

Global Broadband Access Markets:

xDSL, Cable Modems and the Threat from
Broadband Satellite, Wireless and All-Optical
Solutions

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Executive Summary

E-1 Introduction

Like all other segments of the telecommunications market, access is going broadband. The global telecommunications network transforms from its traditional role as a provider of circuit-switched narrowband voice services to one that is primarily packet based, supporting a variety of data-oriented services. A new network architecture is emerging to address this transformation, and is currently being deployed by new carriers and watched closely by incumbents. This architecture is ideally more elegant than its predecessor, requiring fewer layers of management, protocol conversion, and multiplexing. At its core this architecture is primarily optical, leveraging the scalability and flexibility of dense wavelength division multiplexing (DWDM) while reducing the dependence on SONET for multiplexing and aggregation. At its edge this network employs ATM or IP-based multiservice concentrators, routers or switches, which integrate various services onto a single signal format for carriage over the network. At the customer premise, confusion still reigns. That is the subject of this report: understanding the technologies, market forces and potential surrounding the access market. Narrowband (those solutions under 128 Kbps) are of little interest in today's access market. Thus, this report will focus entirely on broadband solutions, those that exploit the tremendous processing power resident on most business and consumer desktops and the enormous bandwidth being deployed at the core of national and international networks.

The access market has received an enormous amount of attention over the past decade, yet over that period little has been accomplished in actually provisioning broadband access services outside of limited technical and commercial trials in North America, Japan and Europe. The reasons are many. Equipment costs have been prohibitive, proprietary, and useful to only a small number of business users willing to pay for first generation equipment. Early trials of residential broadband technology were met with a lukewarm response from most participants because of cost, complexity and lack of compelling content. And before the Internet, there had been no "killer application" in the consumer market.

1999, however, promises to be the year of broadband access reality. A true convergence of supply and demand is occurring in developed economies, propelling sales of broadband access equipment and forcing governments to react with pro-competitive regulatory schemes meant to encourage market diversity and technical innovation. The forces at work on the broadband access market can be grouped into four main categories:

- **End-User Demand.** This can be attributed largely to the Internet. Where interactive TV technologies and content were slow to take hold, the Internet has been adopted more quickly than any other technology in history. The traffic generated by consumer Internet users is increasing at a rate of 400% per year, with peak-hour traffic predicted to increase by 50% per year over the next five years. The number of Internet users worldwide has grown to nearly 140 million in mid-year 1998, with every region of the globe represented. As the Internet is

folded into everyday life (communications, commerce, news), the demand for higher-speed connectivity has created a widespread opportunity for service providers.

- **Evolving Technology.** The choices facing service providers is both liberating and confusing. Today, broadband access services can be delivered via xDSL lines, cable modem systems, broadband wireless access systems, direct-to-home (DTH) satellite systems, and fiber optic access systems. The choice for each service provider is determined by equipment cost, predicted revenue from service, imbedded infrastructure, and demographics, to name but a few important factors. Technology continues to improve and broaden, adding low-earth orbit satellites in the year 2000, nearly ten varieties of xDSL, varieties of broadband wireless systems, and low-cost optical network architectures.
- **Evolving Regulation.** This has been both an enabler and a hindrance to the evolution of the broadband access market. Where the trend of privatizations and deregulation of single-provider markets has created a framework for competition for access services in many major economies, the process of actually allowing new carriers into formerly closed markets has been arduous. The accords reached through the GATT and the WTO have laid the groundwork for lasting open competition in developed economies throughout the globe. For many countries this remains a phased-in process without immediate results. The long-term implications are quite positive, however. New entrants are emerging in all of the present deregulated markets throughout the globe, and unbundling requirements established by regulators are providing them a wider choice of service possibilities.
- **Evolution from Voice to Data.** As stated in the opening paragraphs of this report, telecommunications networks are transforming from circuit-switched to packet based in order to better support the rapidly expanding use of data services. This evolution is occurring more rapidly than ever anticipated. On many routes in the U.S., the mix of circuit and packet traffic is 50:50. On major intercity routes, such as Boston to New York City, data represents approximately two-thirds of all traffic, and is growing at a rate of 40% to 50% per year, compared to 8% per year for voice. The implications are important. It is widely agreed that by the year 2001, data will represent well over 75% of all telecommunications traffic in the U.S. The current circuit-switched based infrastructure, designed to carry voice, is simply inadequate to accommodate this growth. Incumbent carriers continue to expand their overlay data networks, while new competitive carriers deploy data-only or packet-based networks, giving them distinct advantages for future competition. All carriers, including those in underdeveloped markets that have yet to experience significant growth in data usage, will be forced to make critical decisions regarding their network infrastructure in the coming decade.

Exhibit E-1 Broadband Access Network Options

Broadband Access Solution	Backbone Network	Access Network	Medium	Customer Premise
XDSL (1-8 Mbps)	IP/ATM	Digital Loop Carriers, DSL Access Multiplexers, ATU-C	Twisted Copper Pairs, limit 12 or 18 Kft	ATU-R, Telephone, Personal Computer
FTTC/SDV (51 Mbps)	SONET/ATM	Optical Network Unit	Fiber/Coax drop	Telephone, Passive network termination, Television, Personal Computer
All-Optical Access (unlimited bandwidth)	"Transparent" DWDM	Metro DWDM network	Multiwavelength fiber	Wavelength selecting NT, Enterprise access device, PCs
CATV (30 Mbps)	IP/ATM	Cable Modem Terminal Server	Coaxial cable	Set-top box, IP telephone, TV, cable modem, PC
MMDS/LMDS (50 Mbps)	IP/ATM	LMDS Base Station	12-50 GHz Microwave frequencies	NT, TV, PC, Enterprise access device
Broadband Satellite (up to 1 Gbps)	IP/ATM	Earth Station or satellite itself	28-50 GHz frequencies	Receiver antenna, NT, PC, Enterprise access device

The opportunity in the access market over the next decade is an enormous one for both network equipment manufacturers and service providers. The rise of CLECs in the U.S. and new entrants in Europe and Asia will fuel this market's business segment, while ILECs, national carriers and cable TV operators will compete with CLECs and ISPs for consumer revenues. Whether a service provider decides to offer a complete range of voice, data and video services as many ILECs plan, or specialize in one low-cost broadband service, such as Ka-Band satellite operators, each will face significant competition and seek to fill niches.

When discussing broadband access services, it is important to make clear what the term "access" represents. Today, broadband services are more often than not long-haul or "trunking" services, meaning the broadband segment of the network is at its core, not its edge. A T-3 private line interconnecting two enterprise locations is not a broadband access service under this definition because it provides only high-bandwidth connectivity between two network sites, thereby constituting a trunk. This is clearly a realm of blurry boundaries, yet it is important to make clear that what this report quantifies are access services that provide a level of connectivity not available or not economical today. Thus residential broadband services are all broadband access because none truly exist today.

In the business market, broadband access is more difficult to define because a variety of solutions do exist today, though are limited by their technology and cost. In the business market broadband access is better defined by the technology employed than the service level itself. This report, therefore, quantifies the use of xDSL, cable modems, broadband satellites, LMDS and all-optical solutions for access services at rates above 1 Mbps.

E-2 Broadband Access Market Forces

The forces shaping the broadband access are many, and in 1999 are predicted to peak simultaneously in most major telecommunications services markets. These forces include:

- **The proliferation of low-cost, high-performance desktop computers in businesses and households.** The level of processing power currently outstrips the ability of most networks, creating pent-up demand for greater access capacity and network functionality.
- **The growth of the Internet.** The Internet has become responsible, to one degree or another, for every important telecommunications development since 1995. The Internet will continue to drive telecommunications innovations for the foreseeable future.
- **Competition.** Competition for telecommunications service revenues may in fact be the most important driver of broadband access solutions in the coming decade. As new carriers seek to differentiate themselves from incumbents, broadband access solutions are offered that provide low-cost, high-bandwidth alternatives to traditional access solutions.

Exhibit E-2 Global Internet User Forecasts, 1996-2003

	North America	Latin America/ Caribbean	Asia-Pacific	Europe	Africa	Total
1996	33.30	0.42	5.30	9.70	1.10	49.8
1997	48.90	1.47	9.81	17.00	1.27	78.4
1998	80.69	3.68	19.12	30.00	1.45	134.9
1999	111.35	4.90	33.46	42.00	1.75	193.4
2000	133.61	7.10	58.55	56.70	2.18	258.2
2001	149.65	10.30	87.83	76.55	2.84	327.2
2002	164.61	14.94	109.79	103.34	3.69	396.4
2003	181.07	21.66	137.24	129.17	4.79	473.9

The applications driving multimedia network deployment are many, though it is possible that the Internet will be the ubiquitous platform for most multimedia applications for the next decade. Because the Internet offers easy access to a standardized platform, multimedia has the potential to succeed more rapidly than in its previous proprietary, and

therefore costly, formats. It is important, therefore, for service operators to design, as well as possible, around the traffic patterns and technology of the Internet. This has delayed the optical access market to a certain degree because it forces operators, particularly telcos, to consider redesigning their access networks around a packet-based service rather than a switched circuit-based service. To a certain extent this favors CATV operators in the early race to deliver multimedia services, but telco adoption of xDSL and ATM technology could quickly put them in a position of operating an efficient, scalable network that easily accommodates the bursty nature of multimedia traffic.

E-3 Broadband Access Market Opportunities

Opportunities exist for all classes of carriers in the broadband access market. Each carrier class in a competitive environment will be seeking new ways to differentiate themselves from new entrants or incumbents, and today the clear choice is low-cost bandwidth and data-oriented architectures.

Incumbent Access Providers

Incumbent access providers, namely the ILECs in the US and national PTTs and PTOs throughout the world, broadband access technologies represent a significant opportunity in a highly competitive marketplace. In the US, ILECs are faced with competition in all their formerly regulated markets and must respond by; 1) either forging into new services such as long distance and wireless or 2) preserving their relationship with existing customers by offering a wider range of access services at competitive rates. Incumbent operators are often slow to act because their regulatory obligations and enormous embedded base of equipment. This embedded base is often a hodge-podge of analog, digital, asynchronous and synchronous co-existing under a massive network management and operations support system that is costly and cumbersome to upgrade.

For these reasons, ILECs must choose their broadband access solutions very carefully, being sure to leverage customer loyalty and a perception of excellent reliability. It is likely, therefore, that ILECs in the long term will embrace options that both integrate well with existing systems while maintaining levels of reliability similar to their Class 5 switches and management systems. Among the choices presented today (xDSL, cable modem, broadband wireless or satellite, or all-optical) the answer from ILECs has been uniformly in favor of xDSL, with a long-term emphasis on migrating towards all-optical solutions. XDSL solutions leverage their existing imbedded copper base, while all-optical solutions leverage their deployed fiber cabling while providing the necessary flexibility and scalability to react to dynamically evolving data services.

Competitive Local Exchange Carriers and Integrated Communications Providers

CLECs are clearly the carrier group to watch in the broadband access market. Though presently do not have the customer base to drive a substantial access market over the long term, the prospects of full service competition in North America, Europe and most of Asia is setting the stage for a dramatic increase in the number of CLECs and integrated communications providers (ICPs).

Key findings of Pioneer's research into CLECs as broadband access providers include the following:

- CLECs are evolving from pure-play local exchange service providers into ICPs, which use their fiber-based or broadband wireless-based networks to provide any number of telecommunications services over a multiservice access architecture. This creates a competitive advantage for those ICPs that derive increased leverage from network assets and sales personnel.
- Capital expenditures are shifting emphasis from fiber optic infrastructure deployment to access equipment, evidenced by increases in access lines, Internet and data customers, and the emergence of Data CLECs wholesaling DSL services on unbundled copper loops.
- As local exchange markets increase in competitiveness, CLECs are quickly taking market share away from incumbents, which are encumbered by regulations, legacy infrastructure, and entry into long distance and wireless services.
- CLECs are well positioned to take advantage of the "new network architecture," in which all telecommunications services are provided over a low-cost, packet-oriented network that employs ATM and IP. This architecture reduces the need for costly SONET and TDM-oriented network equipment, and is much more scalable, flexible and cost-effective in dealing with bursty data traffic.
- CLECs are moving from a build stage to a more marketing and sales driven stage, creating novel, differentiated services as opposed to simple discounted private line or bypass services. At the same time, CLECs are serving directly more customers through their own facilities than through the use of resale and unbundled elements.
- The resale business is becoming less attractive and viable in today's market. The CLEC business is becoming a network business, thus CLECs will be deploying broadband access solutions to better serve their business customers with enhanced solutions rather than discounted services.

Cable TV Operators

Cable TV operators have been examining the broadband data market for nearly a decade, but have been slow to adopt the necessary infrastructure for reasons of cost, lack of developed standards, and lack of available access equipment. By and large these obstacles have been overcome in 1998 and cable TV operators are making important strides in gaining the lead in the broadband access race in the U.S. and the world. At present, three key drivers exist in the broadband cable access market in developed economies. These include:

- MSOs have aggressively upgraded their networks to support two-way services using hybrid fiber-coax (HFC) architectures, though a great deal of work needs yet to be done.
- The emergence of data-over-cable standards, which have sparked the cable modem vendor market.
- A serious focus on enhancing customer marketing programs and customer service.

Cable operators, therefore, are at present in the best position to provide broadband consumer access solutions because of their consumer focus, broadband connection to the 160 million worldwide cable subscribers, and ability to act quickly in adopting new services. The success of co-branded service offerings such as @Home and RoadRunner also indicate the cable industry at present is operating under a more successful business model for consumer broadband access than its LEC competitors.

Cable MSO's have not been as successful in attracting business customers to their data networks, though the @Work service is presently serving over 2,000 subscribers in North America with high-speed Internet access and remote access services over a cable data infrastructure. The difficulty at present is a perceived lack of quality to support mission critical data services. In that light, cable MSOs will likely find their greatest success in small and medium-sized businesses seeking only to access the Internet at broadband rates, or provide low-cost telecommuting options to their employees.

The cable industry has long been considered technologically feeble, and willing to cut corners in order to keep profit margins high. This type of operation, or perception, will be unacceptable in the provision of cable data services, particularly once real competition exists from telcos and satellite operators. The work of CableLabs in North America has improved the industry's image, and the development of true cable data standards will also encourage the use of cable modems beyond the residential sector, though in limited numbers.

Wireless/PCS Operators

Wireless/PCS operators will be looking to broadband access solutions to complement their mobile offerings. Presently, these operators use broadband wireless technology for backhaul trunking applications to concentration or switching centers. As LMDS access equipment evolves wireless operators will be capable of providing broadband wireless local loop services as part of a bundled wireless package that may eventually include wireless cable services. Compared to the other operators, wireless operators may be the least likely to adopt broadband access technology in the near term, as most are focused on digitizing their networks and enhancing their services to remain competitive with other wireless voice providers. This strategic decision is explored in greater detail in Chapter 6 dealing with LMDS and broadband wireless services.

Broadband Wireless Operators

Broadband wireless operators today such as Teligent, WinStar and ART are providing point-to-point data and trunked voice services as CLECs in major metropolitan area markets. As LMDS technology and equipment becomes available to these operators in 1999 they will be capable of expanding their services to include point-to-multipoint offerings that are ideally suited for small and medium-sized businesses seeking low-cost remote access solutions.

Satellite System Operators

Satellite systems operators are presently faced with important choices concerning the future of their operations. These choices are brought on by the emergence of global competition in the satellite industry, the availability of spectrum in the Ka-Band suitable for broadband service delivery, and the dwindling revenues from traditional telephony and cable distribution services. Broadband services allow satellites to stay current with the evolving terrestrial network architectures and service platforms. In addition, satellites' inherent broadcast capabilities allow them to serve a useful role in the proliferation of the Internet as a provider of low-cost, wide coverage content distribution. In the same way satellites today distribute video programming content through the world at a low cost with high reliability, they will also serve burgeoning Internet demand by distributing Internet content from its current concentration in the U.S. to foreign markets. Today, the satellite industry generates only \$180 Million in revenues from Internet services providers utilizing their satellites. Most owners of satellite transponders today available for lease include PanAmSat, Intelsat, SES, AsiaSat, Loral, and Eutelsat. Carriers such as Teleglobe use these satellites to provide Internet connectivity to Australia and Asia at a low cost. Other satellite providers are providing high-bandwidth Internet access services directly to consumers and businesses using a telephone line return path, establishing an early presence in the satellite Internet access market.

Satellite system developers will invest over \$25 billion in establishing broadband satellite systems over the next decade, already planned systems are well underway and the

expected mergers and consolidations are occurring, most notably among Motorola and Teledesic.

The broadband satellite market will take shape, beginning in 2001, when the first wave of true Ka-Band satellites are launched. In the meantime, integrating satellite systems to offer services globally rather than regionally enables system operators to expand their services and increase their capacities for global services. A number of satellite providers have already begun to integrate their services on the ground or via intersatellite links. Applications development is also ongoing, with a current focus on such broadband applications as desktop-to-desktop videoconferencing, electronic messaging & facsimile, direct-to-home video, distance learning & corporate training, Internet access, telemedicine, electronic transaction processing, and satellite news gathering.

Internet Service Providers and Data CLECs

ISPs have recently been exerting significant pressure on carriers to provide them with low-cost broadband access solutions and remain frustrated with a slow response from ILECs and lack of offerings from competitive carriers. ISPs are generally relegated to offering high-speed access to the Internet backbone via traditional T1 or T3 private lines at a relatively high cost compared to projected pricing for ADSL and alternative broadband access services. ISPs are faced with choosing to develop their own broadband access networks at a high cost or buying high speed access from wholesalers, better known today as "Data CLECs." As the ISP industry consolidates further, capital will be available within these large organizations to directly fund access facilities deployment, rather than simply backbone construction and expansion. ISPs in many instances can evolve into integrated service providers, partnering with competitive access providers to reach endusers directly with a full suite of telecom solutions.

E-5 The Global Broadband Access Market, 1998-2007

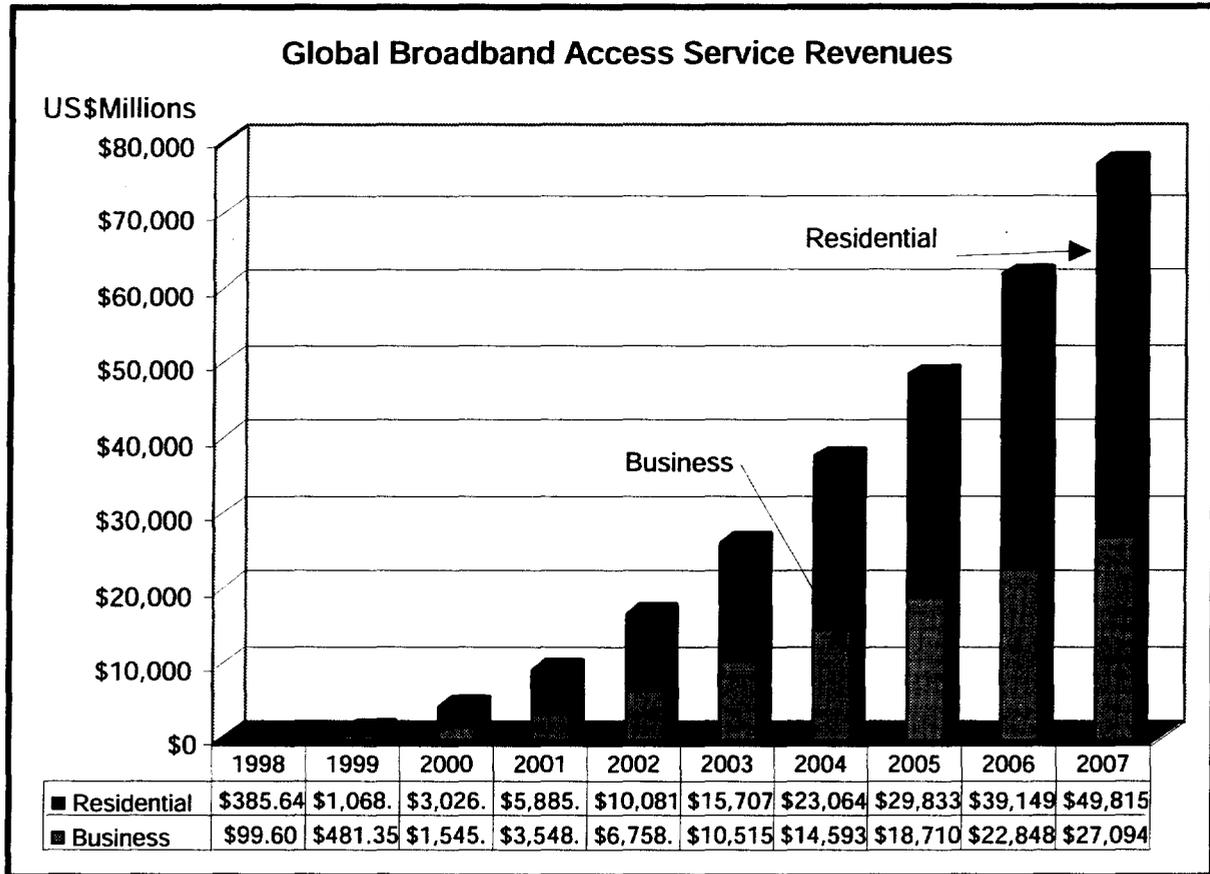
The global broadband access market is on the verge of a major expansion. In total, Pioneer Consulting forecasts reveal an important emerging market to be addressed by a variety of technologies, each occupying its own niche. No one technology is a clear leader, though broadband satellites fared quite well versus the competing technologies because of Pioneer's belief that satellites match the goals of the Internet and a global information infrastructure, which is driving this market.

Because they provide service on a global or continental basis, satellites are well-positioned to address the access market with unique advantages. These advantages have been discussed in earlier chapters, but essentially satellites have the ability to create uniformity tomorrow where heterogeneity rules today. The success of DTH satellite services has paved the way for broadband satellites. Satellite constellation will effectively create an Internet in the Sky, as Teledesic has named it, that will improve on the current terrestrial Internet and provide a global broadband backbone.

The total broadband access market is presently quite small, as we have limited it here to those users of novel access technologies and architectures. This has excluded those users of traditional private lines and broadband WAN services. Those users are in fact experiencing a broadband access service in many instances, but this report means to quantify the market for emerging technologies. In 1998, the total subscriber base of broadband access systems is estimated at 750,000 subscribers. This is quite a small figure to start from, but 1999 appears to be the year in which at least xDSL and cable modems truly see widespread deployment in major competitive markets. In the years between 1998 and 2002 those two technologies will battle for market share, with cable modems taking an early lead. But our forecasts indicate each will face significant competition from broadband satellites after 2002, when global LEO constellations are in orbit and current DTH providers have launched their own Ka-Band satellites for a mix of narrowcast digital video services and broadband access services. Cable modems will lead the market in terms of total subscribers throughout the forecast period, but satellites are predicted to gain a larger revenue stream because of their ability to address residential and business customers equally well.

By the year 2007, the end of the forecast period, total global broadband access subscribers will reach 136.05 million, representing an access service market of \$76 billion. As has been evidenced by the ISP market today, access revenues will comprise only a small portion of total service provider revenues, thus the entire broadband access services market will likely exceed \$500 billion in 2007.

Exhibit E-3 Global Broadband Access Service Revenues



North America will lead the globe in terms of subscribers and revenues over the forecast period. North America remains the region of the globe with the most intense and uniform competition. Coupled with the high concentration of Internet content and information workers relying on that content, North America is well-positioned to lead the global broadband access market for the foreseeable future. Subscribers of broadband access services will rise from 470,000 in 1998 to over 48.33 million in 2007. Broadband satellites are forecast to emerge as a leader in this region by the end of the forecast period, though in the near term cable modem and xDSL solutions will be fight closely for market leadership. Cable modems win the race in the next five years because of their ability to address the residential market effectively, but Pioneer believes broadband satellites will prosper over the long term because of their ability to address the demands of broadband users uniformly throughout North America over a common infrastructure.

Global broadband access equipment markets are poised for tremendous growth. The market for broadband access equipment is forecast to increase from \$669 million to over \$8 billion in 2007, after reaching a peak of \$9 billion in 2006. Price erosion and a gradual decrease in new subscribers accounts for the slightly diminishing market after 2006, though rehab, upgrade and replacement CPE may keep the market steadily

increasing beyond 2006. The equipment included in these forecasts is primarily access devices, termination equipment in central offices or remote terminals, and network infrastructure devoted to the provision of broadband access services. For broadband satellite services, only user terminals were included, as the cost of satellites and ground station equipment skews the forecast and is inconsistent with comparable forecasts.

Revenues from broadband access services will exhibit significant growth over the forecast period, creating a \$76 billion global market in the year 2007. Over the forecast period broadband satellites will emerge as the leader in service revenues (\$30 billion in 2007) by their ability to cover the widest possible audience, offer a mix of basic and multimedia telecommunications services over the same infrastructure in all global markets, and support consumer and business applications over a common technological platform that extends beyond the localized service territories of its competitors. In the forecasts presented below, broadband access service revenues include only broadband services. Carriers can expect to generate significant additional revenues from the provision of basic telecommunications services, e-commerce and transactional services, and other interactive content and applications.

Exhibit E-4 Global Broadband Access Subscriber Summary, 1998-2007

