varied time periods to try to contact each telephone number, the interview period extended over about 8 weeks, and attempts were made to contact refusals and convert them into interviews.

Because we did not have information on those contacted who chose not to participate in the survey, we could not estimate the impact of the nonresponse on our results. Our findings will be biased to the extent that the people at the 52 percent of the telephone numbers that did not yield an interview have different experiences with Internet access than did the 48 percent of our sample who responded. However, distributions of selected household characteristics (including presence of children, race, and household income) for the sample and the U.S. Census estimate of households show a similar pattern.

To assess the reliability of these survey data, we relied on a prior GAO report that made use of the Knowledge Networks/SRI 2004 survey for a similar purpose. In that prior assessment, we determined that the data were sufficiently reliable for our purposes. For this report we reviewed Knowledge Networks/SRI's documentation of survey procedures for 2005 and compared them to the procedures used in their 2004 survey. We determined that their survey methodology was substantively unchanged.

Additionally, we performed electronic testing of the 2005 survey data elements used in this report. We determined that the data were sufficiently reliable for the purposes of this report.

Broadband Deployment and Adoption Models

This appendix describes our models of broadband deployment and adoption. Specifically, we discuss (1) the design of our models, (2) the data sources, (3) our methodology for assessing broadband deployment, and (4) the estimation methodology and results.

Design of Our Broadband Deployment and Adoption Models

A company will deploy broadband service in an area only if the company believes that such a deployment will be profitable. Similarly, a household will purchase, or adopt, broadband service only if the value, or utility, to members of the household exceeds the price the household must pay to receive the service. In this section, we explain the two models we developed to examine the factors that influence the deployment and adoption of broadband service.

Deployment Model

A company will deploy broadband service in an area only if the company believes that such a deployment will be profitable. Based on conversations with industry stakeholders, including companies deploying broadband service, we identified a number of factors that influence a company's decision to deploy broadband service. In particular, the following factors may influence the decision to deploy broadband service: population density, terrain, backhaul costs, existing or potential competition, the technical expertise of the population, the income of the population, and regulatory policies (such as rights-of-way policies). We also reviewed relevant studies, and noted the same and additional factors that may influence the deployment of broadband service.[1] Some of these factors, such as the population density and backhaul, will influence the cost of providing broadband service, while other factors, such as the income of the population, will influence the potential revenues that a company may hope to generate. Together, these revenue and cost factors will influence the potential profitability of providing broadband service, and ultimately the decision to deploy broadband service.

To empirically test these hypotheses, we estimated the following econometric model; since all the variables identified above were not

[1]For example, see Tony H. Grubesic and Alan T. Murray, "Waiting for Broadband: Local Competition and the Spatial Distribution of Advanced Telecommunication Services in the United States," *Growth and Change*, vol. 35, no. 2 (2004): 139-165; and James E. Prieger, "The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market?" *Economic Inquiry*, vol. 41, no. 2 (2003): 346-363.

available, we were unable to include some of the variables—such as terrain—in our model. The decision to deploy broadband service is a function of

- the population in the area;
- the population density in the area;
- the percentage of the population residing in an urban area;
- the per-capita income in the area;
- the educational attainment of the population in the area;
- the population teleworking in the area;
- the age of the population in the area;
- the distance to a metropolitan area with a population of 250,000 or more; and
- whether the state in which the area is located imposed a tax on Internet access in 2005.

Adoption Model

Households will purchase, or adopt, broadband service only if the value, or utility, that members of the household receive from the service exceeds the price of the service. In conversations with industry stakeholders, we were told that several characteristics of households influence the extent to which households purchase broadband service; we also reviewed other studies, and noted characteristics of households that these studies associated with the purchase of broadband service.[2] In particular, the following characteristics of households may influence the decision to purchase broadband service: income, education, age of household

[2]For example, see Scott Wallsten, *Broadband Penetration: An Empirical Analysis of State and Federal Policies* (Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies, 2005); Scott J. Savage and Donald M. Waldman, "United States Demand for Internet Access," *Review of Network Economics*, vol. 3, no. 3 (2004): 228-247; and Debra J. Aron and David E. Burnstein, "Broadband Adoption in the United States: An Empirical Analysis" (paper presented at the 31st Annual Telecommunications Policy Research Conference, Arlington, Va., 2003).

members, presence of children in the household, and the technological knowledge of members of the household. These characteristics may be associated with the extent to which a household would benefit from, and therefore value, broadband service, such as using broadband to telework, conduct research for school, and playing games. Industry stakeholders also noted that price influences a household's decision to purchase broadband service.

To empirically test these hypotheses, we estimated the following econometric model; because we lacked data on the price of broadband service, we were unable to include this variable in our econometric model.[3] The decision to purchase, or adopt, broadband service is a function of

- the income of the household;
- the education attainment of the heads of the household;
- the age of the heads of the household;
- the presence of children in the household;
- the racial composition of the household;
- the occupation of the heads of the household;
- the number of people in the household;
- whether the household resides in an urban, suburban, or rural location;
- the number of companies providing broadband service in the area; and
- whether the state in which the household resides imposes a tax on Internet access.

Data Sources

We required several data elements to build the data set used to estimate our deployment and adoption models. The following is a list of our primary data sources. In addition, we list all of the variables, definitions, and

[3]As such, we recognize that the parameter estimates will be biased. We are unable to assess the possible extent of this bias.

sources for the deployment model in table 1 and the adoption model in table 2.

- We obtained data on a sample of households in the United States from Knowledge Networks/SRI, using Knowledge Networks/SRI's product *The Home Technology Monitor™: Spring 2005 Ownership and Trend Report*. From February through April 2005, Knowledge Networks/SRI interviewed a random sample of 1,501 households in the United States. Knowledge Networks/SRI asked participating households a variety of questions about their use of technology, including questions such as whether the household purchased broadband service, and about the household's demographic characteristics.

- From the Federal Communications Commission (FCC), we obtained information on the companies providing broadband service in zip codes throughout the United States in December 2004. For each zip code, FCC provided the names of companies reporting, through the agency's Form 477, that they provided broadband service to at least one residential or small business customer and the type of company providing the service (e.g., cable and satellite).

- We used the most recent information from the U.S. Census Bureau to obtain demographic information for the areas where the households responding to Knowledge Networks/SRI's survey were located.

Table 1: Deployment Model: Definitions and Sources of Variables

Variable	Definition	Source
Deploy	A binary variable that equals 1 if broadband service is available to the household responding to Knowledge Networks/SRI's survey.	FCC 2004 Form 477 and GAO analysis
Internet taxation	A binary variable that equals 1 if the state where the household resides imposes a tax on Internet access.	GAO analysis
Population, in thousands	The number of residents in the area where the household resides, in thousands.	Census Bureau
Urbanization	The percentage of the population residing in an urban area.	Census Bureau
Distance	The distance to a metropolitan area with a population of 250,000 or more.	GAO analysis
Percentage of work-at-home residents	The percentage of the population working from home.	Census Bureau
Percentage of population under 16	The percentage of the population under the age of 16.	Census Bureau
Percentage of population 17 to 24	The percentage of the population 17 to 24 years old.	Census Bureau

(Continued From Previous Page)

Variable	Definition	Source
Percentage of population 65 or older	The percentage of the population 65 or older.	Census Bureau
Percentage of population with a high-school degree	The percentage of the population with a high-school degree.	Census Bureau
Percentage of population with education beyond high school	The percentage of the population with education beyond high school.	Census Bureau
Per-capita income, in thousands	The per-capita income in the area, in thousands of dollars.	Census Bureau
Population density, in thousands	The ratio of population to square miles in the area, in thousands.	Census Bureau

Source: GAO.

Table 2: Adoption Model: Definitions and Sources of Variables

Variable	Definition	Source
Adopt	A binary variable that equals 1 if the household responding to Knowledge Networks/SRI's survey purchases broadband service.	Knowledge Networks/SRI
Internet taxation	A binary variable that equals 1 if the state where the household resides imposes a tax on Internet access.	GAO analysis
Number of broadband providers	The number of companies providing broadband service to the household.	FCC 2004 Form 477 and GAO analysis
Income between $30,000 and $49,900	A binary variable that equals 1 if the household's income is between $30,000 and $49,900.	Knowledge Networks/SRI
Income between $50,000 and $99,900	A binary variable that equals 1 if the household's income is between $50,000 and $99,900.	Knowledge Networks/SRI
Income $100,000 or more	A binary variable that equals 1 if the household's income is greater than or equal to $100,000.	Knowledge Networks/SRI
Race-white	A binary variable that equals 1 if the household reported its race as white.	Knowledge Networks/SRI
College graduate	A binary variable that equals 1 if either the man or woman of the household is a college graduate.	Knowledge Networks/SRI
Age 34 to 49	A binary variable that equals 1 if either the man or woman of the household is 34 to 49 years old, and neither is younger than 34.	Knowledge Networks/SRI
Age 50 or older	A binary variable that equals 1 if both the man and woman of the household are 50 years old or older.	Knowledge Networks/SRI
Children	A binary variable that equals 1 if a child age 17 or younger resides in the home.	Knowledge Networks/SRI

(Continued From Previous Page)

Variable	Definition	Source
Household size	A binary variable that equals 1 if three or more people reside in the home.	Knowledge Networks/SRI
Occupation-professional	A binary variable that equals 1 if the man or woman of the household reports working in a professional position.	Knowledge Networks/SRI
Occupation-clerical, sales, or technical	A binary variable that equals 1 if the man or woman of the household reports working in a clerical, sales, or technical position, and neither reports working in a professional position.	Knowledge Networks/SRI
Occupation-blue collar	A binary variable that equals 1 if the man and woman of the household report working in a blue collar position.	Knowledge Networks/SRI
Occupation-other	A binary variable that equals 1 if the man or woman of the household reports working in a position other than a professional, clerical, sales, technical, or blue-collar position.	Knowledge Networks/SRI
Rural location	A binary variable that equals 1 if the household resides in an area outside a metropolitan statistical area (MSA).	GAO analysis
Suburban location	A binary variable that equals 1 if the household resides in an area inside an MSA but outside the central city of that MSA.	GAO analysis

Source: GAO.

Assessing Broadband Deployment

FCC's Form 477 data include information on companies providing broadband service to at least one residential or business customer in zip codes throughout the United States in December 2004. However, since zip codes can represent large geographic areas, companies providing broadband service in a zip code might not have facilities in place to serve all households in the zip code. Thus, while a household might reside in a zip code in which FCC's Form 477 indicates that broadband service is available, that service might not be available to the household. Additionally, as we note in the text, we identified other concerns with FCC's data. Therefore, we took additional steps to assess whether broadband service was available to households included in Knowledge Networks/SRI's survey. In particular, we took the following steps for each observation in our data set:

- removed firms providing only satellite service;
- removed firms that provided only broadband service to business customers, since residential households were the focus of our study;
- removed large incumbent local exchange carriers when the company was identified as providing service in areas that lay outside of its local

exchange area, since these firms typically provide service only to business customers outside of their local exchange areas;[4]

- removed firms when 2 or more of the 10 largest cable operators reported providing broadband service, since large cable operators rarely have overlapping service territories;
- removed cable operators if the responding household indicated that cable service did not pass the residence; and
- removed companies providing telephone-based broadband service if the household's residence was greater than 2.5 miles from the central office facility, since DSL service is distance limited.

Estimation Methodology and Results

For both the deployment model and adoption model, we are estimating a reduced-form, binary-choice model. That is, broadband service is either deployed in the area or it is not, and the household either purchases broadband service or it does not. Given the binary choice nature of the models, we employed the probit method to estimate the deployment and adoption equations.[5] In this section, we present descriptive statistics and estimation results for the two equations and discuss the results.

Deployment Model

In table 3, we provide basic statistical information on all of the variables included in the deployment model, and in table 4, we provide the results from the probit estimation of the deployment model. Of the 1,501 respondents to Knowledge Networks/SRI's survey, we used 1,402 observations in the deployment model; we were unable to match the zip+4 code for all 1,501 observations with publicly available data, which was necessary to assess whether the residence was 2.5 miles from the serving central office facility.

[4]We did not remove Verizon, since thought its acquisition of GTE, it serves a wide variety of locations as an incumbent exchange carrier.

[5]An alternative method to estimate these equations is the logit model. In a binary choice model, the differences between the logit and probit models are generally not significant. Differences can arise in the multinomial model, where there are three or more choices, because the logit model imposes independence conditions that sometimes do not reflect the conditions being modeled. Such was not the case in our models, since we are estimating binary choice equations.

Table 3: Deployment Model: Descriptive Statistics

Variable	Mean	Standard deviation	Minimum value	Maximum value
Deploy	0.911	0.285	0.000	1.000
Internet taxation	0.546	0.498	0.000	1.000
Population, in thousands	26.022	17.982	0.070	113.935
Urbanization	76.154	33.240	0.000	100.000
Distance	34.361	42.743	0.249	572.803
Percentage of work-at-home residents	3.257	2.064	0.000	33.333
Percentage of population under 16	24.018	4.651	6.225	41.219
Percentage of population 17 to 24	10.585	4.785	0.583	55.113
Percentage of population 65 or older	12.995	5.688	2.195	59.057
Percentage of population with a high-school degree	29.546	9.002	3.121	68.966
Percentage of population with education beyond high school	51.395	16.092	8.836	95.348
Per-capita income, in thousands	44.466	15.597	9.583	164.479
Population density, in thousands	2.976	6.876	0.002	74.814

Source: GAO.

Table 4: Deployment Model: Estimation Results

Variable	Parameter estimate and [p-value]
Intercept	-2.9299 [0.0097][a]
Internet taxation	-0.1486 [0.2275]
Population, in thousands	0.0099 [0.1140]
Urbanization	0.0102 [0.0001][a]
Distance	-0.0012 [0.3115]
Percentage of work-at-home residents	-0.0600 [0.0392][b]
Percentage of population under 16	0.0335 [0.1192]
Percentage of population 17 to 24	0.0198 [0.3027]

(Continued From Previous Page)

Variable	Parameter estimate and [p-value]
Percentage of population 65 or older	0.0468 [0.0271][b]
Percentage of population with a high-school degree	0.0114 [0.3260]
Percentage of population with education beyond high school	0.0121 [0.1957]
Per-capita income, in thousands	0.0270 [0.0074][a]
Population density, in thousands	0.1706 [0.0159][b]
Number of observations	1,402
1-LogL/Log0	32.0077

Source: GAO.

[a]Significant at the 1 percent level.

[b]Significant at the 5 percent level.

Results from our model indicate that several factors related to the cost of providing broadband service and the demand for broadband service influence the likelihood that service will be available in a particular area. Regarding the cost factors, we found that urban areas and areas with greater population density are more likely to receive broadband service. For example, urban areas are about 9 percentage points more likely to receive broadband service than are similar rural areas. These results are consistent with broadband service being less costly to deploy in densely populated, more urban environments, where a similar investment in facilities can serve a greater number of subscribers than is possible in rural areas. Regarding demand for broadband service, we found that areas with greater per-capita incomes are more likely to receive broadband service. Additionally, we found that areas with a greater number of people working from home are less likely to have broadband service and that areas with a greater percentage of people age 65 or older are more likely to have broadband service.

We did not find that taxation of Internet access by state governments influenced the deployment of broadband service. Taxes can raise consumer prices and reduce revenues and impose costs on providers, and thereby possibly reduce the incentive for companies to deliver a product or service. Since we used a binary variable to indicate the presence of taxes, this variable could also potentially capture the influence of other characteristics of the states, in addition to the influence of the tax. Results from our model indicate that Internet access taxes do not affect the likelihood that companies will deploy broadband service; while the parameter estimate has the expected sign, the estimate is not statistically significant.

Adoption Model

In table 5, we provide basic statistical information on all of the variables included in the adoption model, and in table 6, we provide the results from the probit estimation of the adoption model. Since households can only chose to purchase, or adopt, broadband service where it is deployed, we only include households from Knowledge Networks/SRI's survey where we assessed that broadband service was available; based on our analysis, 133 respondents did not have broadband service available. Further, 355 respondents to Knowledge Networks/SRI's survey did not answer one or more demographic questions and 29 did not answer, or did not know, what type of Internet connection their household purchased. Therefore, we excluded these respondents. Thus, we used 901 observations in the adoption model.[6]

[6]We did not find that the households that failed to answer the demographic questions were more or less likely to be online than were the households that answered these questions.

Table 5: Adoption Model: Descriptive Statistics

Variable	Mean	Standard deviation	Minimum value	Maximum value
Adopt	0.336	0.473	0.000	1.000
Internet taxation	0.553	0.497	0.000	1.000
Number of broadband providers	3.307	2.161	1.000	9.000
Income between $30,000 and $49,900	0.223	0.417	0.000	1.000
Income between $50,000 and $99,900	0.336	0.473	0.000	1.000
Income $100,000 or more	0.149	0.356	0.000	1.000
Race-white	0.858	0.349	0.000	1.000
College graduate	0.499	0.500	0.000	1.000
Age 34 to 49	0.378	0.485	0.000	1.000
Age 50 or older	0.424	0.494	0.000	1.000
Children	0.387	0.487	0.000	1.000
Household size	0.465	0.499	0.000	1.000
Occupation-professional	0.442	0.497	0.000	1.000
Occupation-clerical, sales, or technical	0.154	0.361	0.000	1.000
Occupation-blue collar	0.029	0.167	0.000	1.000
Occupation-other	0.244	0.430	0.000	1.000
Rural location	0.052	0.222	0.000	1.000
Suburban location	0.568	0.496	0.000	1.000

Source: GAO.

Table 6: Adoption Model: Estimation Results

Variable	Parameter estimate and [p-value]
Intercept	-1.4919 [0.0001][a]
Internet taxation	-0.1683 [0.0745]
Number of broadband providers	0.0118 [0.6101]
Income between $30,000 and $49,900	0.4531 [0.0024][a]
Income between $50,000 and $99,900	0.7429 [0.0001][a]
Income $100,000 or more	1.1331 [0.0001][a]

(Continued From Previous Page)

Variable	Parameter estimate and [p-value]
Race-white	0.2905 [0.0405][b]
College graduate	0.3525 [0.0009][a]
Age 34 to 49	-0.2239 [0.0759]
Age 50 or older	-0.3316 [0.0217][b]
Children	0.1318 [0.3894]
Household size	0.1241 [0.3894]
Occupation-professional	0.2610 [0.1409]
Occupation-clerical, sales, or technical	0.2098 [0.2867]
Occupation-blue collar	0.2638 [0.3879]
Occupation-other	0.0212 [0.9086]
Rural location	-0.3234 [0.1892]
Suburban location	0.0983 [0.3406]
Number of observations	901
1-LogL/Log0	16.2800

Source: GAO.

[a]Significant at the 1 percent level.

[b]Significant at the 5 percent level.

Our model results indicate that four characteristics influence whether households purchase, or adopt, broadband service. First, we found that households with greater incomes are more likely to purchase broadband service than are lower-income households. For example, the 25 percent of households with the highest income levels were about 39 percentage points more likely to purchase broadband service than the 25 percent of households with the lowest income levels. Second, households with a college graduate are about 12 percentage points more likely to purchase broadband service than are households without a college graduate. We also found that white households are more likely to purchase broadband service than households of other races. Finally, older households are less likely to purchase broadband service than are younger households.

As with the deployment model, we did not find that taxation of Internet access by state governments influenced the adoption of broadband service. As mentioned earlier, we used a binary variable to represent the presence of Internet taxation. As such, the variable may capture the influence of other characteristics of the states in which the households resided, in addition to the influence of the tax. Further, lacking a variable for the price of broadband service, we cannot assess how the imposition of the tax influenced the price of the service and thus the household's adoption decision. Using our model, we found that the parameter estimate had the expected sign—indicating that the imposition of the tax may have reduced the likelihood that a household would purchase broadband service. While the estimate was not statistically significant at the 5 percent level, it was statistically significant at the 10 percent level, perhaps suggesting that it is a weakly significant factor. However, given the nature of our model, it is unclear whether this finding is related to the tax or other characteristics of the states in which households resided.

Additional Communications Technologies

Based on our conversations with stakeholders, and our own research, we identified several emerging technologies that could further the deployment of broadband service.

Broadband over power lines. Broadband over power lines (BPL) is an emerging competitive source of broadband to the home. BPL transmits broadband by using existing electric distribution networks, such as the wires that deliver electricity to consumers. Although there are a few commercial deployments, most BPL efforts are currently at the trial stage. Trials and commercial deployments range across the urban-rural landscape, from Cullman County, Alabama, to Cincinnati.[1] Currently, BPL can provide upstream and downstream speeds of 3 million bits per second (Mbps), and next generation equipment is being developed to provide speeds of 100 Mbps.

Industry stakeholders have identified several concerns with BPL service. First, while traveling across the electric network, BPL can emit signals that interfere with other users of the spectrum, such as amateur radio and public safety. The Federal Communications Commission (FCC) has taken steps to document, mitigate, and alleviate this potential problem. Second, some stakeholders also expressed concern that, due to the age or condition of the electric network, providers in some areas would be unable to transmit Internet data at high speeds. Finally, some stakeholders expressed varied opinions about the feasibility of BPL to bring broadband service to rural areas. Some stakeholders were optimistic about BPL's ability to serve these communities, while others expressed skepticism, pointing out that overcoming BPL's distance limitations would require more equipment and additional costs.

Wireless fidelity (Wi-Fi). Wi-Fi-enabled wireless devices, such as laptop computers, can send and receive data from any location within signal reach—about 300 feet—of a Wi-Fi-equipped access point. Wi-Fi provides data transmission rates, based on the current transmission standard, of up

[1]BPL companies, such as Current Communications, offer the ability to improve the monitoring, detection, and management of the electrical distribution network through improved communication capabilities inherent in BPL equipment. These features increase the attractiveness of BPL to electrical companies, as the companies receive the benefits of improved network operation and potential revenues from broadband service.

to a maximum of 54 Mbps,[2] which is shared by multiple users. Wi-Fi equipment and services are based on the 802.11 series standards developed by the Institute of Electrical and Electronics Engineers (IEEE) and operate on an unlicensed basis in the 2.4 and 5 GHz spectrum bands. Several stakeholders we spoke with said that Wi-Fi service complemented, rather than substituted for, other broadband services.

The number of areas that can access Wi-Fi service, known as "hot spots," has grown dramatically and, according to one equipment manufacturer, may exceed 37,000. Wi-Fi hot spots include such diverse entities as airports, colleges, retail establishments, and even entire towns. Increasingly, municipalities are planning or deploying larger area or citywide hot spots; some municipalities considering or deploying a Wi-Fi network include Atlanta, Philadelphia, San Francisco, and Tempe, Arizona. While Wi-Fi service is widely deployed in urban and suburban areas, some stakeholders identified a few problems with the service. Because Wi-Fi hot spots operate in unlicensed spectrum, interference can be a problem. Several stakeholders we spoke with mentioned congestion or limited distance capability in Wi-Fi as a potential limitation of the service.

Worldwide Interoperability for Microwave Access (WiMAX). With WiMAX service, the distance covered and data transmission speeds can exceed those found with Wi-Fi service. WiMAX can provide data transmission speeds of 75 Mbps with non-line-of-sight service—that is, the signal can pass through buildings, trees, or other obstructions—or up to 155 Mbps with line-of-sight service. In a non-line-of-sight environment, WiMAX can provide service in an area with a radius of 3 miles or more; in a line-of-sight environment, WiMAX can provide service up to approximately 30 miles. WiMAX equipment and services are based on the IEEE 802.16 series of standards and operate in unlicensed and licensed spectrum.

WiMAX networks are being deployed on a trial commercial basis, but some challenges remain for further deployment. More than 150 pilot and commercial deployments of WiMAX networks are currently in use. Because of its greater capabilities in terms of distance and speed, WiMAX can extend wireless broadband to less densely populated communities, where wired solutions may be more expensive to deploy. Stakeholders we spoke with serving smaller, less densely populated areas indicated that they were

[2] Discussions are underway for newer standards for Wi-Fi that would dramatically increase the transmission speeds.

testing or interested in WiMAX to serve their communities. However, concerns have been raised about spectrum availability, interference, and the ability of different manufacturers' equipment to support the same level of broadband applications. FCC has several initiatives under way to increase the availability of spectrum for WiMAX services. While the WiMAX Forum Certification Lab certifies WiMAX equipment, the standard allows manufacturers of equipment various options, such as different levels of security protocols, and thus, not all equipment may support the same level of service, such as carrying voice over the Internet (VoIP) and security.

Third generation (3G) cellular broadband. Recently, several major commercial wireless companies have introduced broadband service based on advances in cellular technology and data protocols. Focused primarily on the business customer and more expensive than cable modem and DSL services, 3G services permit consumers to receive broadband service while mobile. 3G services typically provide data transmission speeds of 400 to 700 kilobits per second (Kbps). There are two competing technologies: EV-DO service, introduced by Verizon and Sprint; and HSDPA, introduced by Cingular. Currently, Verizon Wireless reports that its service is available nationally in 181 major metropolitan markets, covering approximately 150 million people. Sprint reports providing EV-DO service in major airports and business districts in 212 markets, covering approximately 140 million people. For HSDPA service, Cingular reports that its service is available to nearly 35 million people in 52 communities. Industry stakeholders expressed concerns about the ubiquity of service, data transmission speeds, and the monthly costs associated with 3G service. Opinions varied as to whether cellular broadband services would be a competitive threat, or a complementary service, for consumers of other broadband services.

Fiber to the home (FTTH). FTTH provides a high-speed, wire-based alternative to traditional cable and telephone networks. According to the FTTH Council, as of September 2005, 2.7 million homes were passed by fiber and over 300,000 homes were connected to fiber in 652 communities in 46 states. Stakeholders expressed concerns about the high cost associated with deploying FTTH, and also that FTTH deployment was concentrated in urban and suburban communities, or in newly developed communities (known as "greenfields").

Comments from Industry Participants

We provided a draft of this report to several associations representing industry trade groups and state and local government entities for their review and comment. The following associations came to GAO headquarters to review the draft: Cellular Telecommunications and Internet Association (CTIA), National Association of Regulatory Utility Commissioners (NARUC), National Association of Telecommunications Officers and Advisors (NATOA), National Cable and Telecommunications Association (NCTA), National Telecommunications Cooperative Association (NTCA), Satellite Industry Association (SIA), US Internet Industry Association (USIIA), United States Telecom Association (USTA), and Wireless Internet Service Providers Association (WISPA).

Officials from CTIA, NARUC, and NTCA did not provide comments. Officials from NATOA, NCTA, SIA, and USIIA provided technical comments that were incorporated, as appropriate.

USTA officials noted that our discussion of the effects of local franchising on deployment imply that franchise agreements have helped to ensure broad deployment of broadband, but that, in the view of USTA, franchise buildout requirements can deter entry and thus reduce deployment.

WISPA officials expressed concern about our findings regarding the taxation of Internet access and noted that it is important, in their view, that wireless Internet access provided by small providers not be taxed, and in fact, WISPA officials noted that small providers should be provided a tax incentive to encourage investment and expansion in underserved areas. Additionally, these officials expressed concern about the presentation of data on how households currently access the Internet from their homes. WISPA stated that these data understate the importance that wireless access will have toward the goal of universal broadband coverage both within and outside of users' homes. WISPA stated that the report accurately depicts that wireless Internet service providers (WISP) currently hold a minority market share, and WISPA officials note that without certain government policies to foster growth in the wireless industry, WISPs will be at a competitive disadvantage. WISPA officials also expressed concern that the report understates factors that are hindering the growth of the wireless Internet industry—most notably, the need for additional spectrum under 1 Ghz, such as the TV white spaces. Further WISPA noted that the data showing broadband penetration rates in urban, rural, and suburban areas should not be interpreted as indicating that access to broadband is lower in only rural areas. They suggested that differences in broadband penetration rates across these types of locations are not that great and that pockets of areas with no access exist in many areas. As such, WISPA suggests that policy response regarding spectrum availability, USF funding, and Rural Utilities Service be focused on engaging smaller providers that can bring broadband to areas not currently served by the larger incumbent providers.

GAO Contact and Staff Acknowledgments

GAO Contact

JayEtta Z. Hecker, (202) 512-2834 or heckerj@gao.gov

Staff Acknowledgments

Individuals making key contributions to this report include Amy Abramowitz (Assistant Director), Eli Albagli, Stephen Brown, Michael Clements, Sandra DePaulis, Nina Horowitz, Eric Hudson, Bert Japikse, John Mingus, Sara Ann Moessbauer, Karen O'Conor, Lindsay Welter, and Duffy Winters.

GAO's Mission

The Government Accountability Office, the audit, evaluation and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "Subscribe to Updates."

Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, D.C. 20548

To order by Phone: Voice: (202) 512-6000
TDD: (202) 512-2537
Fax: (202) 512-6061

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Gloria Jarmon, Managing Director, JarmonG@gao.gov (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, D.C. 20548

Public Affairs

Paul Anderson, Managing Director, AndersonP1@gao.gov (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, D.C. 20548

PRINTED ON RECYCLED PAPER