Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Inquiry Concerning the Deployment of	)	
Advanced Telecommunications	)	CC Docket No. 98-146
Capability to All Americans in a Reasonable	)	
And Timely Fashion, and Possible Steps	)	
To Accelerate Such Deployment	)	
Pursuant to Section 706 of the	)	
Telecommunications Act of 1996	)	

SECOND REPORT

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By the Commission: Commissioner Ness issuing a statement; Commissioners Furchtgott-Roth and Tristani concurring and issuing separate statements.

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I. INTRODUCTION

1. In this Second Report, the Commission concludes its second inquiry into the availability of advanced telecommunications capability in the United States.[1] In general, we find that advanced telecommunications capability is being deployed in a reasonable and timely fashion, although we identify certain groups of consumers that may be particularly vulnerable to untimely access to this capability. We have seen significant investment in the facilities needed to provide advanced telecommunications capability, steadily rising subscription rates for advanced services, and a proliferation of providers in the marketplace. We are encouraged that these factors will lead to widespread deployment. As with any technology, particularly in its early stages, deployment of advanced telecommunications capability is not uniform across the nation. Some consumers will gain access to that capability before others. While we expect that economic forces will drive deployment as the market develops, it appears that consumers in certain areas of the country may be particularly vulnerable to not receiving timely access to

[1] This inquiry is required by section 706 of the Telecommunications Act of 1996 (the 1996 Act). *See* §706, Pub.L. 104-104, Title VII, Feb. 8, 1996, 110 Stat. 153, reproduced in the notes under 47 U.S.C. §157; *see* Appendix A.

advanced telecommunications capability. As discussed below, we have already taken -- and will continue to take -- steps to ensure that consumers in all regions of the nation have access to advanced telecommunications capability in a reasonable and timely fashion.

2. In its most basic form, advanced telecommunications capability allows users to send and receive large amounts of information. More specifically, advanced telecommunications capability is "high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology."[2] With advanced telecommunications capability consumers can take advantage of advanced services that allow residential and business customers to create and access content, sophisticated applications, and high-bandwidth services. For example, advanced services allow businesses and their customers quickly to exchange data over long distances, doctors to provide real-time diagnosis to patients in remote areas, people with hearing and speech disabilities to communicate through video links using sign language, teachers to create interactive multimedia learning environments for their students, and individuals to have faster, more robust access to the Internet.

3. The E-rate program, authorized by Congress in the 1996 Act and implemented by this Commission, is an example of our commitment to bring the benefits of the information age to all Americans. The E-rate provides support for telecommunications services, Internet access and internal connections, with the goal of allowing every school child and every community to take advantage of modern communications technology -- both to learn more about the world and to become proficient at the skills required in the modern workplace. Those people who benefit from the connections provided through the E-rate, having seen the power of the technology, likely will stimulate demand in their communities by asking for more and better advanced services. The facilities built to serve schools and libraries through the E-rate program can serve as the foundation for more broadly available networks.

4. Recognizing the importance of access to advanced telecommunications capability in modern society, Congress directed the Commission and the states, in section 706 of the Telecommunications Act of 1996, to encourage deployment on a reasonable and timely basis. Congress also instructed the Commission to conduct regular inquiries concerning the availability of advanced telecommunications capability and, based on our findings, to take action to accelerate deployment, if necessary. In our *First Report*, issued in February 1999, we found that the overall deployment of advanced telecommunications capability generally appeared reasonable and timely, given the early stage of deployment.[3] We lacked adequate data, however, to reach more definitive conclusions at that time.

5. In conducting our second inquiry and issuing this Second Report, we expanded our information collection efforts to gain a more comprehensive understanding of the availability of advanced telecommunications capability. First, we issued a Notice of Inquiry on the issue of

[2] *Id.* §706(c)(1).

[3] *Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, CC Docket No. 98-146, Report, 14 FCC Rcd 2398 (1999) (*First Report*).

advanced telecommunications capability in February 2000.[4] In that Notice, we asked four basic questions: (1) What is advanced telecommunications capability? (2) Is advanced telecommunications capability being deployed to all Americans? (3) Is overall deployment reasonable and timely? and (4) What actions will accelerate deployment? Second, in addition to seeking comment and building a record on these four questions, we launched a formal data collection program to gather standardized information from providers of advanced telecommunications capability in the United States, including wireline telephone companies, cable providers, terrestrial wireless providers, satellite providers, and any other facilities-based providers of advanced telecommunications capability.[5] Third, we convened a Federal-State Joint Conference on Advanced Telecommunications Services (Joint Conference), consisting of federal and state regulators, for the purpose of providing a forum for an ongoing dialogue among the Commission, the states, and local and regional entities regarding the deployment of advanced telecommunications capability.[6] The Joint Conference conducted a series of field hearings across the country -- from Alaska to Miami -- to gather data on the deployment of advanced telecommunications capability. The Joint Conference has also begun to develop a publicly accessible database of "best practices" employed in various regions to spur rapid deployment. Finally, we undertook a series of in-depth case studies to gain a detailed understanding of how advanced telecommunications capability is being deployed and used in different communities. Specifically, we examined deployment in Los Angeles County, California; Waltham, Massachusetts; Muscatine, Iowa; Miller, South Dakota; and Wilsondale, West Virginia.

6. Based on all of the information gathered from our Notice of Inquiry, our data collection program, the Joint Conference field hearings, our case studies, and reports from industry, analysts, academics and other agencies, we now issue our Second Report. In the sections that follow, we address the four basic questions we asked in the Notice of Inquiry. We make our judgement as to whether deployment of advanced services to all Americans is reasonable and timely by looking at three major factors. First, we examine subscribership levels, and how they have changed since our *First Report*. Next, we look at levels of investment in infrastructure and projections of future growth with advanced telecommunications capability. Finally, we assess the choices available to consumers today and in the near future, looking at both choices among service providers and among technology options.

7. As Congress directed in section 706, we focus on the *availability* of advanced telecommunications capability. Accordingly, we concentrate our efforts largely on addressing the deployment of the infrastructure necessary to bring advanced telecommunications capability to consumers, as well as the level of subscribership to the services provided over that infrastructure. We recognize, however, that deployment of infrastructure alone does not

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[4] *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, CC Docket No. 98-146, Notice of Inquiry, FCC 00-57 (rel. Feb. 18, 2000) (*Second NOI*).

[5] *Local Competition and Broadband Reporting*, CC Docket No. 99-301, Report and Order, 15 FCC Rcd 7717 (rel. Mar. 30, 2000) (*Data Gathering Order*).

[6] *Federal State Joint Conference on Advanced Telecommunications Services*, Order, 14 FCC Rcd 17622 (1999) (*Joint Conference Order*).

guarantee that the benefits of advanced telecommunications capability will flow to all consumers as Congress intended. Factors such as household income, computer ownership, education, and technical skill, to name a few, all affect whether consumers are able to access the advanced services available through advanced telecommunications capability. We also recognize that the speed and ubiquity of advanced telecommunications capability deployment will depend in large measure on consumers' demand for content and services that require this capability. However, many of these factors implicate a variety of economic, sociological, and demographic issues that are beyond the scope of this report. Nonetheless, as discussed below, the market for advanced telecommunications capability is in its early stages and this Commission has already taken important steps to accelerate and facilitate widespread deployment. We will continue and expand these efforts as we strive to ensure that all Americans have access to advanced telecommunications capability.

II. EXECUTIVE SUMMARY

8. This Report answers the four basic questions we set forth in the Notice of Inquiry.

(1) What is advanced telecommunications capability?

- We retain our current definition: infrastructure capable of delivering a speed in excess of 200 kbps in each direction. We denominate as "high-speed" those services capable of delivering transmission speeds in excess of 200 kbps in at least one direction. Advanced telecommunication capability and advanced services thus are a subset of the larger "high-speed" category.

- We reaffirm that a service may have asymmetrical upstream and downstream transmission paths and still be advanced telecommunications capability as long as both paths are capable of speeds in excess of 200 kbps to the network demarcation point at the subscriber's premises.

(2) Is advanced telecommunications capability being deployed to all Americans?

- In determining whether advanced telecommunications capability is being deployed to all Americans, we examine the networks used to provide those advanced services, including the backbone, the middle mile, the last mile, the last 100 feet, and connection points to those facilities.

- We conclude that, as of December 31, 1999, there were approximately 1.8 million residential subscribers of high-speed services. We further estimate that approximately 1.0 million of these users subscribed to services that meet our definition of advanced telecommunications services. This is a three-fold increase in residential advanced services (again, full two-way services) from the previous year.

- At the end of 1999, there were approximately 1.0 million high-speed lines providing service to large business and institutional customers. We estimate that almost all of these lines satisfy our definition of advanced telecommunications capability.

- Subscribers to high-speed services are spread throughout all fifty states, the District of Columbia, and Puerto Rico. In addition, there is at least one subscriber to high-speed

services in 59 percent of the country's zip codes, and 91 percent of the country's population lives in these zip codes. The data further indicates that population density is highly correlated with the availability of facilities necessary to support advanced services.

- In determining whether advanced telecommunications capability is being deployed to all Americans, we undertake an examination of deployment of advanced services in various locations throughout the United States: Los Angeles County, California; Waltham, Massachusetts; Muscatine, Iowa; Miller, South Dakota; and Wilsondale, West Virginia.

- We also review community-based deployment efforts in order to identify successful strategies that have led to increased access to advanced telecommunications capability; and we examine trends in investment and growth in various high-speed access technologies.

(3) Is overall deployment reasonable and timely?

- Recognizing that the development of advanced services infrastructure remains in its early stages, we conclude that, overall, deployment of advanced telecommunications capability is proceeding in a reasonable and timely fashion. Specifically, competition is emerging, rapid buildout of necessary infrastructure continues, and extensive investment is pouring into this segment of the economy.

- We conclude that there has been ample national deployment of backbone and other fiber facilities that provide backbone functionality. There is no indication that specific types of areas have inadequate access to backbone or functionally equivalent facilities.

- We find that extensive middle mile facilities exist; that innovative compression and modulation techniques continue to expand the capability of existing fiber links; and that the broad geographic distribution of subscribers to high-speed services demonstrates the wide availability of middle mile facilities. Nonetheless, there remains the potential that a bottleneck exists in certain areas and that a lack of competition in that market could lead to high prices.

- We find that, throughout the country, deployment of last-mile facilities to support advanced services is expanding rapidly.

- Despite our conclusion that deployment is reasonable and timely overall, the data support the troubling conclusion that market forces alone may not guarantee that some categories of Americans will receive timely access to advanced telecommunications capability. We identify certain categories of Americans who are particularly vulnerable to not having access to advanced services. These include low-income consumers, those living in sparsely populated areas, minority consumers, Indians, persons with disabilities and those living in the U.S. territories.

- We find that approximately 52 percent of schools have high-speed connections to the Internet, largely as a result of the use of the E-rate for high-speed services.

- Current regulatory requirements will help ensure that advanced services are accessible to persons with disabilities. However, it still appears likely that, in the near future, some

networks and services will be developed that are not accessible to this population.

- There does not appear to be a lack of infrastructure with respect to the last 100 feet, and we are currently considering questions regarding access to inside wires and other such facilities.

(4) What actions by the Commission will accelerate deployment?

- In accordance with our statutory mandate, we are committed to ensuring that advanced services become available to all Americans. We believe the recommendations outlined below, many of which are already are underway in separate dockets, will promote access to advanced services especially to consumers we have identified as being particularly vulnerable to not being served by the operation of market forces alone.

  - We are considering modifications to our collocation rules to provide for competitive access to incumbent LECs' remote terminals.

  - We are considering streamlining the equipment approval process for customer premises equipment with advanced telecommunications capability.

  - Upon completion of our current work on the high-cost support mechanism for rural carriers, and in collaboration with the states, we will consider the appropriate mechanisms to ensure broadband access for customers who do not have access as a result of market forces. In addition, we will further examine our rules for the E-rate program to determine if we can encourage broadband services and connections; and if sharing of school and library facilities can improve access or deployment in surrounding communities.

  - We will consider whether to allow access by multiple Internet service providers to cable companies' infrastructure for the delivery of advanced services.

  - We will examine ways to make more licensed and unlicensed spectrum available for broadband services, as well as ways to enable the increased use of spectrum.

  - We will increase data collection and dissemination practices in order to monitor more closely the deployment of advanced telecommunications capability.

9. We also encourage several additional entities to consider actions that will encourage investment in, and stimulate demand for, advanced services and reduce the cost of deployment. Additionally, we encourage the integration of telecommunications and economic development policies, as well as increased funding for technological research and development, particularly for the purpose of developing solutions to serving remote and low-demand areas.

III. WHAT IS ADVANCED TELECOMMUNICATIONS CAPABILITY?

10. In this section, we address the first question asked in our Second Notice of Inquiry: What is advanced telecommunications capability? Section 706 (b) of the 1996 Act defines advanced telecommunications capability as "high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology." In the *First Report*, we defined "broadband" -- and, in effect, advanced telecommunications capability and advanced

services -- as "having the capability of supporting, in both the provider-to-customer (downstream) and the customer-to-provider (upstream) directions, a speed (in technical terms, 'bandwidth') in excess of 200 kilobits per second (kbps) in the last mile."[7] We stated several reasons for choosing 200 kbps. First, it appeared that Congress intended advanced telecommunications capability to be faster than ISDN service, which operates at a data rate of 128 kbps and was widely available at the time of the 1996 Act.[8] Also, 200 kbps is enough to provide the most popular applications -- to change web pages as fast as one can flip through the pages of a book.[9] Finally, we required that both upstream and downstream paths have this capability because Section 706 (b) uses the words "originate *and* receive."[10]

11. In this Report, we again examine the availability of 200 kbps, or faster, speeds in both the upstream and downstream paths of the last mile. However, we use the terms "advanced telecommunications capability" and "advanced services" to refer to this capability. Since the *First Report*, the terms "broadband" and "broadband services" have come to include a much broader range of services and facilities. In light of its now common and imprecise usage, we decline to use the term broadband to describe any of the categories of services on facilities that we discuss in this report. Rather, we denominate as "high-speed" those services with over 200 kbps capability in at least one direction. Thus, high-speed is the larger category, consisting of those services and facilities with a transmission speed of 200 kbps in at least one direction. Advanced telecommunications capability and advanced services form a subset of this larger category and denote that portion capable of 200 kbps or greater transmission in *both* directions.

12. In keeping our present definition, we follow the suggestion of several commenters who observe that it sets a standard above the bandwidth that most residential customers use today, but well below the fastest rates possible with today's technologies.[11] We view this definition as a benchmark. If it reflects merely what most residential customers want or are receiving today, then we risk setting our sights unduly low. We think Congress meant us to do more.[12] We are particularly reluctant to lower our standard for the upstream path below 200 kbps. To do so would omit transmissions of home and community events, frustrating important applications of advanced telecommunications capability. It would omit lip-reading and signing, denying a major potential benefit for persons with speech and hearing disabilities and those wanting to converse with them. Narrowband upstream paths would also render difficult, if not impossible, many advanced telecommunications capability applications for telecommuting,

[7] *First Report*, 14 FCC Rcd at 2406.

[8] *Id.* n.13.

[9] *Id.* at 2406. 200 kbps is more than enough bandwidth to permit the video transmission of sign language. In comparison, typical business teleconferencing services are 120-250 kbps, conventional televisions are 750 kbps to 1 Mbps, videocassette tapes are 1.5 Mbps, and movie theatre images are several Mbps. As changes in technology, such as compression, advance we may need to revise our definition. *See infra* para. 14.

[10] Section 706(b) (emphasis added); *First Report*, 14 FCC Rcd at 2406-07 & n.17.

[11] Bell South comments at 8; MCI WorldCom comments at 4; OPASTCO comments at 2.

[12] AT&T comments at 2-9; Bell Atlantic comments at 2-5; Citizens Communications comments at 11; GTE comments at 8-9; Metricom, Inc. comments at 4-6; NCTA comments at 26-27; Northpoint Communications, Inc. comments at 6-7; SBC corrected comments at 5-6.

consumer-originated broadcasting, distance education, desktop publishing, and health care.[13] We believe that Congress intended advanced telecommunications capability to bring to all Americans a two-way, truly interactive medium, rather than one that is passive and entertainment-oriented.

13. We also re-affirm the other definitional findings of our *First Report*.[14] These findings include that a service may have asymmetrical upstream and downstream paths and still be advanced telecommunications capability as long as both paths provide speeds in excess of 200 kbps to the network demarcation point at the subscriber's premises.

14. We emphasize, as did our *First Report*, that our definition of advanced telecommunications capability will evolve over time.[15] Future reports will reconsider it in light of changing conditions in both supply and demand. We may change the definition, for example, if compression technologies make possible with 100 kbps what now requires more than 200 kbps. We may also increase the speed as higher bandwidths become more affordable,[16] or as demand among millions of residential customers takes firm shape.[17] Periodically reviewing these definitions will ensure flexibility that fits the dynamic, recurrent review process that section 706 contemplates.

IV. IS ADVANCED TELECOMMUNICATION CAPABILITY BEING DEPLOYED TO ALL AMERICANS?

15. In this section, we address the second question that we asked in our Second Notice of Inquiry: Is advanced telecommunications capability being deployed to all Americans? In order to answer this question, it is instructive to begin with a brief overview of the networks used to provide advanced services, followed by a description of the specific technologies employed in those networks. We then discuss the subscribership data reported by providers who completed our Broadband Survey. Next, we discuss our findings from the case studies we conducted in various communities across the nation. The case studies provided us insight into practices that communities have employed to encourage providers to offer services in their communities, which we detail in the "Best Practices" section of this report. Finally, we discuss industry and analyst assessments of investment and deployment.

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[13] See Public Utility Law Project comments at 5-6 (businesses, hospitals, schools, libraries and museums may choose to locate in low-income neighborhoods only if they can transmit as well as receive data at high-speeds).

[14] *First Report*, 14 FCC Rcd at 2406-2407 (advanced telecommunications capability must be two-way and switched, but upstream and downstream paths need not be in the same self-contained offering; advanced telecommunications capability includes facilities that have been upgraded or otherwise altered in ways that make them capable of high-speed bandwidth).

[15] *Id.* at 2407-2408.

[16] Commercial Internet Exchange comments at 4.

[17] We may also elaborate the definition of advanced telecommunications capability to include maximum allowable amounts of latency, delay and packet loss. Two-way video conferencing, for example, could be degraded to a significant degree if a certain technology or congestion in a network introduced a one-second delay in the exchange of video or audio signals.

A. Overview of the Networks Used to Provide Advanced Services

16. Advanced services are provided using a variety of public and private networks that rely on different network architectures and transmission paths. Some of these networks, like the Internet, are public in the sense that access to the network is open to all users. Other networks, like those built and maintained by corporations for their internal use, are private in the sense that access to the network may be restricted to a particular class of users, often the corporation's employees. Moreover, depending on the network, data may travel from the sender to the recipient over various architectures and transmission paths such as copper wire, cable, terrestrial wireless radio spectrum, satellite radio spectrum, or a combination of these and other media. In addition, data may be transmitted using different communications protocols that manage and direct traffic at different layers of a particular network.[18]

17. Although advanced services are provided over myriad combinations of public and private networks using a variety of transmission paths and protocols, for the purposes of this report we focus on the physical components of the network infrastructure. For simplicity, we have divided network infrastructure into four general categories: backbone, middle mile, last mile, and last 100 feet.[19] In addition, we refer to the points of connection between these components of the network as connection points.

18. In conceptualizing the categories of network infrastructure identified above, we find it helpful to analogize network infrastructure to a system of roads. In our simplified analogy, each of the categories corresponds to a different type of road:

> Backbone -- Multi-lane Interstate Highway: Backbone provides a long-distance, high-capacity, high-speed transmission path for transporting massive quantities of data, much like the way a large multi-lane interstate highway allows large amounts of traffic quickly to travel long distances. Most backbone consists of fiber optic lines, either buried in the ground or laid under the sea. In addition, backbone can be provided using satellite systems and radio spectrum.
>
> Middle Mile -- Divided Highway: As its name suggests, middle mile facilities provide relatively fast, large-capacity connections between backbone and last mile, similar to the way a divided highway may connect local roads to multi-lane interstate highways. Middle mile facilities can range from a few miles to a few hundred miles. They are often constructed of fiber optic lines, but microwave and satellite links can be used as well.

[18] For instance, the Internet Protocol (Transmission Control Protocol/Internet Protocol suite) supports interconnections across any physical transport medium, including wireline, terrestrial wireless and satellite, at various rates, and can support various applications. Other transmission protocols such as asynchronous transfer mode (ATM) or frame relay exist within other networks capable of supporting advanced telecommunications capabilities.

[19] These four network components are useful for organizing our analysis; however we recognize that because of the wide variety of network architectures and transmission media that deliver advanced telecommunications capabilities, some of these categories may overlap or be absent in a specific situation. Additionally, we note that the pictures and maps in this report depict logical and symbolic simplifications of the extremely complex and dynamic interconnections that support advanced telecommunications capabilities and services.

Last Mile -- Local Road: The last mile is the link between the middle mile and the last 100 feet to the end-user's terminal. The last mile is analogous to the local road between a larger, divided highway and a traveler's driveway. A last mile with advanced telecommunications capability provides speeds in excess of 200 kbps in each direction. Last miles may consist of cable modem service, digital subscriber line (DSL) service, terrestrial wireless service, or satellite service. Some last-mile segments -- for example those on certain cable systems -- provide faster downstream speeds than upstream speeds either because their network configurations will not support the higher upstream speed or because they rely on a telephone return path.

Last 100 Feet -- Driveway: The last 100 feet is the link between the last mile and the end-user's terminal, which is similar to the way a driveway connects a traveler's home or office to a local road. The last 100 feet includes the in-house wiring found in a consumer's residence, the wiring in an apartment or office building, the more complex wiring in a wireline local area network, or the wireless links in a local wireless network.

Connection Points -- Intersections, On-Ramps, and Interchanges: Connection points are the places at which the various components of the network interconnect, often with the aid of an electronic or optical device (e.g., switches and routers between the middle mile and backbone), so that data can move across the network. Connection points are analogous to the intersections, on-ramps, and interchanges between local roads, divided highways, and multi-lane interstate highways.

B. Components of the Network

19. In this section we examine each of the components of the network described above, both in terms of the technology used and the types of entities providing these components. We focus particularly on the last mile because it is a critical link between existing backbone and middle mile infrastructure on the one hand and the last 100 feet to the end-user's terminal on the other hand. In examining each component of the network, we also attempt to identify any major technological barriers to deployment of advanced telecommunications capability.

1. Backbone Facilities

20. At the core of the physical infrastructure supporting advanced telecommunications capabilities are nationwide backbone transport facilities.[20] Much of the terrestrial fiber optic backbone in this country has been constructed along public rights of way created for railroad, telephone, and electric-utility owned companies. Providers have created additional backbone capacity in the form of undersea cables and satellite systems.

21. National backbone transport providers in the United States include large nationwide providers such as AT&T, WorldCom and Sprint and a number of smaller facilities-

[20] In this report we use the term backbone to refer to high-speed physical transport. Our use of the term is broader than, and distinguishable from, an Internet backbone that uses interstate transport networks to transport Internet traffic.

based transport providers, as depicted on the following map, Figure 1.[21] There are an additional 35 to 50 wireline, terrestrial wireless and satellite-based national Internet backbone providers, with varying amounts of physical facilities.[22] The major Internet backbone providers transport traffic with capacity ranging from approximately 155 Mbps to over 10 Gbps (OC-3 to OC-192 equivalent speeds).[23]

22. Although the cost of building and maintaining backbone facilities is high, there do not appear to be significant technological barriers to deployment of these facilities. To date, advances in fiber optic and microwave technologies have allowed backbone capacity to keep pace with demand for backbone facilities.[24] While backbone capacity does not appear to present a barrier to deployment of advanced telecommunications capability at this time, the ability to access that capacity presents other questions which are addressed later in this section.

2. Middle Mile Facilities

23. Middle mile facilities provide transport or routing from last mile aggregation points in order to interconnect and exchange traffic with national backbone providers or directly with other middle mile networks. It appears that most fiber optic, middle-mile facilities, like backbone, exist along public rights of way.[25] Other middle miles include fixed wireless and satellite links.[26]

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[21] KMI Corp., *North American Fiberoptic Long-Haul Routes Planned and in Place*, May 2000. Copyrighted. Permission to reproduce paper copies obtained from KMI. No electronic reproduction permitted.

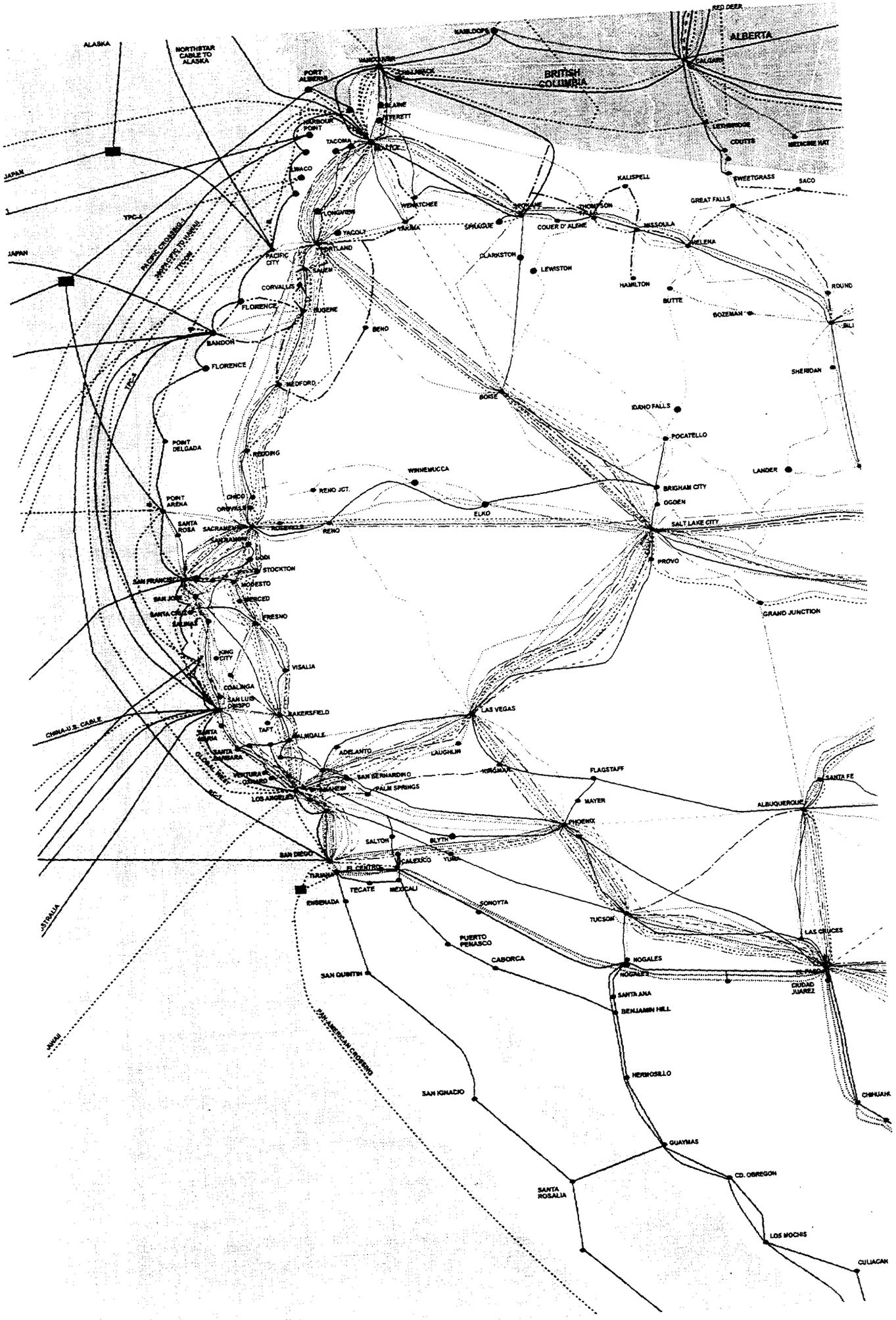
[22] Boardwatch Magazine's Directory of Internet Service Providers, Introduction to the Directory of Internet Service Providers (1999) (visited July 25, 2000) <http://boardwatch.Internet.com/isp/summer99/introduction.html> (listing 44 Internet backbone service providers); National Telecommunications and Information Administration & Rural Utilities Service, *Advanced Telecommunications in Rural America: The Challenge of Brining Broadband Service to All Americans* < http://www.ntia.doc.gov/reports/ruralbb42600.pdf> at 8 (Apr. 2000) (*NTIA/RUS Report*).

[23] Boardwatch Magazine's Directory of Internet Service Providers, Introduction to the Directory of Internet Service Providers (1999) (visited July 25, 2000) <http://boardwatch.Internet.com.isp.html>; *Hubs and Spokes: A Telegeography Internet Reader*, TeleGeography, Inc., (2000)

[24] *See, e.g.*, Price Waterhouse Coopers, *Technology Forecast: 2000, Carrier Backbone Transmission Networks* at 452-63 (2000).

[25] In a recent study, NECA suggests construction of additional transport facilities across private property, including farm land, significantly increases the cost of construction. NECA Rural Broadband Cost Study, 2000 (visited Aug. 1, 2000) <http://www.neca.org/broadban.asp>.

[26] *See* AT&T comments at 19-21; *NTIA/RUS Report* at 9.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NORTHSTAR CABLE TO ALASKA
JAPAN
TPC-4
PACIFIC CROSSROADS
JAPAN-PERU TO HAWAII
TICOM
TPC-3
CHINA U.S. CABLE
GLOBAL CROSSING
PCCI
AUSTRALIA
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EVERETT
HOQUIAM POINT
TACOMA
SEATTLE
LEWISTON
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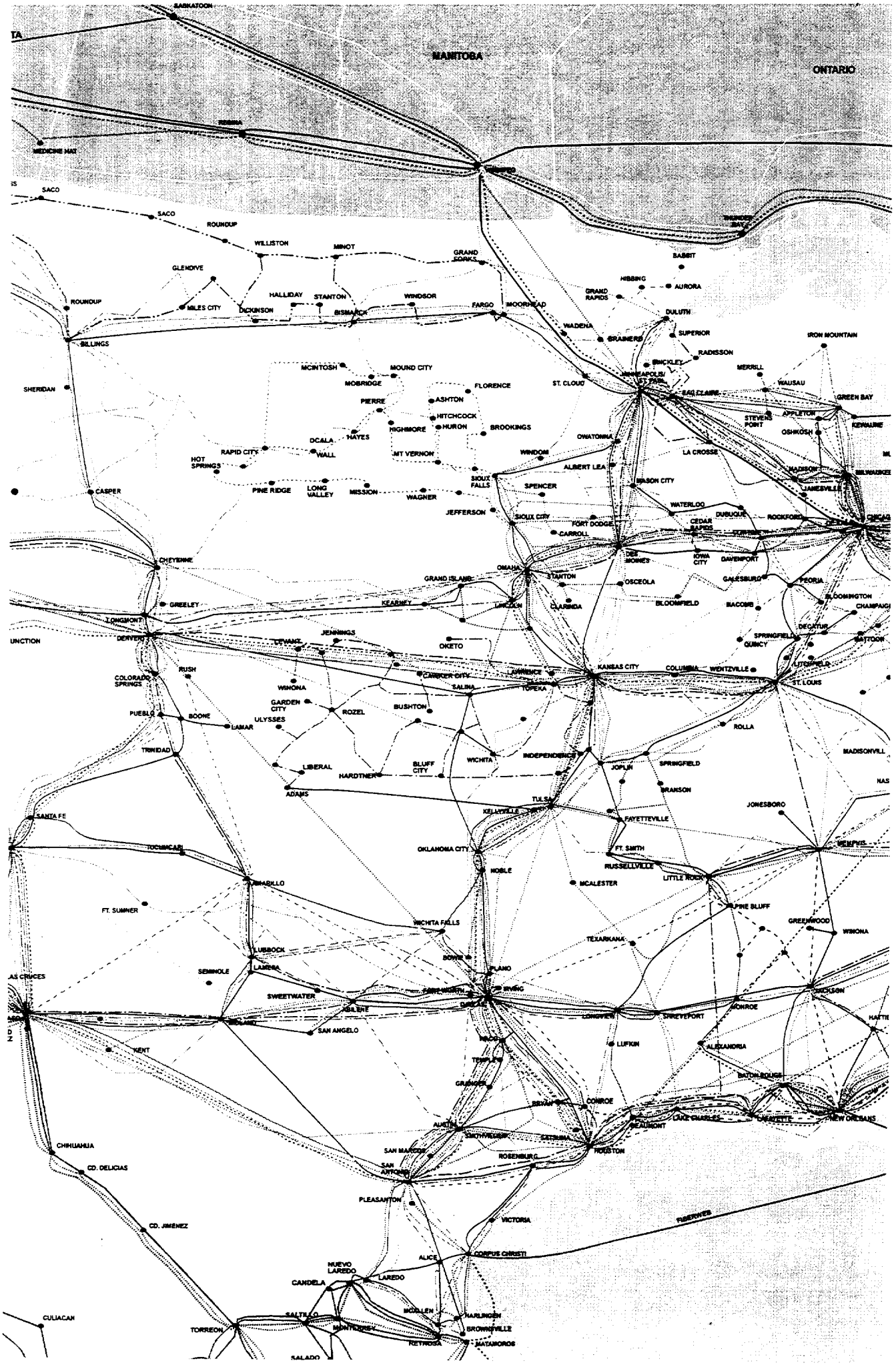
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INDEPENDENCE
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BLUFF CITY
HARDTNER
ADAMS
LIBERAL
MADISONVILL
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GARDEN CITY
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EAU CLAIRE
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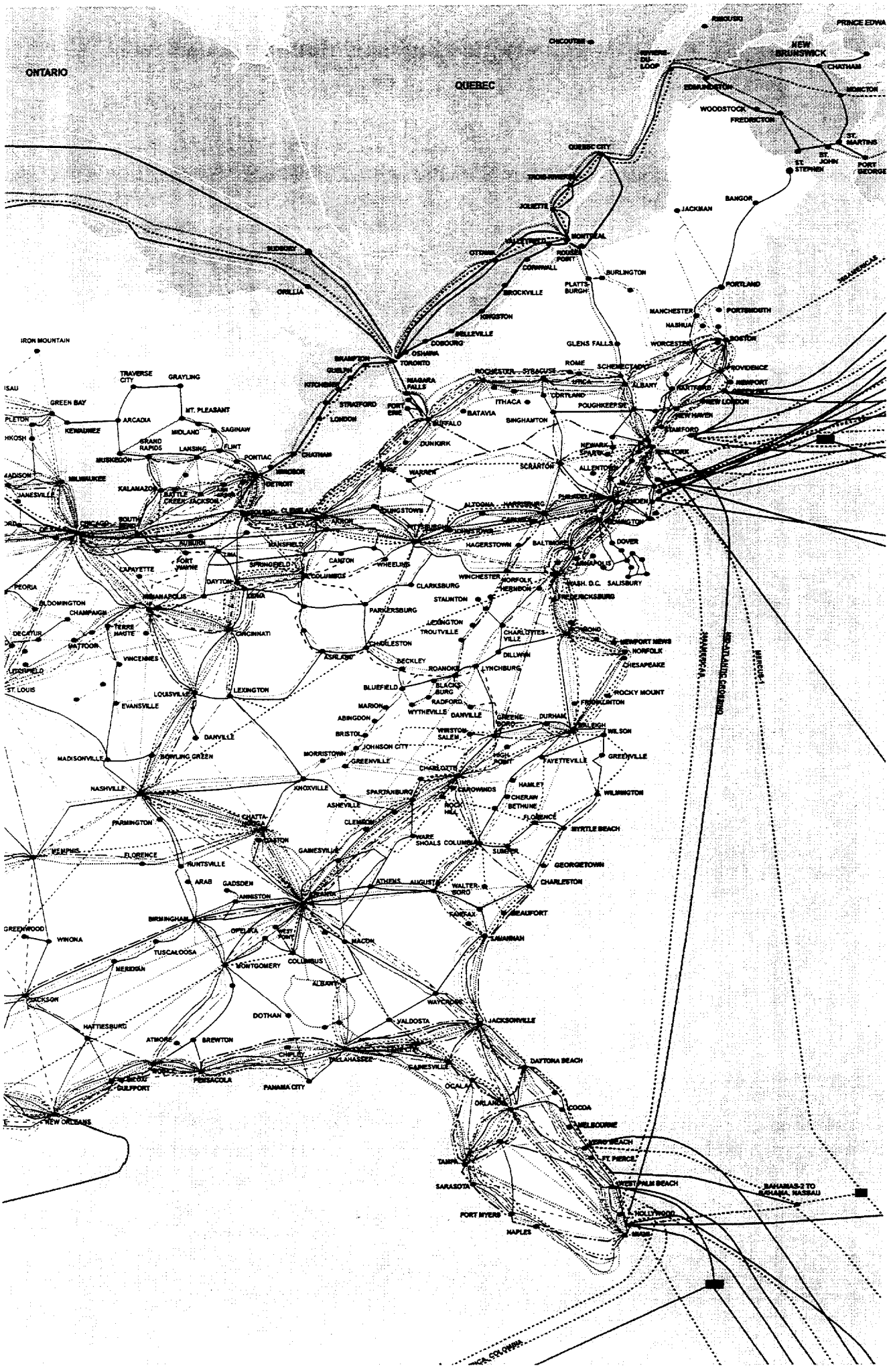
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MONTREAL
OTTAWA
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BURLINGTON
PLATTSBURGH
SUDBURY
ORILLIA
BROCKVILLE
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PORTLAND
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MIDLAND
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ROANOKE
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ST. LOUIS
LOUISVILLE
LEXINGTON
BLUEFIELD
BLACKSBURG
ROCKY MOUNT
EVANSVILLE
MARION
RADFORD
WYTHEVILLE
DANVILLE
FRANKLINTON
ABINGDON
GREENSBORO
DURHAM
RALEIGH
WILSON
DANVILLE
BRISTOL
WINSTON SALEM
MADISONVILLE
BOWLING GREEN
MORRISTOWN
JOHNSON CITY
GREENVILLE
HIGH POINT
FAYETTEVILLE
GREENVILLE
CHARLOTTE
NASHVILLE
KNOXVILLE
SPARTANBURG
CAROWINDS
HAMLET
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ASHEVILLE
ROCK HILL
CHERAW
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BEAUFORT
GREENWOOD
WINONA
OPELIKA
WEST POINT
MACON
SAVANNAH
TUSCALOOSA
MERIDIAN
MONTGOMERY
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VALDOSTA
JACKSONVILLE
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ATMORE
BREWTON
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TALLAHASSEE
GAINESVILLE
DAYTONA BEACH
PENSACOLA
GULFPORT
PANAMA CITY
OCALA
ORLANDO
COCOA
MELBOURNE
NEW ORLEANS
VERO BEACH
FT. PIERCE
TAMPA
WEST PALM BEACH
SARASOTA
BAHAMAS-2 TO BAHAMA, NASSAU
FORT MYERS
HOLLYWOOD
NAPLES
MIAMI
MIDATLANTIC GROUND
MIDCUB-1
MIAMIBRICK

North American Fiber Optic Long-haul Routes Planned and in Place

U.S.

- AEPCommunications IL,IN,KY,OH,WV,VA,NC
- ALLTEL-OH,PA,MD,DC, VA,NC,SC,GA,FL,TN,AK, NB,KS
- AT&T(nationwide)
- BonnevillePower Authority-WA,OR,MT
- Broadwing(IXC) (nationwide)
- BTI-(eastcoast)
- C3Communications TX,OK,AK,LA
- CAPROCK NM,TX,OK,AK,LA
- CFNFibernet VA,NC,SC,GA
- ColumbiaTransmission (easternhalfofU.S.)
- ConectivCommunications PA,NJ,DE,MD
- ElectricLightwave (nationwide)
- Enron(nationwide)
- Entergy-TX,LA,AK,MS,TN
- Florida Power & Light - FL
- Frontier - (nationwide)
- GPU Telecom Services PA, NY, OH, WV, VA, MD, DC, MA
- GST Telecom (western half U.S.)
- Iowa Network Services IA, SD, MN, IL, MO, NB
- ITC Deltacom (southeast U.S.)
- KINNET - KS
- Level 3 Communications (nationwide)
- Main Inc. - MT, ND
- MCIWorldCom (nationwide)
- McLeodUSA - ID to IN
- MP Telecom - MI
- Net Lec - MI
- NEON - New England
- Norlight - MN, WI, IL, IN, MI
- NTS Communications WA to IL to TX
- Onvoy - MN
- Pathnet - IL, IA, NB, CO, NM, TX
- PF.NET (nationwide)
- Qwest (nationwide)
- South Dakota Network - SD
- Sprint (nationwide)
- Touch America (nationwide)
- Valleynet - PA, MD, VA, WV, TN
- Williams (nationwide)
- WIN Network - MN, WI

UNDERSEACABLEKEY
InPlace
Plannedorunderconstruction

CANADA

- AT&T CANADA
- BCT.TELUS
- BLOOD HILLS TELECOM
- SHAW FIBERLINK
- SPRINT CANADA
- 360NETWORKS

MEXICO

- ALESTRA
- AVANTEL
- BESTEL
- MAXCOM
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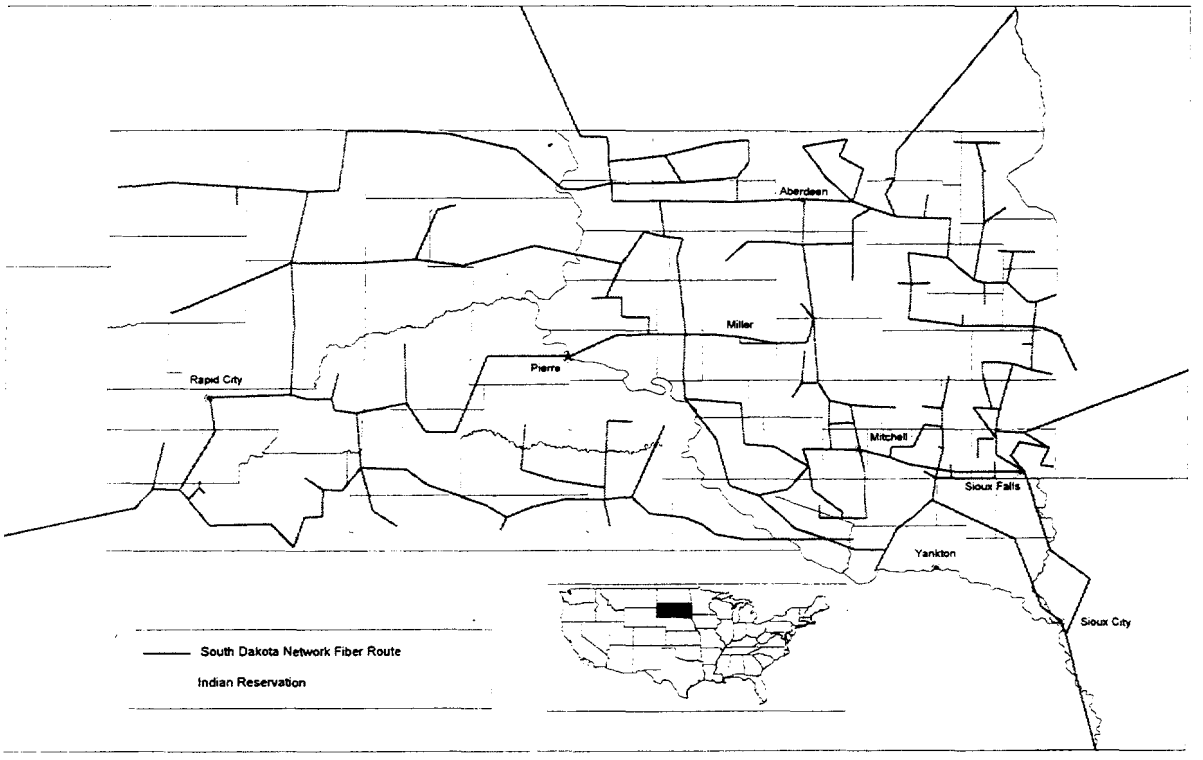
24. Many middle mile facilities were originally built by telephone and cable companies for ordinary telecommunications or cable television services. For example, the fiber optic connections that transport telephone traffic between telephone company central offices can be considered middle mile facilities. Additional examples of middle mile networks include statewide networks such as the fiber optic network in South Dakota and numerous regional commercial enterprises.[27] The following map, Figure 2, shows South Dakota's state-wide network.



25. Many providers of middle mile transport lease capacity on their networks to non-facilities based Internet service providers (ISPs) and high-speed providers, who find the transport speeds adequate to meet their needs. For example many local exchange carriers (LECs) currently lease the fiber or high-speed lines connecting their central offices. Most cable systems also have fiber or satellite transport facilities to regional and national backbone, which they may lease to other providers. In addition, there are entities known as Global Service Providers providing interLATA transport service.[28]

[27] Examples of regional commercial networks include: Electric Lightwave, with an OC12 trunk in the Pacific Northwest; CapRock Communications, which connects second tier communities in Texas; and the recently formed America's Fiber Network, a consortium of energy and telecom companies that promises to provide transport facilities to the nations Tier 2 and Tier 3 cities. *See* Electric Lightwave (visited July 25, 2000) <http://www.eli.net>; America's Fiber Network *ex parte* (June 28,2000); America's Fiber Network, *Is the Digital Divide a Mirage?*, 5/1/2000 at 42, (2000).

[28] *See T-NETIX* (visited July 25, 2000) <http://www.uswest.com:80/ps/gsp.html> (for information about US West's Global Service Provider).

26. As demand for middle mile facilities has increased, existing providers and new providers have deployed additional facilities. As Figure 3 demonstrates, in the past five years, the amount of fiber miles deployed in the United States has doubled.[29] Interexchange carriers, incumbent and competitive local exchange carriers, cable television companies and others, including fixed wireless service providers, have invested enormous amounts of money into construction of fiber facilities.[30]

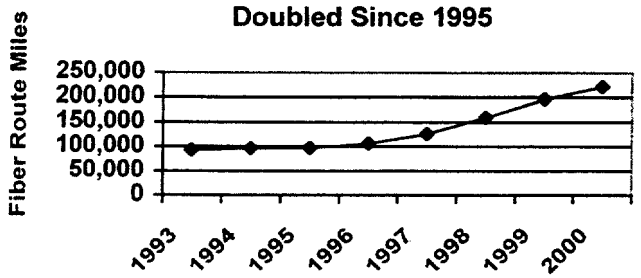


Figure 3 - US Fiber Route Miles Have Doubled Since 1995

Source: FCC Fiber Deployment Report (1993-1998); MMTA & TIA, 2000 MultiMedia Telecommunications Market Review and Forecast (1999-2003)

27. We noted in the *First Report* that high capacity fiber connects to almost every local exchange carrier central office.[31] Indeed, significant amounts of unused high capacity fiber, typically referred to as dark fiber, exist within the fiber conduit connecting local exchange carrier central offices.[32] In part because of the lack of ubiquitous alternative middle mile transport, we recently determined that interoffice dark fiber transport qualified as an unbundled network element.[33] This determination allows competitive carriers access to interoffice dark fiber.[34]

3. Last Mile Facilities

28. Last mile facilities provide the connection between middle mile facilities and the last 100 feet to an end-user's terminal. While all components of the network play important roles in the delivery of advanced services, we focus particular attention on the deployment of last mile facilities because they are often the missing link in communities that do not have access to

[29] Fiber miles are the sum of the number of miles of each cable multiplied by the number of fiber strands in each cable; this includes both lit and unlit strands. *Fiber Deployment Update, End of Year 1998*, FCC, Industry Analysis Division (visited July 25, 2000) <http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/Fiber/fiber98.pdf> (FCC Fiber Deployment Update, 1998).

[30] Multimedia Telecommunications Ass'n & Telecommunications Industry Ass'n, *2000 MultiMedia Telecommunications Market Review and Forecast, Fiber Optic Spending*, at 67 (2000).

[31] *First Report*, 14 FCC Rcd at 2417 ("High-capacity fiber goes into almost every telephone central office in this country, and new Dense Wave Division Multiplexing technology will increase its capacity hugely.")

[32] The local exchange carriers that serve about 90% of local customers had, at the end of 1999, a total of 10.2 million fiber miles of dark fiber. The vast majority of this was between central offices. *See ARMIS Report* (visited July 25, 2000) <http://gullfoss.fcc.gov:8080/cgi-bin/websql/prod/ccb/armis1/forms/43-08/frame1a.hts>.

[33] *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, Third Report & Order & Fourth Further Notice of Proposed Rulemaking, 15 FCC Rcd 3696, 3853 (1999) (*Dark Fiber Order*) ("a competitive wholesale market for alternative network elements has not developed for dedicated transport, in part because of the lack of ubiquitous transport alternatives.") *petitions for reconsideration & appeal pending.*

[34] *Dark Fiber Order*, 15 FCC Rcd at 3772, 3376, 3785-86 ("interoffice transport"), 3843-45 ("we modify the definition of dedicated interoffice transport to include dark fiber"), 3852-55.

advanced telecommunications capability. The last mile connection to the end-user can take the form of cable modem service, digital subscriber line service (DSL) or some other LEC-provided service, terrestrial wireless service, or satellite service. Some operators of last mile facilities, like cable providers, transport data entirely over facilities that they own. Others, including many terrestrial wireless providers, lease transport to regional and/or national connection points from local exchange carriers. Last mile facilities called very small aperture terminals (VSATs) may also use satellite links to transport traffic to middle mile facilities or directly to the national backbone networks.[35] In the sections that follow, we examine each of the four major technologies used to provide last mile facilities: cable modem service, DSL and other LEC-provided services, terrestrial wireless, and satellite service. We discuss the types of entities that provide these last mile facilities, from the technology used to deliver advanced services and subscribership rates, to their investments in infrastructure and analysts' forecasts, as well as the significant technological barriers to deployment of each technology.

a. Overview of Cable Modem Service

29. Cable companies offer advanced services, most notably high-speed Internet access services, using cable modem technologies. Cable modem technologies rely on the same basic network architecture used for many years to provide multichannel video service, but with upgrades and enhancements to support advanced services.[36] The typical upgrade incorporates what is commonly known as a hybrid fiber-coaxial (HFC) distribution plant. HFC networks use a combination of high-capacity optical fiber and traditional coaxial cable.[37] Most HFC systems utilize fiber between the cable operators' offices (the "headend") and the neighborhood "nodes." Between the nodes and the individual end-user homes, signals travel over traditional coaxial cable infrastructure. These networks transport signals over infrastructure that serves numerous users simultaneously, i.e., a shared network, rather than providing a dedicated link between the provider and each home, as does DSL technology. As discussed below, the shared architecture of cable networks poses certain challenges for providers that seek to offer high-speed Internet access or other advanced services over cable infrastructure.

30. Before offering high-speed Internet and other two-way high-speed services, most

[35] Very small aperture terminals or "VSATs" are small earth stations or antennas usually designed to operate in the Ku satellite band that are installed at a user location to allow two way communications via satellite. In addition to providing point to multipoint data network services to merchants to transmit credit card, inventory management and other business related data, VSATs are used for distance training and high speed intranet and Internet access.

[36] As noted in the *First Report*, our inclusion of cable modem technology in our assessment of advanced telecommunications capability does not implicate any determination by this Commission as to whether cable services constitute telecommunications services.

[37] HFC networks can be composed of any combination of fiber and coaxial cable. The most common architecture is fiber to the node (FTTN) which involves a fiber cable to each cluster of subscriber homes or neighborhood, where the optical signal is converted for coaxial cable for delivery to individual homes. Less common architectures include fiber to the curb (FTTC) where a single strand typically serves between 8 and 16 homes, and fiber to the home (FTTH) where each individual home has its own fiber termination point. *See* Texas A&M University, Department of Computer Science (visited July 25, 2000) <http://www.cs.tamu.edu/people/jhamann/hfc/node3.html>.

cable providers upgrade their networks.[38] This process often includes extending optical fiber closer to the end-user and improving system quality to reduce signal leakage.[39] Through this upgrade process, cable operators typically increase the system's transmission capacity to 550 MHz or 750 MHz, which allows the operator greater flexibility in allocating bandwidth for two-way high-speed services without reducing the capacity available for existing video services.[40]

31. Upgrading a system for high-speed Internet service typically requires installation of equipment that enables the transmission of digital data packets: routers, switches, and a cable modem termination system. Further, to allow the high-speed transmission of data over the cable infrastructure in both the upstream and downstream directions, operators install amplifiers and optical lasers in both directions. Without such equipment, providers typically can provide high-speed service only in the downstream direction and must rely on a telephone line return path. Once an HFC network is upgraded, new services are available to all homes passed by the upgraded infrastructure. This contrasts with DSL technologies, where variations in legacy outside plant conditions can limit access to certain end-users even in upgraded areas, and with wireless technologies where line-of-sight requirements may be a factor.

32. Many cable systems providing high-speed data services offer asymmetric service, as the great majority of available bandwidth is allocated for downstream transmissions. The limited remaining bandwidth available for the return path results in lower upstream speeds. Most systems' upstream capacity appears to be sufficient to support current consumer demand for established services such as web surfing. In some instances, however, this asymmetric service may not offer sufficient upstream speed to qualify under our definition of advanced telecommunications capability. As consumers use applications with higher upstream requirements such as video conferencing, cable operators may need to allocate greater network capacity for upstream transmission.

33. Under optimal conditions, and using the best available technology, an upgraded cable system can provide maximum downstream speeds of 27 Mbps and maximum upstream speeds of 10 Mbps, more than sufficient to qualify as advanced telecommunications capability.[41] In practice, however, cable transmission speeds typically range from several hundred kilobits per second to 1.5 Mbps. The lower speed is attributable to several factors. First, because of the

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[38] Cable operators are struggling to meet consumer demand for high-speed residential Internet access. *See e.g.*, Richard Bilotti, Benjamin Swinburne, Morgan Stanley Dean Witter, *Broadband Industry Update – The Time to Buy Selectively* at 3 (2000). One analyst notes that sufficient labor appears to be in place to accommodate the upgrade schedules of the major cable operators. *See* Stanford C. Bernstein & Co. and McKinsey & Co., Inc., *Broadband!* at 71 (2000) (Bernstein/McKinsey, *Broadband!*).

[39] Signal leakage can result in either lost data or the transmission of unusable data. Digital signals are composed of discrete packets of information and carry error-correcting codes that can regenerate any lost data. If these error-correcting codes are lost due to system leaks, the packets may not be transmitted accurately or may be re-assembled incorrectly at the receiving end.

[40] Operators typically devote approximately 90% of their system capacity to traditional video services. Bernstein/McKinsey, *Broadband!* at 39.

[41] *See Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming*, CS Docket No. 99-230, Sixth Annual Report, 15 FCC Rcd 978, 1004, ¶ 56 (2000) (*1999 Video Competition Report*). In most cases, however, cable operators offer a maximum theoretical downstream capacity of 10 Mbps.

shared architecture of cable networks, the bandwidth – and consequently the speed – available to any single user drops as the number of simultaneously active users increases.[42] Second, a system's transmission speed is affected by the proportion of capacity devoted to advanced services. Third, congestion on the Internet itself often limits the speed of access to well below 10 to 27 Mbps. Given these limitations on system throughput, cable operators typically offer a "maximum speed available" rather than a guaranteed stable speed of service.

34. High-speed Internet access over cable is available primarily to the residential market.[43] Several factors may explain this. First, cable operators historically have deployed facilities for video services to the residential market. This leaves them poorly situated to offer service to many business districts. Second, cable's shared network architecture makes it difficult for providers to guarantee the consistent high speeds and secure transmissions that some business customers require. Third, the relatively narrow bandwidth typically allocated to upstream transmission renders cable unable to provide upstream speeds and symmetric transmission capabilities sufficient to support the requirements of some business customers.[44]

b. Overview of Digital Subscriber Line Service

35. Since 1996, local telephone carriers have offered consumers high-speed data service through their digital subscriber line (DSL) service offerings. With the addition of certain electronics to the telephone line, carriers can transform the copper loop that already provides voice service into a conduit for high-speed data traffic. While there are multiple variations of DSL, some of which we discuss below, most DSL offerings share certain characteristics. With most DSL technologies today, a high-speed signal is sent from the end-user's terminal through the last 100 feet and the last mile (sometimes a few miles) consisting of the copper loop until it reaches a Digital Subscriber Line Access Multiplexer (DSLAM), usually located in the carrier's central office. At the DSLAM, the end-user's signal is combined with the signals of many other customers and forwarded though a switch to middle mile facilities.

36. The most common form of DSL used by residential customers is asymmetric DSL, or ADSL.[45] As its name suggests, ADSL provides speeds in one direction (usually downstream) that are greater than the speeds in the other direction.[46] Many, though not all, residential ADSL offerings provide speeds in excess of 200 kbps in only the downstream path with a slower upstream path and thus do not meet the standard for advanced telecommunications

[42] *See 1999 Video Competition Report*, 15 FCC Rcd at 1004, ¶ 56.

[43] *See infra* para. 0; Jeff Camp, Richard Bilotti, Simon Flannery, and Mary Meeker, Morgan Stanley Dean Witter, *The Broadband Report - Reaping What You Sow: ROI in the Broadband Market* at 13 (2000) (Morgan Stanley Dean Witter, *Broadband Report*).

[44] Morgan Stanley Dean Witter, *The Broadband Report* at 12.

[45] In using the acronym "ADSL," we are referring generally to DSL service that is asymmetric, not the specific protocol ADSL.

[46] AT&T reply comments at 3; Bell Atlantic comments at 4; GTE comments at 9; NTCA comments at 3.

capability.[47] However, ADSL permits the customer to have both conventional voice and high speed data carried on the same line simultaneously because it segregates the high frequency data traffic from the voice traffic. This segregation allows customers to have an "always on" connection for the data traffic and an open path for telephone calls over a single line. Thus a single line can be used for both a telephone conversation and for Internet access at the same time. A survey of various LEC web sites indicates that prices for low-end ADSL service typically range from $39.95 to $49.95 per month. Faster ADSL services ranged from $99.95 to $179.95 per month. Installation fees ranged from free, typically where customers are offered "DSL in a box,"[48] to $99.95, where a technician visit is necessary to install premises equipment.

37. In contrast to ADSL, symmetric DSL (SDSL) provides users with equal speeds in the downstream and upstream path, usually in excess of 200 kbps. Because of the symmetrical nature of SDSL, it is well-suited to applications that require high-speed capacity in the upstream path, such as videoconferencing. Because of its higher capacity needs, SDSL service typically requires a dedicated copper pair for its high-speed data transmissions. The price of SDSL service currently ranges from $150 to $450 per month, with installation costs ranging from free to $1550, and equipment costs from $225 to $360, depending on the transmission speed desired and the equipment purchased.[49]

38. DSL service is subject to certain limitations that currently prevent it from being deployed as a last mile facility to all potential end-users. First, it is distance sensitive. Currently, an ADSL customer must be within approximately 18,000 feet of the carrier's central office; SDSL customers must be between 10,000 and 12,000 feet of the central office depending on the speed of the service in question.[50] Eighty percent of the subscriber loop plant falls within these distance limitations,[51] and thus is capable of supporting DSL service, but this factor remains an impediment to DSL deployment in more sparsely populated and remote locations. New technologies may allow DSL deployment at substantially greater distances.[52]

39. The second factor limiting the deployment of DSL to some potential customers is the presence on their loops of load coils and bridged taps, devices that were used to enhance the quality of voice traffic over the copper. While they improve the quality of voice transmission, these devices prevent the deployment of DSL service over a line on which they are installed.

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[47] Depending on the configuration of the ADSL technology deployed by the carrier, rates ranging from 1.544 Mbps to 6.1 Mbps can be achieved in the downstream path, and rates ranging from 90 kbps to 640 kbps may be achieved in the upstream path.

[48] "DSL in a box" is a form of ADSL in which the provider sends the customer filters and a modem that the customer installs. By having the customer install these filters, the provider avoids sending a technician to the customer's premises, thus reducing the time and cost associated with establishing ADSL service.

[49] Based on a survey by Commission staff of SDSL service offering posted on the Internet.

[50] As distance from the telephone company's central office decreases, the potential data rate increases.

[51] *General Introduction to Copper Access Technologies*, (visited Aug. 1, 2000) <http://www.adsl.com/general_tutorial.html>.

[52] AT&T comments at 11 ("Next generation Digital Loop Carrier deployed using fiber distribution facilities to the central office makes DSL throughput virtually independent of customer distance from the central office").

Thus, in contrast to an upgraded cable network, which can offer upgraded service to all homes it passes, LECs must "condition" each end-user's line by removing the load coils and bridged taps while increasing the strength of the signal to maintain the quality of the line's voice traffic. Moreover, older loops or loops in need of maintenance, which may occur in poor or inner-city areas, pose additional problems for the deployment of DSL service. Frayed insulation or poorly spliced loops can cause signal leakage, which can result in poor quality transmission.

40. A third factor that impedes DSL deployment is the choice by some incumbent local exchange carriers to abandon copper wire and instead deploy Digital Loop Carrier (DLC) in their networks. DSL service is incompatible with most currently deployed DLC systems. However, it appears that new DLC products will allow DSL providers to circumvent this limitation.

c. Overview of Other LEC-Provided Wireline Services

41. In addition to DSL offerings, many local exchange carriers offer more traditional high-speed, circuit switched services like T1 lines, which have been available for some time. The monthly charge for T1 service can range from $450 to $2000, with installation cost ranging from $750 to $5500, depending on the transmission speed desired and equipment purchased.[53] Additionally, local exchange carriers have used fiber technology for many years for their interoffice plant. It is also used to deliver signals at speeds in excess of 45 Mbps directly to certain large business customers. Most residential and smaller business customers currently do not need the transmission speed of fiber, and the cost of fiber service generally makes it prohibitive for all but the largest users. Several fiber-based residential architectures have been devised[54]; however, the high cost associated with deploying this technology makes it economically viable, if at all, only in the most densely populated of residential settings.[55]

d. Overview of Fixed Wireless Service

42. Wireless services and technologies have the potential to deliver high-speed services to residential, rural, and otherwise underserved areas and to increase competition in the last mile in the near future. As discussed below, fixed wireless technologies may offer unique advantages and quick-to-market solutions for the delivery of high-speed services in a number of circumstances.[56] At present, however, technical limitations may constrain the breadth of their

[53] Based on a survey by Commission staff of T1 service offerings posted on the Internet.

[54] SBC's "Project Pronto" is an architecture that is focusing on residential customers and pushes fiber closer to the end-user in an effort to offer high-speed access to a larger number of customers in its service areas. SBC comments at 3. *See also SBC's New Broadband Neighborhood Network* (visited August 1, 2000) <http://www.sbc.com/Technology/data_strategy/project_pronto/dsl.html>.

[55] For instance, SBC estimates it will take an investment of over $6 billion to achieve its planned network conversions. *See SBC Announces Supplier for Broadband Network Project* (visited Aug. 1, 2000) <http://www.sbc.com/News_Center/Article.html?query_type=article&query=19991103-04>.

[56] While the future of wireless high-speed services likely will include mobile service, it does not appear from our recent Broadband Survey that any providers currently are offering mobile data service at a speed that comports with the our definition of high-speed. No provider that met our 250 high-speed line (or wireless channel) threshold reported delivering high-speed service over mobile wireless technology. Nor do industry analysts report that any provider is offering such service. Accordingly, we discuss only fixed wireless offerings in this report.

overall deployment and their effectiveness in certain settings. At this point, many of these services are in an earlier stage of deployment than the traditional "wired" services, cable-modem and DSL technology, but significant growth is anticipated over the next three to five years, potentially leading to service to millions of households.

43. In a fixed wireless system that provides high-speed services to consumers, a provider generally attaches to a customer's premises a radio transmitter/receiver (transceiver) that communicates with the provider's central antenna site. The central antenna site then acts as the gateway into the public switched telephone network or the Internet for these transceivers. The radio signals that travel over this network architecture serve as a substitute for the copper wire or cable strand that connects customers to the network in traditional, wired technologies.

44. Providers of fixed wireless services typically can deploy their networks much more quickly and with substantially less expense than is required to build a network capable of supporting either cable-modem or DSL service. First, wireless networks are free of the substantial costs associated with installing and maintaining wires that run to a customer's premises.[57] These savings make wireless technology especially well suited to deployment in many rural areas, where substantial distances between customers may be cost-prohibitive for wireline technologies. Wireless technologies may also serve as an economic alternative in urban areas where consumers are not otherwise served by certain forms of wireline technologies. For example, only a small percentage of multi-tenant office buildings are currently served by fiber networks. Thus, fixed wireless services may make high-speed access more affordable for those small and medium-sized businesses for which direct fiber connections remain too expensive.

45. Second, the relative ease of installation of this technology allows wireless providers to deploy their networks much more quickly than is possible for providers that must actually install wires leading to each customer's premises. This permits wireless providers to respond rapidly and dynamically to developing demand for advanced telecommunications capability.

46. Third, the architecture of a wireless network allows providers to roll out their facilities in a manner more closely related to the product demand they encounter. A traditional wired provider often will install the network infrastructure in an entire area before it begins to market its service in that area. Thus, a cable provider will upgrade its cable plant throughout a neighborhood when it begins to offer advanced telecommunications service to the neighborhood's residents even if initial subscription rates are low. Similarly, a DSL provider likely will make certain network investments in an area where it intends to offer service before it signs up its first customer. By contrast, once a wireless provider has installed its antenna in an area, it completes the last-mile connection by installing an on-premises transceiver only for those customers who have actually subscribed to its service. This incremental build-out process allows wireless providers to avoid much of the up-front investment that traditional wired advanced telecommunications capability providers must make.

47. Although wireless services can generally be deployed more rapidly and at lower

[57] *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services*, Fourth Report, 14 FCC Rcd 10145, 10267 (1999) (*Fourth Report*).

cost than comparable wireline services, they remain subject to certain technical limitations that may reduce their effectiveness in certain areas and for certain purposes. For example, in addition to requiring access to telecommunications equipment closets and any necessary in-building wiring, wireless providers often must obtain access to rooftops for the placement of antennas. This can become particularly problematic in the case of multi-tenant buildings, in which a building owner may resist permitting access. Also, many, though not all, fixed wireless technologies are subject to line-of-sight restrictions. Thus, there must be an unobstructed path from a wireless provider's antenna to the customer's antenna on the rooftop of a building. While certain advances in wireless technology may help to overcome this limitation in the future, buildings, topographical features, certain adverse weather conditions, and even vegetation can interfere with the provision of service.

48. While physical infrastructure costs of wireless networks may be significantly less than wireline networks, wireless networks require access to spectrum. Some of the wireless systems providing high-speed services today obtained free spectrum licenses and other providers obtained spectrum through auctions.[58] The explosive growth in recent years of wireless networks has created substantial demand for spectrum. New wireless and satellite services are increasingly constrained by spectrum scarcity and encumbrances,[59] which may result in substantial additional acquisition costs in the future.

49. There are several different bands of spectrum over which wireless providers offer their services. The characteristics of the service, their means of deployment, and the service's potential technical limitations all vary somewhat over the different spectrum bands. Accordingly, we briefly discuss each separately below.

50. The Upperbands (above 24 GHz). The technologies deployed in the "upperband" spectrum generally provide data rates of up to 155 Mbps, a speed adequate to support a host of multimedia applications.[60] As a general matter, wireless services in the upperbands may suffer signal loss in adverse weather conditions. However, by adjusting factors such as cell size and transmission power, these systems can be engineered to the standard reliability level for telecommunications networks. Fixed wireless technologies operating in these bands have relatively small cell sizes, with an average cell radius of between three and five miles. Also, since upperband signals behave more like visible light than cellular or PCS signals, wireless networks deployed in these spectrum bands require a clear line of sight between transmitters and

[58] Spectrum licenses have garnered nearly $24 billion in winning bids since the Commission received authority to auction spectrum, with spectrum capable of providing high-speed terrestrial services receiving bids over $1.2 billion. *FCC Wireless Telecommunications Bureau AuctionTopics, General Auction Data, Summary Matrix* (visited July 28, 2000) <http://www.fcc.gov/wtb/auctions/Welcome.html>.

[59] *See Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, Policy Statement, 14 FCC Rcd 19,868 (1999) (*Spectrum Reallocation Policy Statement*).

[60] The upperbands of spectrum include those with frequencies of 24 GHz and above. The largest commercial deployment of wireless high-speed systems has occurred in the 24 GHz (formerly known as Digital Electronic Messaging Service or "DEMS"), 28 GHz (Local Multipoint Distribution Services or "LMDS"), and 39 GHz bands.

receivers. Terrain, buildings, and even vegetation may interfere with the provision of service.[61]

51. The Lowerbands (below 3 GHz). *MDS.* Fixed wireless high-speed is currently provided by multipoint distribution service (MDS) in the 2 GHz range.[62] MDS was originally a video programming service. More recently, MDS providers have been shifting their business focus to providing high-speed Internet access, including two-way service.[63] The downstream Internet speeds reported by MDS operators range from 750 kbps to 11 Mbps. Until recently, upstream transmission often relied on a telco-return and consequently was much slower.

52. MDS transmissions have a substantially greater radius than upperband fixed wireless services, generally 25 to 35 miles versus three to five miles for upperband services. This is partly because MDS signals do not degrade in adverse weather conditions. MDS's larger radius makes the service well suited for not only urban and suburban residential customers, but also customers in rural, underserved, and unserved areas, where the larger cell-size substantially reduces the cost of providing service.[64] MDS typically has functioned best with a direct line of sight between the transmitter and the receiver. However, recent technological developments may

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[61] The most significant operators in the upperbands are Teligent, Inc. and WinStar Communications, Inc., both of which are currently targeting business customers. In 1999, WinStar's wireless network expanded to sixty domestic markets, up from thirty at the end of 1998. *WinStar Reports Fourth Quarter Results; Revenue, Gross Margin and EBITDA Continue Sharp Improvement*, Press Release, WinStar Communications, Inc. (Feb. 10, 2000). With this coverage, WinStar claims to be able to reach more than 292 million people. WinStar, *WinStar Communications Gets FCC OK for Added Spectrum*, Press Release WinStar Communications, Inc. (Mar. 22, 2000). By the end of 1999, it claimed 23,000 customers, 618,000 lines, and access rights to more than 8,000 buildings. *WinStar Reports Fourth Quarter Results; Revenue, Gross Margin and EBITDA Continue Sharp Improvement*, Press Release, WinStar Communications, Inc. (Feb. 10, 2000).

In 1999, Teligent completed its plan to roll out service in forty U.S. markets, covering more than 100 million people. *Teligent Reports $31 Million In 1999 Revenue; Expands Reach To Four Continents*, Press Release, Teligent (Mar. 6, 2000). At the end of 1999, Teligent claimed more than 15,000 customers, 166,000 lines and access rights to more than 7,500 buildings. *Id.*

In addition to these two providers, at least five other wireless carriers are in the process of testing or rolling out their service in more limited numbers of markets: NEXTLINK; Advanced Radio Telecom, Inc.; SPEEDUS.COM; Highspeed.com L.L.C.; and Touch America, a wholly owned subsidiary of the Montana Power Company. *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services*, Fifth Report, FCC 00-289, at App. E (rel. Aug. 3, 2000) (*Fifth Competition Report*).

[62] The Multipoint Distribution Services (including multichannel multipoint distribution service and the instructional television fixed service) operate in the 2000-2700 MHz bands. 47 C.F.R. § 21.900 *et.seq.*; 47 C.F.R. § 74.901 et seq. As of the end of 1999, there were at least nine MDS companies offering high-speed Internet access. *See infra* note 142.

[63] *See Request for Declaratory Ruling on the Use of Digital Modulation by Multipoint Distribution Service and Instructional Television Fixed Service Stations*, 11 FCC Rcd 18839 (1996); *Amendment of Parts 21 and 74 to Enable Multipoint Distribution Service and Instructional Television Fixed Service Licensees to Engage in Fixed Two-Way Transmissions*, Report and Order, 13 FCC Rcd 19112 (1998), *Order on Reconsideration*, 14 FCC Rcd 12764 (1999).

[64] Sprint comments at 4, 7; Wireless Communications Ass'n Int'l comments at 3; WorldCom comments at 11-12. Homes and offices in Phoenix can subscribe to Sprint's high-speed MDS service for $39.95 per month. *See Sprint Launches First Broadband Wireless Market in Phoenix*, (visited May 16, 2000) <http://www3.sprint.com/Stemp/press/releases/200005/200005080990.html>.

help to overcome this restriction.[65]

53. *Broadband PCS.* Although cellular and broadband Personal Communications Services (PCS) spectrum technically can support high-speed services, relatively few licensees are currently using their frequencies in this manner. The primary offering in that spectrum is AT&T's Project Angel system, which uses broadband PCS spectrum[66] to reach homes and small businesses outside of AT&T's cable television systems.[67] AT&T maintains that it plans to price its high-speed data offering at a substantial discount to the competing ADSL offering. In particular, AT&T announced at the end of 1999 that it plans to charge residential customers $29.95 per month for a high-speed (1 Mbps) fixed wireless access line in the Dallas/Ft. Worth area.[68] According to AT&T, this compares with a $39.00 monthly charge for an access line (256kbps) plus a $12.00 monthly charge for renting a modem in the case of ADSL.[69]

54. *Wireless Communications Service (2.3 GHz).* WorldCom is using Wireless Communications Service (WCS) spectrum[70] for the return path of certain high-speed Internet access service trials it is conducting.[71] AT&T also plans to use its WCS licenses for its fixed wireless service.[72] This year, BellSouth will begin testing one-way, high-speed Internet access using WCS spectrum at a downstream speed of 1.5 Mbps.[73]

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[65] For example, in December 1999, Cisco released an MDS cellularization technology that captures signals as they bounce off buildings and other objects and redirects them to end-user transceivers. Cliff Edwards, *Cisco Hopes Advances New Wireless Technology Strategy for Internet*, AP NEWSWIRES, Dec. 2, 1999. At least two companies have announced plans to deploy this technology, known as Vector Orthogonal Frequency Division Multiplexing, this year. *Nucentrix Broadband Networks and Cisco to Deliver First VOFDM-Based Wireless Broadband Internet Services*, News Release, Nucentrix Broadband Networks, Feb. 4, 2000; *WorldCom Adds Dallas to 'Fixed Wireless' Service Trials*, News Release, WorldCom, Inc., Apr. 5, 2000. A start-up called NextNet, Inc. has also developed an end-to-end MDS system with a desktop customer-premises unit that requires no rooftop antenna and no inside wiring connections. NextNet, Inc., *Products* (visited Jan. 20, 2000) <http://www.nextnetworks.com/products_prod_bottom.html>.

[66] Broadband PCS services operate between 1850 and 2200 MHz.

[67] As initially deployed, the system permits two voice channels, data rates up to 512 kbps, and "always-on" Internet access. AT&T Corp., Form S-3, Feb. 2, 2000, at 60; *IPO Debut in 2000: AT&T to Launch Wireless Tracking Stock, Beef Up Fixed Wireless*, COMMUNICATIONS DAILY, Dec. 7, 1999. AT&T expected the service to be capable of four voice channels and speeds up to one Mbps by mid-year 2000, *id.* and anticipates a full-scale rollout in 2001. AT&T Comments at 17. Early this year, Project Angel was serving 200 customers in Dallas. AT&T Corp., Form S-3, Feb. 2, 2000, at 60.

[68] Lew Chakrin, AT&T Fixed Wireless, presented at 1999 Analysts' Meeting, December 6, 1999.

[69] Lew Chakrin, AT&T Fixed Wireless, presented at 1999 Analysts' Meeting, December 6, 1999.

[70] WCS service operates on the 2305-2320 MHz and 2345-2360 MHz bands.

[71] Wireless One, Form 10-K, Mar. 31, 1999. These trials are occurring in Baton Rouge, LA, Jackson, MS, and Memphis, TN.

[72] AT&T Corp., Form S-3, Feb. 2, 2000, at 53.

[73] *Mexico-U.S. Talks Heat Up on DARS Interference Concerns*, AUDIO WEEK, Apr. 24, 2000; *BellSouth Launching Trial to Cross Digital Divide*, WIRELESS TODAY, Dec. 10, 1999. BellSouth's trial will take place in Houma, LA. If trials are successful, BellSouth reports it will upgrade the system to two-way service. *Id.*

55. *Unlicensed spectrum.* A handful of companies across the U.S. use unlicensed spectrum in the 2 GHz and 5 GHz spread spectrum bands to offer short-distance high-speed Internet access and other high-speed services, such as wireless wide area network or local area network systems for businesses. As of April 2000, at least eleven companies were reportedly providing these services in twenty-three markets.[74] Unlicensed spectrum, which may be used without a license but is not protected from interference from other services, offers a low-cost means for smaller companies to enter the wireless high-speed market.[75]

e. Overview of Satellite Service

56. Satellite service provides another option for last mile facilities with its own set of unique characteristics. In most current residential satellite-based last mile facilities, only the downstream path is provided by satellite; the upstream path is often provided by a standard dial-up telephone connection. Thus, many current residential satellite offerings are capable of providing speeds in excess of 200 kbps only in the downstream path, and therefore do not meet the definition of advanced telecommunications capability.[76] Nonetheless, satellite-based last mile facilities may provide consumers and small businesses in geographically remote and sparsely populated areas with access to high-speed services that would not otherwise be available. Moreover, several satellite providers have announced plans to begin offering residential service with the downstream and upstream paths both provided by satellite.[77]

57. High-speed satellite service is currently provided to both residential and business customers. Much of the current business use is for bursty high-speed service and data communications such as credit card verification or inventory control. Most of this traffic apparently is handled under private contractual arrangements similar to private line service. A growing number of business customers are also using satellite service for Internet connections.

58. Hughes' DirecPC provides high-speed service in the downstream direction at speeds ranging up to 400 kbps. Upstream transmissions use conventional telephone dial-up connection, typically at 28.8 kbps or 56 kbps. DirecPC charges between $19.99 and $49.99 per

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[74] *EMCEE Completes Equipment Installation for Sunbury Broadband's Wireless Internet System,* PR Newswire, Sept. 14, 1999; IJNT.net, Inc. Form 10KSB/A, Filed May 10, 2000; SkyLynx Communications, Inc., Form 10KSB, Filed Apr. 14, 2000; *United Online Web Page* (visited May 23, 2000) <http://www.uoli.com>.

[75] Many of the unlicensed operators are small start-ups, and some, such as SkyLynx, are local or regional ISPs that have added a fixed wireless offering for customers who demand high-speed access. Metricom is currently deploying its Ricochet2 service, which provides full Internet access, fixed or mobile, at an overall transmission rate of 128 kbps, in 21 markets. *See Watch 128 kbps Mobile Data Service Become a Reality* (visited May 23, 2000) <http://www.metricom.com/about/128kbps_progress.htm.>. Micro Design Systems provides high-speed wireless hand-held LAN computer system integration currently used by some brokerage firms. Micro Design Services, LLC (visited July 12, 2000) <http://www.microdesignservices.com>. Infrared Communications Systems, Inc. offers last mile facilities using unlicensed infrared spectrum and advertises speeds ranging from 1.544 Mbps to 622 Mbps over distances of a few hundred meters to more than 3.5 miles. *See* Infrared Communications Systems, Inc. (visited July 25, 2000) <http://www.infraredsystems.net>.

[76] In many large business satellite-based offerings, the end-user's terminal (i.e., satellite dish) is capable of both receiving and sending data. This allows for downstream and upstream speeds that exceed 200 kbps.

[77] *See infra* paras. 201 - 202.

month depending upon the number of hours of service and whether an ISP is included in the package.[78] Necessary hardware, including installation materials start at $189.99.[79]

59. Satellite-based last mile facilities have some limitations. Consumers must have a clear line of sight to the south in order to access satellite-based services. Areas subject to extreme rain or snow may have difficulty receiving satellite signals in those conditions. Additionally, DirecPC does not provide service using its standard receiving antenna to Alaska and Hawaii, because the satellite currently used to carry DirecPC service does not provide a sufficiently robust signal to operate reliably with small antennas located there.[80] It may be technically feasible, using a larger dish, to receive DirecPC outside the continental United States, however, DirecPC does not support or guarantee its system when installed using a non-standard dish.[81] Furthermore, because DirecPC currently relies on a telephone return path, a subscriber may incur toll charges depending on the distance to the closest point of presence or may be required also to incur an additional expense to subscribe to a dial-up Internet service provided through a toll-free number.

f. Last 100 Feet Facilities

60. The last 100 feet typically refers to the final infrastructure segment from the end of the local access network to the end-user's terminal. This includes in-building wiring, local area networks and wireless local area networks. There do not appear to be technological barriers for last 100 feet facilities; indeed there are a variety of wireline and wireless options for constructing these facilities.[82] Nevertheless, the cost of some of these facilities may be a significant factor in the deployment of advanced telecommunication capability in the small business or school and library context. Additionally, certain last 100 feet segments may be in poor condition and consequently unable to support advanced services. Unlike a residential setting with a handful of users, small businesses or schools and libraries may have multiple users accessing advanced services simultaneously. This need for simultaneous access may require upgrades to the existing in-building wiring and other last 100 feet facilities, which may have been originally installed only with enough capacity for standard voice telephony services. In addition, access to last 100 feet facilities may be controlled by someone other than the end-user, such as the landlord of a multiple tenant dwelling. This also may create access barriers for these facilities, especially for competitors of the incumbent service provider.

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[78] *See DirecPC – How Much Does It Cost?* (visited Aug. 15, 2000) <http://www.direcpc.com/consumer/cost/cost.html>.

[79] *See DirecPC – Where Can I Buy It?*, <http://www.direcpc.com/consumer/buy/usa.html#search> (visited July 6, 2000); *Satellite Internet Access Cable Modem Dish DirecPC* (visited July 6, 2000) <http://www.infodish.com/Products/products.html>.

[80] *DirecPC - Where Can I Buy It?* (visited August 1, 2000) <www.direcpc.com/consumer/buy/buy.html>.

[81] *DirecPC - Owner's Club-FAQ's* (visited August 1, 2000) <www.direcpc.com/consumer/owners/faqs/faqs.html>

[82] *See DirecPC Two-Way Service Also to be Offered as DirecTV Broadband Satellite Service* News Release (Apr. 27, 2000) (visited Aug. 4, 2000) <http://www.hns.com/news/pressrel/csp_pres/p042700.htm>; *Gilat-to-Home Frequently Asked Questions* (visited Aug. 2, 2000) <http://www.gilat2home.com/faq/index.html>.

g. Connection points

61. In the preceding discussion, we have examined the various components of the network. In order for advanced services to be delivered to end-users, however, these components must interconnect with each other at the places we loosely describe as connection points -- those places at which traffic passes between the various components of networks. High-speed networks exchange traffic at a variety of different places and in a variety of different mechanisms. For example, public telephone networks, including local, long distance and international networks, interconnect at Points of Presence (POPs) or through other interconnection arrangements. Satellite networks exchange traffic with terrestrial networks. Internet backbone service providers exchange traffic at network access points (NAPs), Metropolitan Area Exchanges (MAEs),[83] and through other public and private peering and transit arrangements. National Internet backbone providers report operating commercial exchange points in over 200 cities in the United States and having over 900 POPs where they interconnect with regional networks, private networks and other providers.[84] As usage and demand increase, network operators establish additional arrangements for the exchange of traffic.[85]

C. Overview of Deployment – Survey Data

1. Commission's Broadband Survey

62. In this section of the report, we discuss data obtained through the Commission's first systematic, nationwide survey of subscription to high-speed services, which began earlier this year.[86] The Commission's "Broadband Survey" required any facilities-based firm that provides 250 or more high-speed service lines (or wireless channels) in a given state to report basic information about its service offerings and customers.[87] We note again that in this report -- and in our Broadband Survey -- we use the term "high-speed services" to include not only those services that meet our definition of advanced services (*i.e.*, in excess of 200 kbps in both directions simultaneously) but also to include services that only support an information carrying

[83] *See, e.g., Exchange Point Information* (visited July 24, 2000) <www.ep.net> (listing 55 Internet exchange points in North America); Boardwatch Magazine's Directory of Internet Service Providers, *The Internet - What Is It?* (visited July 25, 2000) <http://www.boardwatch.com/isp/summer99/Internetarch.html>.

[84] Boardwatch Magazine's Directory of Internet Service Providers, *Introduction to the Directory of Internet Service Providers* at 4 (12th Edition, 2000); Tisha White, *Backbone Profiles* (visited July 18, 2000) <http://www.ispworld.com/isp/bb/Backbone_Profiles.htm> (listing 41 Internet backbone service providers); *NTIA/RUS Report* at 8.

[85] In response to Internet congestion and delay, content creators, service providers and users employ different strategies, including caching and web hosting server site selection. Caching is the practice of placing copies of the popular content nearer to the users on web servers off of the major Internet exchanges or in major cities. Web hosting site selection permits a content creator to locate its content off of a major access point in order to maximize accessibility to their content while minimizing latency and intermediary network routing. Both these strategies minimize the impact of the location of content creator on the accessibility of the content created.

[86] *See Data Gathering Order*, 15 FCC Rcd 7717 (adopting FCC Form 477 as a vehicle for collecting this information). In this report, we refer to the Local Competition and Broadband Reporting program as the "Broadband Survey."

[87] *See* Form 477, available at <http://www.fcc.gov/Forms/Form477/477.xls>.