From its extensive testing with PCS vendors, Cox Communications has determined that in order for cable operators to successfully compete in PCS deployment their networks must be upgraded to: 1) fiber to no more than 1,000 home nodes, 2) two-way activation, 3) one transmitter per node, 4) at least 550 MHz, 5) a minimal number of amplifiers, 6) high reliability and quality. Most cable operators that wish to deploy PCS over their networks are actively engaged in meeting these minimum requirements (*See Fiber to the Node Economics for PCS Deployment, p. 21.*)

Moreover, cable operators will overlay PCS architecture over existing HFC plant that has been upgraded with two-way electronics and wireline telephony equipment. The economics of the wireless overlay are illustrated in the following economic data. Again, these figures are hypothetical and not representative of any system in particular, but are useful to generally illustrate the costs of the cable industry's evolving infrastructure from video-only to wireline to wireless telephone services. Industry analysts estimate a wireless PCS overlay to cost $475-500 per subscriber, a cost savings of $250-300 over the telephone industry's comparative PCS integration costs.[36]

[36] Richard Bilotti, *The Cable Television Industry-Deploying Wireline and Wireless Telephony*, Dec. 12, 1994, p. 20.

Fiber to the Node Economics for PCS Deployment [37]

[Hypothetical Suburban Fiber Ring]

Regional Fiber Ring Demographics

Total Homes Passed	500,000	Basic Subscribers	300,000
Basic Penetration	60.0%	# of Headends	20.0
Homes Passed by Headend	25,000	Subs per Headend	15,000

CATV System Architecture

Total # of Nodes per headend	50	Homes per node	500
Node size	300	Node per PCS base	5.0
Total Base stations per headend	5.0	Bases per ring	200

Base Station Demographics

Homes passed per Base station	2500	Penetration - Homes	13.2%
PCS Penetration-Basic subs	22.0%	PCS Subs per node	66
PCS Subs per Base station	330	PCS Subs per headend	3,300
PCS Subs per Fiber ring	66,000		

	Total Costs	**Cost per PCS sub**
Base Station Expenditures	$560,000	$8.48
Radio Frequency Expenditures	$19,152,000	$290.14
Mobility Mgt. Expenditures	$9,408,000	$142.53
Headend Equipment Expenditures	$2,179,200	$33.01
Switching Equipment Expenditures	$2,100,000	$ 31.81
Total PCS Expenditures	**$31,380,000**	**$475.39**
Total Fixed Capital Expenditures	**$10,986,000**	**$166.16**
Total Variable Expenditures	**$20,142,000**	**$309.23**

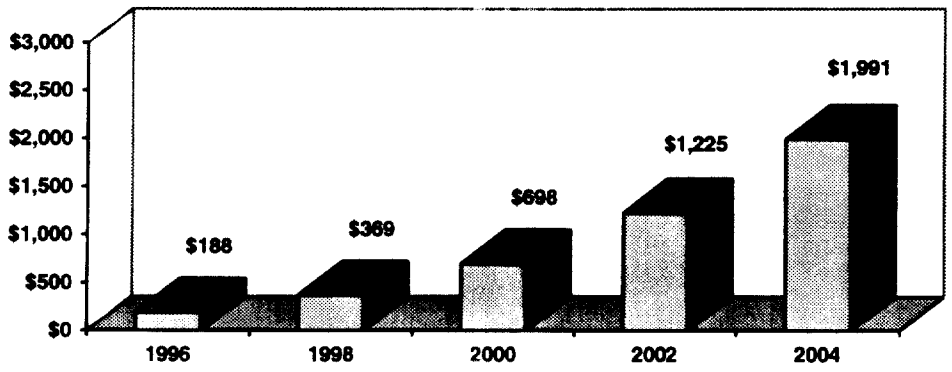
[37] Richard Bilotti, *The Cable Television Industry-Deploying Wireline and Wireless Telephony*, Dec. 12, 1994, p. 19. (Excerpts only, contact Morgan Stanley for detailed report).

C. Alternate Telephone Access

Cable companies currently provide a limited number of telephony services to business users through subsidiary competitive access providers (CAPS). **These companies are fiber rich telecommunications networks that provide "private line" connections from a customer's premise to the point of presence of the long distance carrier.** The private line connection bypasses the local telephone monopoly provider and represents one of several telephony services cable companies are well positioned to deliver

Alternate access involves connecting customers and long-distance carriers without the use of the local telephone company facilities. Many cable companies own equity interests in alternate access companies. The largest of such companies, Teleport Communications Group (TCG), is 100% owned by several major cable operators.[38] **Three of the four owners are also partners in Sprint Spectrum L.P.**

Cable Industry Alternate Access Revenue 1996-2004
(in millions)



Source: Paul Kagan Associates Inc., *10-Year Cable TV Industry Projections*. The Cable TV Financial Databook, July 1995, p. 8.

[38] Cable operators Tele-Communications Inc. (29.9%), Cox Cable (31.1%), Comcast Corporation (20%) and Continental Cablevision (20%) own TCG, which operates in 51 markets and 22 states.

Several cable operators are involved in providing non-switched alternate access services to business customers that require direct access to a long distance carrier or a dedicated link between two end users. These alternate access subsidiaries are usually fiber rich companies that build "fiber rings" around metropolitan business districts and provide a redundant path for two-way traffic at costs typically lower than the monopoly local telephone company. **Additionally, these fiber rings are also the foundation of regional hub networks that facilitate the incremental integration of new services such as full two-way high speed data access to online services and the Internet.**

Alternative Local Exchange Provider Fiber Data
(1994)

Alternate Access Company	Route Miles	Fiber Miles	States	Buildings
Teleport Communications Group	3,902	167,314	17	1,560
Time Warner Telecommunications	550	16,660	3	113
Eastern Telelogic **	325	13,000	3	350
Jones Lightwave	NA	NA	3	NA
Cox FiberNet	NA	NA	NA	NA

Note: The amount of fiber in a carrier's network is an indicator of the network's traffic capacity.

** Eastern Tele-logic is 51% owned by Comcast Corporation

IV. CABLE DATA SERVICES

A. High Speed Data Access

The cable industry's broadband platform makes cable the optimal medium for transmitting vast amounts of information -- data, graphics, and video -- at high speed. **Moreover, the evolution to two-way transmission capability for high speed data access facilitates the introduction of telephone services over HFC infrastructure.** Cable can currently carry data up to 1,000 times faster than transmission over ordinary copper twisted pair phone lines and 100 times faster than ISDN (integrated services digital network) phone lines.

Because of this superiority, cable is poised to become the preferred medium for gaining access to commercial on-line services, the Internet, the World Wide Web, and the multimedia portion of the Internet. Home and business PC users will soon be able to transmit data and graphics at a fraction of the time current providers transmit material. Already Continental has installed and is operating a broadband communications network for Boston College that allows 6,600 students to connect to video and high speed data services, including high speed Internet access, in their dormitory rooms. In addition, 150 classrooms and 250 administrative offices and a number of off-campus sites also are connected to the network. The Boston College system has been operational since last fall. Continental has just signed an agreement to install a similar system for another university and is in discussions with other institutions concerning the provision of similar services. **By the year 2004, cable high speed access revenues are expected to reach $3.2 billion annually.**[39] Currently, Continental and many other cable operators are in numerous cable modem trials.[40]

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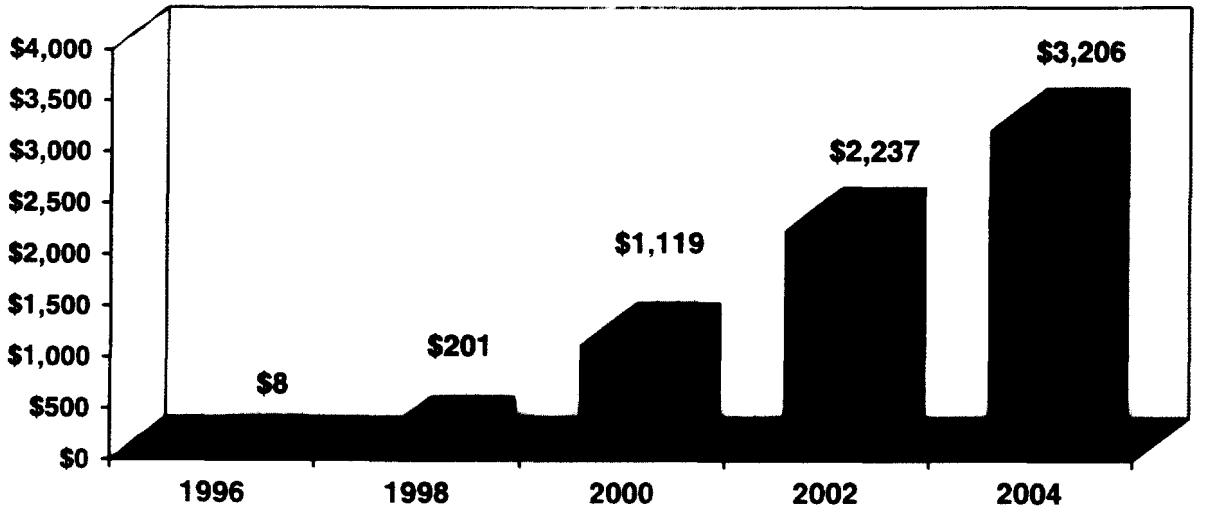
[39] Paul Kagan Associates Inc., *Cable Modem Projections*, Cable Modems: A Strategic Analysis, Nov. 1995, p. 79.
[40] See *Appendix C: Cable Television High Speed Data Access Offerings and Trials* for listing of cable industry involvement.

B. Technological Overview

The cable industry's two-way, high bandwidth HFC networks make ideal conduits for digital transmissions. As fiber upgrades are completed, the cable industry's networks will become more "passive" thus increasing the two-way practicality of data transmissions over cable lines. "Passive" architectures have fewer ingress-generating amplifiers that interfere with upstream return path capability. **In the near future, most network traffic (audio, video, telephony and data) will be digital. Therefore, the current investments in two-way digital capability will have long term benefits for cable operators and their customers.**

Cable High Speed Information Access Revenues 1996-2004
(in millions)



Source: Paul Kagan Associates Inc., *Appendix A:--Cable Modem Projections*, Cable Modems: A Strategic Analysis, Nov. 1995, p. 79.

Cable systems are generally "low-split" systems that utilize the 5 MHz to 40 MHz band for return path transmissions. This schematic is sometimes problematic because of the traffic in that area and its proximity to the first television channel at 54 Mhz. However, there are several solutions to return path interference. One such solution is being implemented in the Time Warner Full Service Network where the "high split" above 550 MHz is being utilized for return path transmissions. The 550 MHz to 1 GHz spectrum is cleaner (i.e., less traffic) but is more costly to achieve and maintain. Other techniques such as activating "dark fibers" and reducing nodal size can lessen traffic and interference and create more bandwidth for return path transmissions.

Cable modems and demand for high speed access will drive the activation of return paths in many systems. Cable modems generally fall into three categories: 1) modems for personal computers, 2) modems for LAN-to-LAN network bridges, and 3) modems for LAN-to-LAN routing.[41] The cable customer will access the Internet or On-line service using a cable modem, a standard Ethernet card, and 10baseT (thinnet) cable to the personal computer.[42] Modulators and servers are located at the cable systems headend, where the cable system interconnects with the Internet or outside information service provider.[43] Cable companies can operate as "pipeline" services or become full-service providers of Internet access and other value-added services.[44]

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[41] Mike Huffaker, *Cable modems can be an economical choice for Internet access*, Telephony, Nov. 27, 1995.
[42] Id. at 46.
[43] Id.
[44] Id. at 48.

Information access over cable lines provides customers with two primary benefits, speed and freedom. The higher bandwidth of fiber-coax lines provides faster data transmission speeds than traditional telephone lines and the cable connection does not interfere with normal telephone activity.[45]

High speed data access over HFC plant is economically attractive due to the existing investments in infrastructure. The incremental investments necessary to upgrade coaxial cable plant to HFC and telephony, coincidentally, provides a two-way broadband platform for high speed data transmission. The current economics of high speed data access are largely relative to the cost of the cable modem. Current prices range from $600 to $1,000; as these prices decline, **cable modem technology will be deployed incrementally over existing HFC two-way networks.**

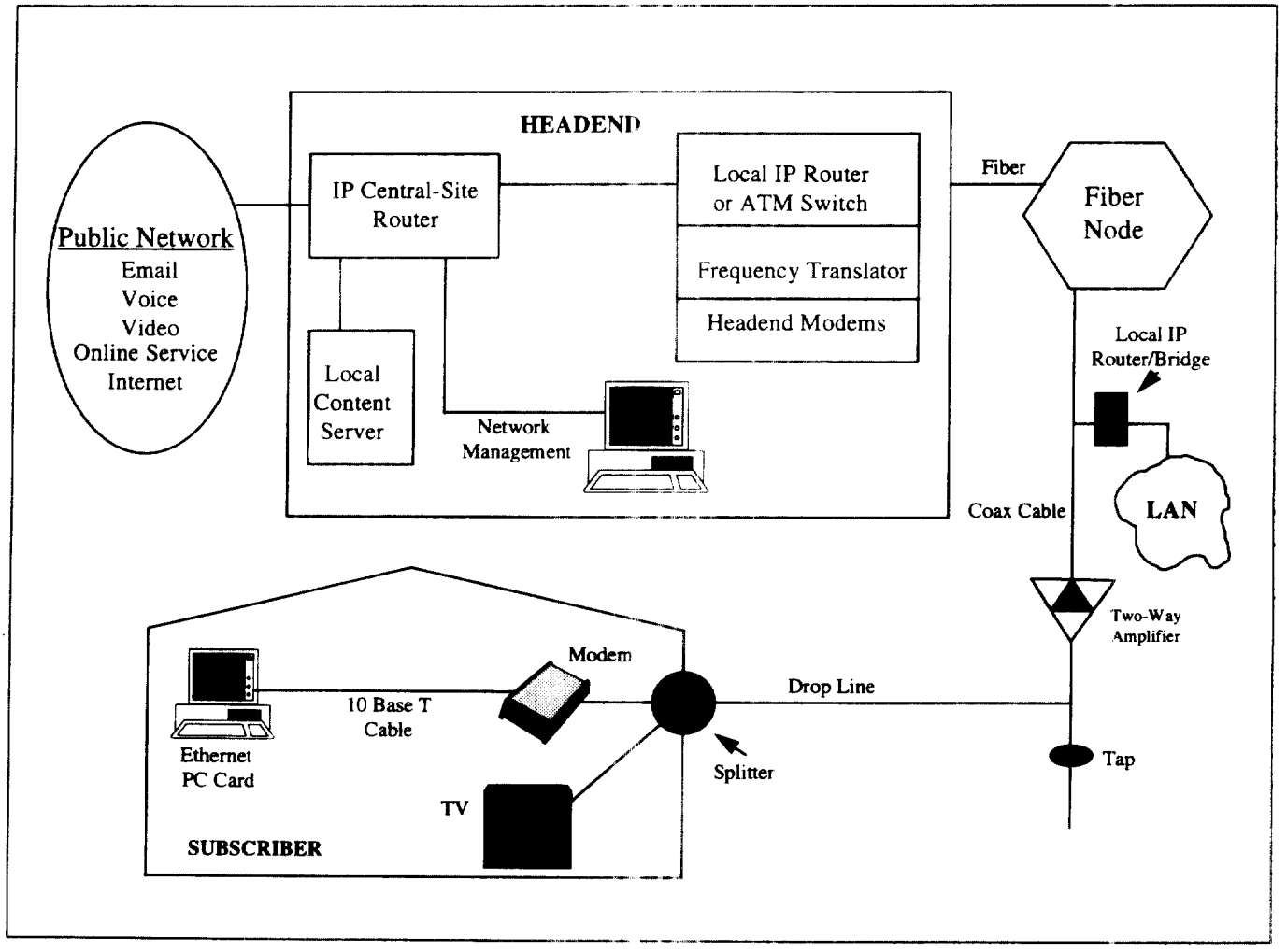
The HFC Strategy[46]

	Digital Video	Telephony	Internet Access
Revenue	$20-$25/mo.	$30-$70/mo.	$30-$35/mo.
Variable costs	$350-$450/sub.	$500-$600/sub.	$75-$125/sub
Fixed costs	$150-200/HP	----------$100-$150/HP----------	

[45] Id.

[46] Paul Kagan Associates Inc., *Cable TV Investor*, Feb. 29, 1996, p. 2.

Cable Modem/HFC Architecture



APPENDICES

A Cable Industry Involvement in Local Telephony

B Cable Industry Personal Communications Service Markets

C Cable Television High Speed Data Access Offerings and Trials

CABLE INDUSTRY INVOLVEMENT IN LOCAL TELEPHONY

Cable Company	Access Provider	Markets	Status
Adelphia Communications	Hyperion Telecommunications	Syracuse, NY	Access
		Binghamton, NY	Access
		Buffalo/ Rochester, NY	Access
		Burlington, VT	Access
		Jacksonville, FL	Access
		Stuart, FL	Access
		West Palm Beach, FL	Access
		Winchester, VA	Access
Cablevision Systems Corp.	Cablevision Lightpath, Inc.	Long Island, NY	Certified and Offering switched local exchange service
Comcast Corporation	Eastern TeleLogic (51%)	King of Prussia, PA	Access
	Florida Telecom. Services Inc. (100%)	Florida	Certified for local exchange service
	Teleport Communications Group (20%)	Baltimore, MD	Certified for local exchange service
		Bellingham, WA	Certified for local exchange service
		Bergen, NJ	Access
		Boston, MA	Certified for local exchange service
		Boulder, CO	Access
		Brockton, MA	Certified for local exchange service
		Chicago, IL	Certified for local exchange service
		Cleveland, OH	Access
		Dallas, TX	Certified for local exchange service
		Danbury PMSA	Certified for local exchange service
		Denver, CO	Access
		Detroit, MI	Certified for local exchange service
		Fort Lauderdale, FL	Certified for local exchange service
		Ft. Worth, TX	Certified for local exchange service
		Gary, IN	Access
		Hartford, CT	Certified for local exchange service
		Houston, TX	Certified for local exchange service
		Indianapolis, IN	Access
		Kenosha, WI	Certified for local exchange service
		Jersey City, NJ	Access
		Lawrence, MA	Certified for local exchange service

CABLE INDUSTRY INVOLVEMENT IN LOCAL TELEPHONY

Cable Company	Access Provider	Markets	Status
Comcast Corporation	Teleport Communications Group (20%)	Los Angeles, CA	Certified for local exchange service
		Miami, FL	Certified for local exchange service
		Middlesex, NJ	Access
		Milwaukee, WI	Certified for local exchange service
		Nassau, NY	Certified for local exchange service
		Newark, NJ	Access
		New Haven, CT	Certified for local exchange service
		New London, CT	Certified for local exchange service
		New York, NY	Certified for local exchange service
		Oakland, CA	Certified for local exchange service
		Omaha, NE	Access
		Orange, CA	Certified for local exchange service
		Phoenix, AR	Certification Pending
		Pittsburgh, PA	Certified for local exchange service
		Portland, OR	Planned
		Providence, RI	Access
		Racine, WI	Certified for local exchange service
		San Jose, CA	Certified for local exchange service
		St. Louis, MO	Access
		Salt Lake City, UT	Planned
		San Diego, CA	Certified for local exchange service
		San Francisco, CA	Certified for local exchange service
		Seattle, WA	Certified for local exchange service
		Tacoma, WA	Certified for local exchange service
		Trenton, NJ	Access
		Washington, DC	Planned
		W. Palm Beach, FL	Certified for local exchange service
	MH Lightnet	New Jersey	Access
Continental Cablevision	Teleport Communications Group (20%)	Same as other TCG	Same as other TCG
	CCI Telecommunications	10 California counties	Certified for local exchange and resale service
		Florida	Certified for local exchange
		Michigan	Planned
		New Hampshire	Pending
	TeleFiber Networks of Illinois (100%)	Illinois	Certified non-switched voice

CABLE INDUSTRY INVOLVEMENT IN LOCAL TELEPHONY

Cable Company	Access Provider	Markets	Status
Cox Enterprises	Teleport Communications Group (31.1%)	Same as above	Same as other TCG
	Cox Fibernet	Norfolk, VA	Access
		New Orleans, LA	Pending
		Oklahoma City, OK	Access
Harron Cablevision	Harron Communications	Utica, NY	Access
Jones Telecommunications	Jones Lightwave	Atlanta, GA	Access
		Chicago, IL	Access
		Tampa, FL	Certified
		St. Petersburg, FL	Certified
		Broward Co., FL	Certified
		Alexandria, VA	Pending
Tele-Communications Inc.	Teleport Communications Group (29.1%)	Same as other TCG	Same as other TCG
	TCI Chicago/Motorola/Teleport	Arlington Heights, Il	Trial
	TCI Conecticut/Nortel/Teleport	West Hartford	Trial
Time Warner Cable	Greater Rochester Cablevision	Rochester, NY	Certified & offering local exchange service
	Time Warner AxS of Austin	Austin, TX	Access
	Carolina AxS/Vision Cable	Charlotte, NC	Pending
	AxS of Cincinnati	Cincinnati, OH	Certified to provide local exchange service in Ohio
	MetroComm Axs	Columbus, OH	Pending applications in 37 Ohio counties
	Indiana Digital Access	Indianapolis, IN	Access
	AxS of Florida	Maitland, FL	Certified for local exchange service
	TW / Memphis Fibernet	Memphis, TN	Certified for local exchange service
	TW / Oceanic Communications	Mililani, HI	Pending
	Kansas City FiberNet	Kansas City, MO	Access
	Time Warner Telecommunications	California	Certified for local exchange service
	Time Warner Raleigh / Durham	Raleigh, NC	Access
	FIBRCOM	San Antonio, TX	Access

CABLE INDUSTRY PERSONAL COMMUNICATIONS SERVICE MARKETS[1]

Cable Company	Location	Population[2]	License
Sprint Spectrum L.P.	New York	26,410,597	M001-B
Cox Cable Communications	Los Angeles-San Diego	19,145,232	M002-A
Sprint Spectrum L.P.	San Francisco-Oakland	11,891,177	M004-A
Sprint Spectrum L.P.	Detroit	10,001,009	M005-B
Sprint Spectrum L.P.	Dallas-Ft. Worth	9,694,157	M007-B
Sprint Spectrum L.P.	Boston-Providence	9,452,712	M008-B
Sprint Spectrum L.P.	Philadelphia	8,927,748	M009-B
American Personal Comm.[3]	Washington D.C.-Baltimore	7,777,875	M010-A
Sprint Spectrum L.P.	Minneapolis-St. Paul	5,986,039	M012-A
Sprint Spectrum L.P.	Miami-Ft. Lauderdale	5,136,581	M015-A
Sprint Spectrum L.P.	New Orleans-Baton Rouge	4,925,269	M016-A
Sprint Spectrum L.P.	St. Louis	4,663,926	M019-B
Sprint Spectrum L.P.	Milwaukee	4,541,432	M020-A
Sprint Spectrum L.P.	Pittsburgh	4,102,766	M021-A
Sprint Spectrum L.P.	Denver	3,880,637	M022-A
Sprint Spectrum L.P.	Seattle (excluding Alaska)	3,827,175	M024-B
Sprint Spectrum L.P.	Louisville-Lexington	3,556,648	M026-B
Sprint Spectrum L.P.	Phoenix	3,510,140	M027-B
Sprint Spectrum L.P.	Birmingham	3,244,076	M029-A
Sprint Spectrum L.P.	Portland	3,059,948	M030-B
Sprint Spectrum L.P.	Indianapolis	3,017,475	M031-A

[1] Based on Results of FCC Broadband PCS Auction No. 4, Blocks A and B.

[2] Population figures as of 4/1/90 U.S. Census, U.S. Department of Commerce, Bureau of the Census.

[3] APC, a Sprint Spectrum affiliate and Pioneer's Preference Licensee, is the first company to commercially offer PCS service.

CABLE INDUSTRY PERSONAL COMMUNICATIONS SERVICE MARKETS

Cable Company	Location	Population[4]	License
Sprint Spectrum L.P.	Des Moines-Quad Cities	3,006,139	M032-B
Sprint Spectrum L.P.	San Antonio	2,986,524	M033-A
Sprint Spectrum L.P.	Kansas City	2,913,304	M034-A
Sprint Spectrum L.P.	Buffalo-Rochester	2,777,046	M035-A
Sprint Spectrum L.P.	Salt Lake City	2,573,372	M036-B
Sprint Spectrum L.P.	Little Rock	2,274,933	M037-B
Sprint Spectrum L.P.	Oklahoma City	1,877,478	M041-B
Sprint Spectrum L.P.	Spokane-Billings	1,863,335	M042-B
Sprint Spectrum L.P.	Nashville	1,767,391	M043-A
Sprint Spectrum L.P.	Omaha	1,659,273	M045-B
Sprint Spectrum L.P.	Wichita	1,124,174	M046-B
Sprint Spectrum L.P.	Tulsa	1,096,396	M048-B
	Total Pops	**182,671,984**	

[4] Population figures as of 4/1/90 U.S. Census, U.S. Department of Commerce, Bureau of the Census.

CABLE TELEVISION HIGH SPEED DATA ACCESS OFFERINGS AND TRIALS

Company	Location	Services	Subcribers	Partners / Vendors
Adelphia Communications	Coudersport, PA	High Speed Data	50	LANcity Corp., DEC
	Charlottesville, VA	High Speed Data	100	Zenith, DEC
Cablevision Industries	Selma, NC	High Speed Data	8	LANcity Corp
Cablevision Systems Corp.	Boston, MA	Internet Access	n/a	LANcity Corp.
	Long Island, NY	On-line Services	90	Prodigy, AOL, Zenith
Comcast Corporation	Union, NJ	Work-at-home	200	AT&T
	Lower Merion, PA	High Speed Data	75	Intel, Hybrid Networks, AOL
	Tallahassee, FL	Distance Learning	10	LANcity
	Cherry Hill, NJ	Distance Learning	10	Zenith
	Willow Grove, PA	High Speed Data	n/a	General Instrument
Continental Cablevision	Greater Boston, MA	Internet Access	200	BBN Planet, LANcity Corp.
	Exeter, NH	Cablemedicine	12-15	Exeter Health Resources, Exeter Hospital
	Chestnut Hill, MA	High Speed Data	6,600	Boston College
Cox Cable Communications	San Diego, CA	On-line Services	160-180	Prodigy, Zenith, Cisco, H-P
	Warwick, RI	High Speed Data	n/a	LANcity Corp.
Jones Telecommunications	Alexandria, VA	Internet Access	7	LANcity, Jones Digital Dimension
	Palmdale, CA	Internet Access	2	LANcity, Zenith,H-P, MCI
	Chicago, IL	PC Interconnection	10	Spry, Cisco
	Jefferson Co., CO	Internet Access	2	Spry, Colorado Supernet, LANCity
	Augusta, GA	All of the above	10	ANS C+RE Systems
Media General	Fairfax City, VA	On-line Service	5	Prodigy, Sprint, MCI, Zenith, Motorola

CABLE TELEVISION HIGH SPEED DATA ACCESS OFFERINGS AND TRIALS

Company	Location	Services	Subcribers	Partners/Vendors
Rogers Cablesystems	Toronto, Ontario	On-line Service	n/a	CompuServe
	Newmarket, Ontario	CableLink	7	Zenith, Sun Microsystems
Scripps Howard Cable	Sacramento, CA	On-line Services	1,700	The Tube Cubed
Tele-Communications, Inc.	Sunnynvale, CA	Internet Access	100	@Home, Motorola, Kleiner Perkins Caufield
	Seattle, WA	On-line Service	25,000	@Home, Microsoft Network
Time Warner Cable	Elmira, NY	On-line Service	500	Excalibur, H-P, Motorola, AOL
	San Diego, CA	High Speed Data	n/a	Toshiba Corp.
Viacom	Castro Valley, CA	High Speed Data	250	Motorola, Prodigy, AOL

Source: *Broadband Trial Players and Their Equipment Suppliers*, On Demand, June/July 1994, at 12; *What's Real in '95*, On Demand, Feb. 1995 at 20; CableLabs, *CableNet Company Involvement in Current and Planned Cable Company Technology Trials*, Specs, Dec. 1994, at 4; *Dialing For Dollars*, Convergence, May 1995 at 18; Mike Langberg, *Sega's Launch*, S.J. Mercury News, July 29, 1994, Alan Breznick, *Thoroughly Modern*, Cable World, Nov. 27, 1995, at 48., NCTA, *Technology Survey 1995*, Paul Kagan, *Cable Modems: A Strategic Analysis*, Nov. 1995.