Telecommunications Services

Industry Report

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- ADSL is an opportunity for the large LECs in our universe; AIT, BEL, BLS, GTE, SBC, and USW.
- We expect ADSL to be an integral piece of the large LECs' data services strategies.

Research

August 27, 1998

ADSL Has The Potential To Solve The Bandwidth Bottleneck And Add To Large LEC Net Income Growth

Highlights

- We estimate that asymmetric digital subscriber line (ADSL) will increase the aggregate large local exchange carrier (LEC) net income growth rate by 50 basis points in 2000, 90 basis points in 2001, and 120 basis points in 2002 after initially reducing the aggregate net income growth rate by 70 basis points in 1999. On a dollar basis, we expect ADSL to be dilutive to aggregate large LEC net income by about $120 million in 1999 and $40 million in 2000 before becoming accretive by about $170 million in 2001 and $500 million in 2002.
- ADSL is a cost-effective solution to satisfy the tremendous pent-up demand for bandwidth in the residential and small to mid-sized business markets.
- We expect widespread deployment to begin in the second half of 1999.
- We estimate that the large LECs, the five regional Bell operating companies (RBOCs), and GTE (GTE—50, rated Hold) will have 8.7 million residential ADSL subscribers by the end of 2002.
- Our analysis focuses on the residential segment of the market. Successful deployment of ADSL in the small to medium business segments could represent upside to our analysis.

Investment Conclusion

We believe that there is significant pent-up demand in the residential and small to mid-sized business markets for high-bandwidth services. The bottleneck preventing the satisfaction of this demand has been the lack of bandwidth available to these market segments. ADSL is a technology that solves the bottleneck by increasing bandwidth dramatically, by as much as 100 times the bandwidth available today through dial-up modems. ADSL not only delivers high bandwidth but also does so in a cost-effective manner by utilizing the existing telco copper plant.

We believe that the large LECs will begin deploying ADSL aggressively in the second half of 1999 once near-term challenges, including the finalization of standards and the development of plug and play capability, have been met. We believe that competition from cable modems—especially in light of AT&T's pending acquisition of TCI—will spur on the large LECs to deploy ADSL as quickly as possible.

We believe that ADSL deployment will increase the aggregate large LEC net income growth rate by 50 basis points in 2000, 90 basis points in 2001, and 120 basis points in 2002 after

Table 1. Prudential Securities Wireline Telecommunications Services Universe

August-27-1998 — Earnings Data — P/E Ratios

Company	Recent Price	Rating	Earnings Per Share 1997A	1998E	1999E	Estimated EPS Growth 97A/96A	98E/97A	5-Yr.	P/E on 97EPS	98EPS	Ind. P/E (S&P 500) 97EPS	98EPS	Target Price	Upside/ Downside	Yield	Dividend
Long Distance (Industry Rating: Strong Buy)																
AT&T (T)	56 9/16	S. Buy/Subject	$2.24	$3.40	$4.05	24.6%	26.8%	46.9%	16.6	16.6	73%	63%	74	31%	2.3%	$1.32
MCI (MCIC)	40	S. Buy	1.11	1.90	1.70	-4.9%	69.5%	39.8%	57.3	57.3	200%	173%	67	33%	0.1%	0.05
Sprint (FON)	71 11/16	S. Buy	2.52	1.80	2.25	-16.8%	28.8%	25.3%	39.6	39.5	174%	143%	95	33%	1.4%	1.00
WorldCom (WCOM)	52 3/16	S. Buy/Sub	0.48	0.82	1.35	120.8%	112.8%	35.9%	56.7	35.8	247%	129%	70	34%	0.0%	0.00
Frontier (FRO)	35 3/16	Hold	0.97	1.87	1.20	10.3%	35.2%	7.6%	61.1	24.7	100%	115%	36	6%	2.7%	0.69
Weighted Average						36.0%	51.9%		37.5	23.8	164%	111%			1.8%	
Large Incumbent Local Exchange Carriers (ILECs) (Industry Rating: Hold)																
Ameritech (AIT)	47 3/16	S. Buy	2.14	2.33	2.63	9.8%	12.8%	9.7%	22.1	17.9	99%	94%	61	29%	2.9%	1.20
Bell Atlantic (BEL)	48	S. Buy	2.65	2.72	3.05	18.0%	12.1%	9.3%	18.0	14.1	89%	66%	57	33%	3.8%	1.84
BellSouth (BLS)	43 63/16	Hold	2.84	3.20	3.70	14.8%	13.5%	11.7%	20.2	17.0	68%	63%	73	11%	2.9%	1.44
GTE Corp. (GTE)	59	Hold	2.99	3.05	3.50	5.2%	14.6%	9.8%	18.4	14.3	78%	67%	64	29%	3.8%	1.88
SBC Communications (SBC)	49 5/16	S. Buy	1.75	2.10	2.45	18.5%	16.7%	12.5%	19.2	65.5	84%	77%	47	17%	2.3%	0.96
U S WEST (USW)	42	Hold	2.83	3.80	3.75	5.3%	8.3%	5.9%	17.3	66.8	76%	79%	55	6%	4.1%	2.14
Weighted Average						12.1%	13.6%		18.3	15.1	89%	74%			2.8%	
Competitive Local Exchange Carriers (CLECs)																
RCN Corporation (RCNC)	17 13/16	S. Buy	(3.71)	(3.34)	(4.25)	NM	NM	NM	NM	NM	NM	NM	35	96%	—	—
ICG Communications (ICGX)	20 3/8	S. Buy	(10.31)	(8.69)	(5.32)	NM	NM	NM	NM	NM	NM	NM	45	117%	—	—
Intermedia (ICIX)	20 1/8	S. Buy	(5.40)	(8.34)	(9.14)	NM	NM	NM	NM	NM	NM	NM	48	86%	—	—
S&P 500	1,094.19		44.65	47.26	50.72	5.4%	7.3%		22.9	21.4					1.5%	15.84

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Source: Company reports and Prudential Securities estimates.

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reducing the aggregate net income growth rate by 70 basis points in 1999. We don't expect ADSL to have a material effect on 1998 net income growth.

We Expect ADSL To Help Sustain Large LEC Earnings Momentum

The large LECs are facing accelerating competition on all fronts. In the wireless business the days of a stable duopoly consisting of the incumbent LEC and one competitor are gone. Most markets now have two cellular competitors and one or more personal communications services (PCS) competitors (the top 50 markets have at least one PCS provider). Large LEC core wireline operations are also increasingly under attack. Competitive local exchange carriers (CLECs) seeking to take advantage of the opportunity opened up by the Telecommunications Act of 1996 have collectively invested billions of dollars in facilities addressing the business market and, with AT&T's (T—56 9/16, rated Strong Buy) recently announced merger with TCI, it appears that many consumers will soon have a facilities-based alternative to the incumbent LEC.

In the face of this present and imminent competition, the large LECs have continued to record double-digit earnings growth. This performance has been driven by two primary factors: strong growth in the telecommunications industry, particularly in data services; and improving operating efficiencies at the core telco. Merger synergies have also boosted the earnings of select companies. Going forward, however, these factors will not be enough. The industry is on the verge of a new era of intensified competition, and the large LECs will need to take advantage of growth opportunities in new lines of business in order to sustain double-digit earnings growth. RBOC entry into the long-distance business is the largest near-term opportunity, of course, and we believe that this process will begin in 1999. We believe that the other major opportunity for the large LECs will be data services, which we expect to be the growth engine of the telecommunications industry for years to come. We expect ADSL to be a critical piece of the RBOCs' data services strategy.

Growth In Data Services Is Driving Demand For Bandwidth

Demand for high-bandwidth data services is growing rapidly across the telecommunications industry as the world becomes more and more "networked." Businesses and consumers are connecting to public networks—most notably the Internet—and private networks such as corporate intranets and extranets in order to gain access to applications that enable electronic commerce, telecommuting, telemedicine, remote learning, on-line gaming, videoconferencing, video-on-demand, and Internet "surfing." These networked applications have the potential to increase the efficiency of businesses radically and to enhance consumers' personal and professional lives.

The growth in the Internet has been explosive and is projected to continue. IDC estimates that the overall U.S. Internet services market will grow to $18.3 billion in 2000 from $3.3 billion in 1996. WorldCom (WCOM—52 3/16, rated Strong Buy/SBI), whose Internet efforts are focused on the business segment, has reported Internet revenue growth in excess of 70% in the last several quarters versus the year-ago period and has indicated that Internet bandwidth demand is doubling every three to four months. GTE's Internetworking unit (formerly BBN) also focuses on the business segment and is reporting comparable volume increases. We estimate that by 2001, 3.5 million, or 44%, of U.S. small business will be connected to the Internet versus 1.5 million, or 23%, in 1996. We expect the number of work-at-home professionals connected to the Internet to grow dramatically as well. We estimate that by 2001, 20 million, or 45%, of work-at-home professionals, including those that work at home part-time, will be connected to the Internet versus 5.1 million, or 17%, in 1996. In the consumer dial-up segment, rapid growth is exemplified by America Online's (AOL—110 1/16, rated Hold by Prudential Securities Senior Computer Services Analyst Paul Merenbloom) achievement of 12.6 million U.S. customers as of the end of June 1998, which represented internal growth of around 28%.

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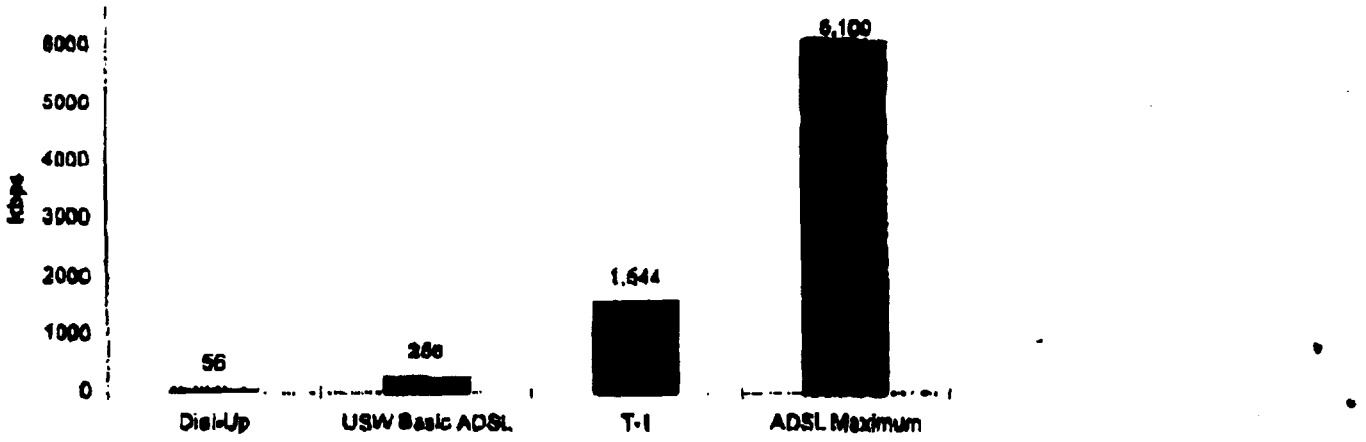
Exhibit 1. ADSL's Maximum Downstream Bandwidth Dwarfs That Of Today's Dial-Up Modems



Source: Company reports and Prudential Securities estimates.

The Local Loop Bottleneck Is Preventing Even Greater Growth

While the aforementioned growth statistics are impressive, we believe they would be significantly higher if it weren't for one main factor: the bandwidth bottleneck in the local loop. The services mentioned above are "broadband." That is, they require bandwidth well in excess of that provided by today's dial-up modems, whose maximum is 56 kilobits per second (kbps). For example, good quality videoconferencing requires symmetrical bandwidth of at least 384 kbps. Video-on-demand requires about 1 megabit per second (Mbps) downstream. Optimal Internet surfing requires up to 700 kbps of downstream bandwidth, since that is about as fast as the Internet will run due to general congestion.

The inter- and intra-city segments of the marketplace are aggressively accommodating—and indeed accelerating—the Internet/data services revolution. Established interexchange carriers (IXCs) carriers, such as Sprint (FON—71 11/16, rated Strong Buy), are increasing bandwidth capacities of their fiber optic networks exponentially through dense wave division multiplexing (DWDM). And new carriers such as Qwest (QWST—34 7/16, not rated) and Level 3 (LVLT—39, not rated) are building nationwide, state-of-the-art, high-capacity packet-switched networks. Within most major U.S. metropolitan areas there are now multiple fiber rings—we estimate Atlanta has more than ten—and carriers are likewise beginning to look to DWDM as a means of expanding bandwidth.

In the customer access portion of the network, the local loop, the situation is unfortunately quite different. While fiber and its scaleable bandwidth now spans the nation's inter- and intra-city networks, the local loop still consists primarily of copper, a material that to date has been ill-suited to broadband applications because of its inherent lack of bandwidth. The residential market is still nearly 100% copper, although LECs are deploying fiber-to-the-curb architecture in new builds (and one innovative CLEC, RCN [RCNC—17 13/16, rated Strong Buy] is driving fiber all the way into multiple dwelling units). In the business market, the largest customers are typically in buildings connected with fiber (or broadband wireless technologies at frequencies as high as 38 Gigahertz). Many more businesses are connected through T-1s (1.544 Mbps of bandwidth), but the average cost of a T-1 is $450 per month

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Table 2. The Large LECs Have All Announced Aggressive ADSL Deployment Plans

	First Commercial Deployment	1998 Lines Addressed (million)	1998 Markets	1998 Central Offices	1999 Lines Addressed (million)	1999 Markets
Ameritech	Jun-98	Stated goal: available to 70% of all customers within 2 and a half years.				
Bell Atlantic	Sep-98	2.0 by Year-End	n.a	68	7.0	n.a
BellSouth	Aug-98	1.7 by Year-End	7	80	4.9	30
GTE	Jun-98	6.0	35	350	n.a	n.a
SBC	Jul-98	5.1 by Sept	n.a.	87	n.a	n.a
USW	Oct-97	5.5 by July	n.a.	223	n.a	n.a

"n.a." indicates that an estimate is not currently available.
Source: Company releases and Prudential Securities estimates.

Table 3. RBOC Initial Basic ADSL Offerings Vary Considerably

	Speed Down/Up Kbps	Transport Price	Internet Access Price	Total Service Price	Install. Fee	Modem Cost
Ameritech	1,500/640	$35.00	$23.95	$59.95	$150.00	$125.00
Bell Atlantic*	640/90	$39.95	$20.00	$59.95	$99.00	$99.00
BellSouth**	1,500/640	$40.00	$19.95	$59.95	$99.95	$199.95
GTE***	256/256	$30.00	$21.00	$51.00	$60.00	$199.00
SBC	384/128	$59.00	$30.00	$89.00	$125.00	$199.00
USW	256/256	$40.00	$19.95	$59.95	$199.00	$109.00

* $99 modem price is for Bell Atlantic.net subscribers.
** Price is reduced by $10 if the customer subscribes to BellSouth's Complete Choice vertical services package.
*** Customer has the option of leasing the modem for $12 per month instead of purchasing the modem.

Source: Company reports and Prudential Securities estimates.

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ithin a wide range), a prohibitive sum for many small to d-sized businesses. In summary, today practically all nsumers and many small to mid-sized businesses do not ve affordable high-bandwidth connectivity, and this is venting the delivery of high-bandwidth services.

DSL To The Rescue!

)SL is one of a family of digital subscriber line hnologies (xDSL) that enable the transmission of higher dwidths over copper telephone lines. We will ncentrate on ADSL, since it is the technology being anced by the large LECs as a solution to the local loop dwidth bottleneck. ADSL is capable of delivering both ce and data over a pair of copper wires, with maximum upstream data speeds of up to 6.1 Mbps, or over 100 es faster than today's maximum dial-up modem speed of kbps (Exhibit 1). ADSL's maximum upstream speed is) kbps, which means that symmetrical speeds of up to) kbps are possible. ADSL, by making use of the sting telco copper plant, is an economical solution for telcos and a large portion of the associated capital enditures are variable (i.e., "success based"). An ADSL nection to the Internet is "always on" and eliminates the onvenience of dialing into an Internet service provider. o, the reliability of the voice service is not compromised e voice service will not fail in the event of ADSL ure. A more technical discussion of ADSL is included r in this report.

of the large LECs have announced aggressive ADSL out plans (Tables 2 and 3).

U S West (USW—52, rated Hold) has been the early leader. USW began commercial deployment of ADSL in Phoenix in October of last year and now has the service deployed in 223 central offices (COs) in 40 cities serving 5.5 million access lines.

BellSouth (BLS—65 13/16, rated Hold) has been operating an ADSL trial in Birmingham with about 200 customers and plans to roll out service to 80 COs in 7 markets by the end of 1998—New Orleans, Atlanta, Birmingham, Jacksonville, Raleigh, Charlotte, and Ft. Lauderdale—and to a total of 30 markets by the end of 1999.

- Bell Atlantic (BEL—43, rated Strong Buy) plans to begin offering ADSL service to the Washington, D.C.; Pittsburgh; and Philadelphia metropolitan areas in September of this year and to address the New York and Boston markets next year. The company estimates that it will deploy ADSL in COs serving 2 million lines by the end of this year and 7 million lines by the end of 1999.

- SBC's (SBC—40 5/16, rated Strong Buy) Pacific Bell subsidiary plans to deploy ADSL in 87 COs serving 4.4 million households and 650,000 business customers in 200 communities by the end of this summer, and commercial deployment in some areas is already under way. We expect that SBC's Southwestern Bell subsidiary will make ADSL deployment announcements in the near future.

- GTE plans to offer ADSL out of between 350 and 375 COs that serve over 6 million lines in over 30 markets by the end of this year. GTE plans to begin commercial service in some markets as early as this month (August).

- Ameritech (AIT—47 5/16, rated Strong Buy) currently offers ADSL in select parts of Chicago and Royal Oak, Michigan, and plans to deploy the service in COs serving 70% of its customers within two and a half years.

Competitive Threats Add Urgency

Certainly, the explosive demand for high-bandwidth services is motivation enough for the large LECs to deploy ADSL quickly. Another important motivating factor is the threat of competition. Other players are taking dead aim at the high-speed Internet access market. These competitors include cable companies, CLECs using both wireline and wireless technologies, and satellite companies. The most formidable competitors are the cable companies, who already have an estimated 250,000 high-speed Internet access subscribers in the U.S. In comparison, we believe the large LECs currently have less than 10,000 ADSL subscribers. Industry sources predict rapid growth for the cable companies (Forrester estimates that there will be 13.6

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Table 4. More Telco Customers Are 'Qualified' Than Cable Customers

1. Total U.S. Homes Served By Telcos	100 million
2. % That Are ADSL Qualified	56% or 55 million
3. Total U.S Homes Passed By Cable	95 million
4. Cable Customers	68 million
5. % Of Cable Customers Served By High-Speed Internet Access Ready Plant	15% to 20% (10 million to 14 million).

Source: Company reports and Prudential Securities estimates.

million North American high-speed cable modem subscribers by 2002).

AT&T Joins The Fray

AT&T's planned acquisition of TCI (TCOMA—37 3/16, not rated) intensifies the cable modem threat to the RBOCs since AT&T intends to accelerate TCI's timetable for upgrading its network to provide high-speed Internet access. TCI's prior network upgrade plans called for completion by the end of 2000, but AT&T hopes to complete the upgrade by as much as six months earlier. TCI and its affiliates account for about 30% of the homes in the U.S., but AT&T doesn't plan to stop there. AT&T plans to find a way to address the remaining 70% of homes on a facilities basis, and further deals or alliances with cable companies are a possibility. AT&T is targeting 30% penetration of TCI's customers with high-speed Internet access within 5 years, which would be over 3 million subscribers.

We believe that telco ADSL connections will keep pace with high-speed cable modem connections for several reasons.

- First, it will take the cable companies time to upgrade their plant to enable high-speed Internet access. In contrast, the majority of telco lines are already ADSL-qualified. As shown in Table 4, we estimate that the ratio of large LEC customers with ADSL-qualified loops to cable customers with Internet-access-ready cable plant is currently between 4 and 6 to 1. Arguably, the telcos could more rapidly deploy ADSL.
- Second, we believe the deployment costs of ADSL and cable modems will be comparable and that neither side will have a significant cost advantage. Our current estimates of infrastructure costs for the respective services are in Table 5. We estimate that the cable companies must spend $225 per home passed to prepare their network for three new services: advanced digital video services, wireline telephony, and high-speed data. Once that $225 of fixed investment has been made, incremental expenditures must be made to provide each of the three services. The cable companies do not attempt to allocate the $225 per home passed investment to the respective services, but in our analysis we assume that one third of the $225, or $75, is spent to enable high-speed data.

Table 5. We Estimate That High-Speed Data Infrastructure Costs Are Similar For The Cable Companies And Telcos

Cable (High-Speed Data Modem)		Telco (ADSL)	
Infrastructure cost per home passed to upgrade network	$225	Infrastructure cost*	$200
Infrastructure cost per subscriber	314	DSLAM	500
Infrastructure cost per subscriber allocated to high-speed data	105		
Assumed high-speed data penetration of subscribers	18%		
Data infrastructure cost per data subscriber	578		
Headend equipment cost per subscriber	50		
Total High-Speed Data Infrastructure Cost Per Subscriber	629	Total ADSL Infrastructure Cost Per Subs	700

* Assuming a 7.4% penetration, as discussed in our financial assumptions section.
Source: Prudential Securities estimates

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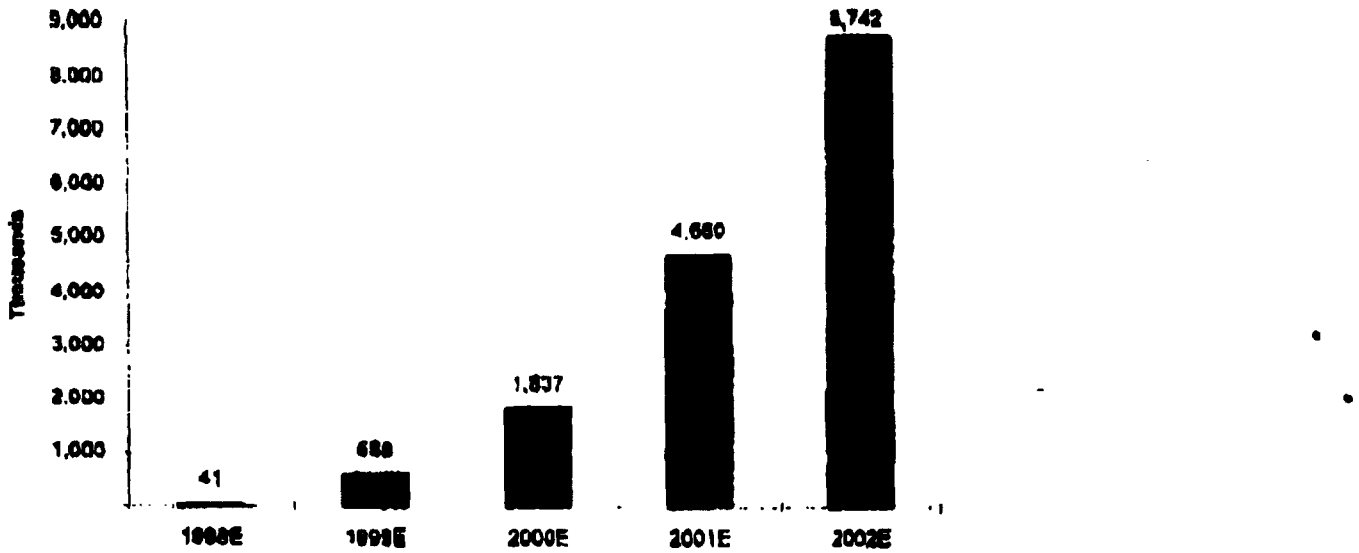
Exhibit 2. We Expect The Large LECs To Achieve 8.7 Million Residential ADSL Customers By 2002



Source: Company reports and Prudential Securities estimates.

- Using our assumed high-speed cable modem penetration of cable subscribers of about 18% (by 2002), we arrive at a fixed investment per data subscriber of $579. We add $50 of variable investment for equipment at the cable headend for a total of $629 of infrastructure investment.

- In comparison, we estimate that the telcos must spend about $500 per customer for equipment (DSLAM) in the central office. In addition, we estimate the telcos must spend $200 per customer for general infrastructure improvements such as interoffice trunking (increased bandwidth), facilities preparation, tools and testing equipment, and ATM switches. Thus, our estimated total infrastructure investment per subscriber for the telcos is $700.

- Both sides have more costs in addition to the above infrastructure costs. In both cases the customer needs a modem. Currently, ADSL modems cost about $220 and cable modems cost $325-$350. In both cases the service provider sends out a technician to provision the service, which costs an estimated $150 (1.5 hours at $100 per hour fully loaded cost). Both telcos and cable companies anticipate that the cost of the modems and hardware in general will drop over time, and both envision provisioning the service without dispatching a technician.

- Third, we believe the performance characteristics of ADSL and cable modems will be comparable. Cable companies boast of very high potential speeds (up to 10 Mbps), but the bandwidth is shared among subscribers and speeds may be much slower depending upon the number of subscribers using the service at one time. Telcos pitch ADSL as being superior since it offers dedicated, unshared bandwidth.

In areas in which both the telcos and cable companies compete, we expect market share to be close to evenly split. On the telco side, we expect small LECs and CLECs to

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Table 6. Our Forecast Leads To 8.7 Million Residential ADSL Lines By 2002

	1998E	1999E	2000E	2001E	2002E
Ameritech					
Total Residential Lines (000s)	13,231	13,628	14,037	14,458	14,892
ADSL Qualified Residential Lines	7,939	10,903	11,230	11,567	11,914
-- Percentage	60%	80%	80%	80%	80%
ADSL Customers	3	72	229	586	1,108
-- Penetration	0.0%	0.5%	1.6%	4.1%	7.4%
Bell Atlantic					
Total Residential Lines (000s)	26,050	26,831	27,636	28,465	29,319
ADSL Qualified Residential Lines	15,630	21,465	22,109	22,772	23,456
-- Percentage	60%	80%	80%	80%	80%
ADSL Customers	11	142	450	1,154	2,182
-- Penetration	0.0%	0.5%	1.6%	4.1%	7.4%
BellSouth					
Total Residential Lines (000s)	18,475	17,134	17,810	18,532	19,273
ADSL Qualified Residential Lines	6,590	13,707	14,255	14,825	15,418
-- Percentage	40%	80%	80%	80%	80%
ADSL Customers	7	90	290	751	1,434
-- Penetration	0.0%	0.5%	1.6%	4.1%	7.4%
GTE					
Total Residential Lines (000s)	13,535	14,009	14,499	15,007	15,532
ADSL Qualified Residential Lines	8,121	11,207	11,599	12,006	12,425
-- Percentage	60%	80%	80%	80%	80%
ADSL Customers	6	74	238	608	1,156
-- Penetration	0.0%	0.5%	1.6%	4.1%	7.4%
SBC					
Total Residential Lines (000s)	21,722	22,591	23,495	24,435	25,412
ADSL Qualified Residential Lines	13,033	18,073	18,795	19,548	20,330
-- Percentage	60%	80%	80%	80%	80%
ADSL Customers	9	119	382	991	1,891
-- Penetration	0.0%	0.5%	1.6%	4.1%	7.4%
USW					
Total Residential Lines (000s)	11,580	11,928	12,286	12,654	13,034
ADSL Qualified Residential Lines	4,632	9,542	9,828	10,123	10,427
-- Percentage	40%	80%	80%	80%	80%
ADSL Customers	5	80	250	570	970
-- Penetration	0.0%	0.8%	2.0%	4.5%	7.4%
Total					
Total Residential Lines (000s)	102,594	106,121	109,772	113,551	117,462
ADSL Qualified Residential Lines	55,945	84,897	87,816	90,841	93,970
-- Percentage	55%	80%	80%	80%	80%
ADSL Customers	41	585	1,837	4,680	8,742
-- Penetration	0.0%	0.6%	1.7%	4.1%	7.4%
Net Adds		546	1,249	2,823	4,061

Source: Prudential Securities estimates

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wide 30% of ADSL lines by 2002, which means that our al telco ADSL forecast in 2002 is 12.4 million lines, sisting of 8.7 million provided by the large LECs and provided by small LECs and CLECs (Exhibit 2, Table Our forecast focuses on the residential segment of the rket since we believe that the preponderance of ADSL es will be deployed there. However, we believe that DSL will also be a valuable service for small businesses some mid-sized businesses. Success in the business rket would provide upside to our forecasts.

hile the looming battle between the telcos and cable mpanies has grabbed headlines, we believe that the sence of scrappy "data CLECs" providing xDSL vices should not be ignored. These CLECs lease bundled loops from the RBOCs and install their own DSL equipment. Their early focus has been on the small mid-sized business market where they provide fractional l bandwidths or full T-1 bandwidth at a discount to the BOC. Northpoint Communications (privately held) offers all to mid-sized businesses symmetrical DSL services at eeds up to 1.04 Mbps. The company believes that it will able to address 40%-50% of the 7-10 million businesses its nationwide target market through 500-700 llocations by the end of 1999. It is likely that Northpoint ll also target high-end consumers as its reach expands. orthpoint began rolling out services in some cities in April 1998 and has more than 500 customers.

ecent FCC Proposals Would Serve To peed Deployment of ADSL Services

arlier this year the RBOCs filed Section 706 (of the elecom Act) petitions with the FCC, seeking, among other ings, relief for xDSL services from the Section 251 resale d unbundling requirements and the freedom to offer DSL services without tariff regulation, price cap gulation, and section 272 separate subsidiary quirements. The RBOCs argued that resale and ibundling requirements discourage them from investing in DSL services, to the detriment of the American public. n August 6, 1998, the FCC responded to the RBOC ction 706 petitions and also issued a notice of proposed lemaking (NPRM), which further addressed the issue of ta services deployment. As was widely expected, the CC did not immediately grant the RBOCs the relief they were seeking with their Section 706 requests. However, in its NPRM the FCC did provide the RBOCs with some options aimed at accelerating RBOC deployment of xDSL services.

Most notably, the FCC proposed that an RBOC could opt to form a separate advanced data affiliate that would not be subject to the same regulatory restrictions as the parent. The advanced data affiliate would be free from the mandatory unbundling and wholesale discounts that the Telecom Act imposes on the RBOCs. The RBOC would be required to treat its affiliate the same as it would any other competing carrier offering advanced data services.

Important to note, the FCC's NPRM seeks to establish expanded collocation and unbundled local loop access for CLECs, regardless of whether the RBOC chooses to provide advanced data services through a separate affiliate or not. For this reason, we believe that the FCC's eventual order, which may be complete as early as January or February of 1999 after an October 13, 1998, deadline for comments, will serve to accelerate xDSL deployment. We believe CLECs will be able to deploy the services faster as a result of better collocation and unbundled local loop access and that the RBOCs will respond by deploying their own services as quickly as possible. Even if the RBOCs choose not to operate through a separate affiliate and are therefore required to resell xDSL services, we believe that the preponderance of CLEC xDSL services will be facilities-based since: 1) a facilities-based approach reduces dependency upon the RBOC and allows the CLEC to control service quality; and 2) the resale discounts may not be sufficient to provide attractive financial returns, as has been the case with basic local services resale discounts.

We Don't Believe Satellite Companies Will Play A Major Roll In The Near Term

We don't anticipate that satellite companies will be a meaningful factor in the high-speed Internet access market in the near term. Satellite service offerings are currently limited by several factors.

- First, downstream bandwidth is relatively slow at 192 kbps.

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- Second, upstream bandwidth is via a telephone line at 28.8 kbps.
- Third, the up-front installation charge is much higher than those of the RBOCs or cable companies.
- Fourth, the installation of the dish is not always routine since there must be an unimpeded line of sight with the satellite. This is particularly a problem in urban areas.

In the longer term the satellite companies may become a larger factor in the high-speed Internet access market. For example, Teledesic, a joint venture including Craig McCaw, Boeing, and Motorola, plans to have 288 low-earth-orbit satellites launched by 2002. Once deployed, Teledesic's high speed Internet access offerings could potentially be very competitive with ADSL and cable modems. In the near term, the satellite companies may be a factor in very rural areas in which no alternative high-speed offering exists.

Computer Industry Giants Provide Added Impetus

With pent-up demand waiting to be served and competitors beginning to make inroads, the telcos have plenty of motivation to make ADSL work on their own. But they are also getting help from computer industry giants such as Microsoft, Intel, Compaq and Cisco in making widespread, affordable ADSL a reality. For obvious reasons, these players have a vested interest in bringing broadband services to the consumer. They stand to benefit from supplying the applications and the hardware that consumers and service providers will demand.

Tackling Standards And 'Plug And Play'

These companies are joining forces to tackle two major issues: 1) setting standards for ADSL; and 2) simplifying ADSL into a plug and play experience.

First of all, standards must be set for ADSL. We estimate that there are presently more than 60 DSL manufacturers. Without standards, competing manufacturers' equipment will not necessarily be interoperable and service providers will be hesitant to roll out ADSL on a wide scale since they won't want to risk getting locked into one supplier. Once standards are set and equipment is interoperable, the RBOCs will be able to count on competition among equipment suppliers regardless of the stage of deployment.

The organization with the authority to set DSL standards is the International Telephony Union (ITU). There is no deadline for the ITU to set a standard, but we believe that a standard will likely be set by the first half of 1999. A standards forum called the Universal ADSL Working Group (UAWG) has been formed and intends to submit its recommendation to the ITU in October of this year. The major telecommunications service providers, equipment manufacturers, PC manufacturers, and software manufacturers are all part of the UAWG. Assuming that the ITU takes a few months to evaluate the UAWG's recommendation and issue its decision, a final standard could be established in the first half of 1999.

The UAWG is also working on simplifying ADSL into a plug and play experience. Installing presently deployed ADSL technologies (Exhibit 3) at the customer's premises usually requires the following steps: 1) a "splitter", which separates data traffic from voice traffic on the ADSL line, is installed by the RBOC; 2) an ADSL modem is plugged into the phone jack on one side and to the PC on the other side; 3) an ethernet card is installed in the PC to provide a high-speed connection to the ADSL modem; 4) the PC is configured to enable the ethernet card to work. In our opinion, this process is too complicated for the mass market. (Let's face it, many of us are still trying to figure out how to program our VCRs.) This process may also be too expensive for mass deployment by the RBOCs since it requires a visit by a technician to the customer premises (a "truck roll").

The UAWG is developing a simplified version of ADSL—often referred to as "ADSL.lite"—based on an open and interoperable standard. In order to achieve this greater simplicity, some performance will have to be sacrificed. ADSL.lite will most likely provide maximum downstream speeds of 1.5 Mbps under ideal conditions versus the 6.1 Mbps provided by full-strength ADSL. ADSL.lite will be plug and play due to three innovations: 1) it will be "splitterless" (Exhibit 4); 2) the ADSL modem will be built into the consumer's PC; and 3) ADSL-enabling software

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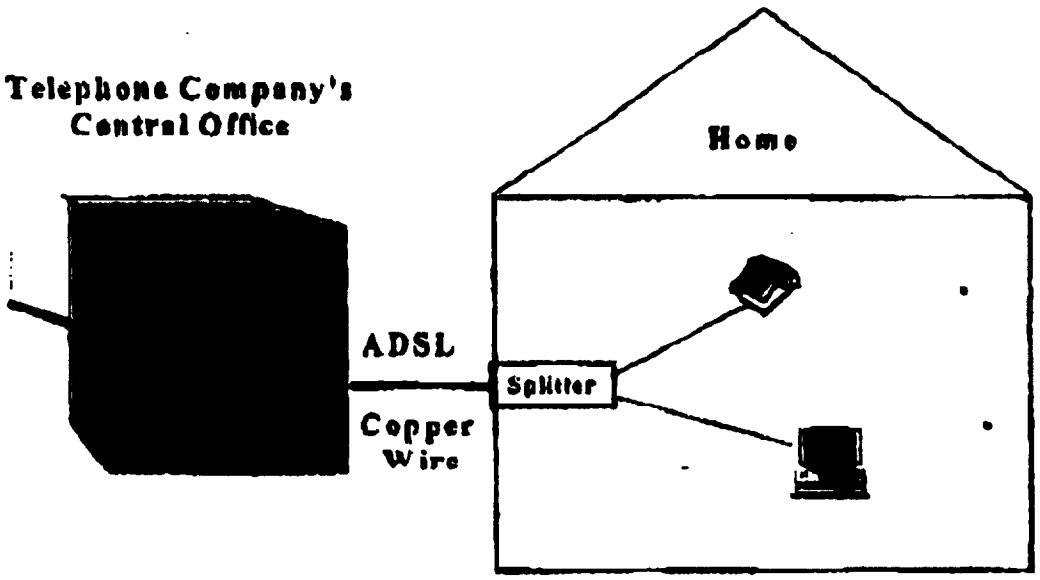
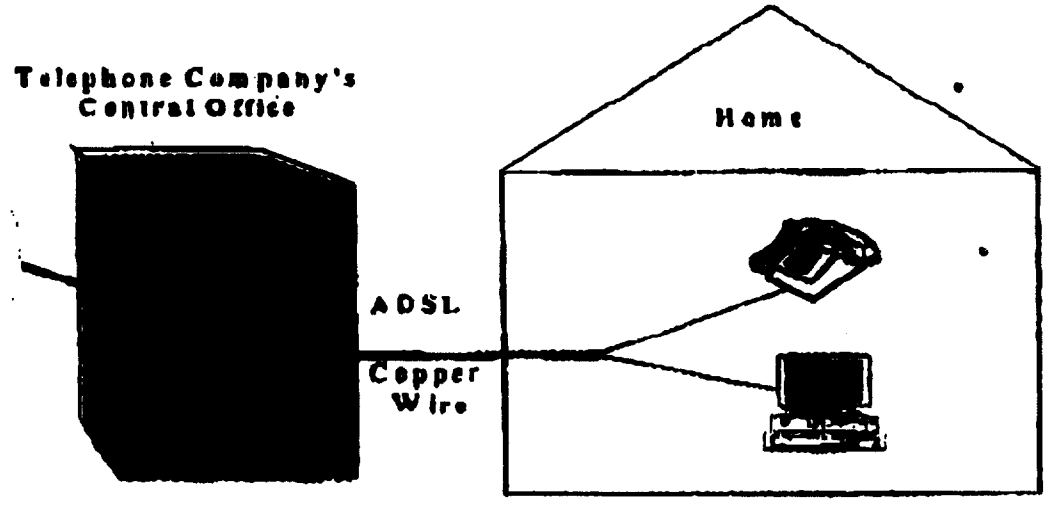
Exhibit 3. Current ADSL Configuration With Splitter Installation



*Truck Roll Required To Install Splitter

Source: Company reports and Prudential Securities estimates.

Exhibit 4. Splitterless Configuration



*No Truck Roll Required. Filter Enables Plug and Play.

Source: Company reports and Prudential Securities estimates

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will be included as part of Microsoft's operating system. To install DSL service in these new PCs, the consumer will merely call the RBOC, plug their phone wire (through a filter) into the PC, and click on a DSL icon. This process will be similar to installing an analog modem today. This scenario will be not only customer-friendly but also much cheaper for RBOCs since no truck roll will be required.

We believe plug and play will be ready to accommodate increasing ADSL deployment in the second half of 1999. Compaq plans to ship its first ADSL-enabled PCs in the third quarter of 1998. While there has been talk of aggressive marketing of plug and play ADSL in the Christmas 1998 season, we don't believe that this is a realistic target. Before they roll out ADSL in a major way, the RBOCs will have to have gained a high degree of confidence in a cost-effective provisioning process (i.e., no truck roll), and we believe it will take them until mid-1999 to accomplish that. For example, even though U S West is installing splitterless ADSL today in most cases, the company always sends out a technician. The RBOCs want to make sure that the customer is satisfied the first time around.

Hardware Costs Appear To Be Cheap Enough...

One of the main inputs into a viable ADSL business model is hardware costs. One of the main hardware costs to the RBOC is the digital subscriber line access multiplexer (DSLAM), the device that resides in the CO. Our visit to this year's SuperComm conference confirmed that there is a dizzying array of ADSL suppliers, each with their own respective twist on the technology. Despite their differences, however, they are currently capable of supplying the large LECs with affordable hardware. For example, Alcatel, the ADSL supplier to the purchasing consortium of Ameritech, BellSouth, and SBC, indicated that those RBOCs had demanded that the cost per subscriber of the hardware must be less than $500 (this excludes the cost of the ADSL modem at the customer premises). We estimate that USW may be able to reduce that cost to $350-$400 per subscriber by the end of this year through the implementation of an innovative modem sharing architecture provided by Cisco Systems. Right now, we estimate that a Cisco DSLAM costs $60,000 to $70,000 and it has 64 ports. Thus, the cost would be about $1000 per port. USW is planning on a modem sharing ratio of about 3.75 to one which would reduce the cost per customer to $350 to $400. The cost per customer does not work out to $1000 divided by 3.75 because of the additional cost of modem sharing equipment. In our single-customer financial analysis we use a hardware cost per customer of $500, which we believe will migrate down over time.

...But The Large LECs Face Additional Near-Term Challenges

In addition to making sure that equipment costs, standards, and plug and play all come into alignment over the next 6-12 months, the RBOCs must iron out other implementation issues. The large LECs must put in place processes to handle wide-scale demand. They must train their field people and their salesforce in ADSL, which is a relatively complex product. They must also be able to diagnose and handle quickly any service problems. The large LECs must also be able to determine quickly whether a customer's loop is qualified for ADSL. The loop must be 18 kilofeet or less and must be free of load coils and bridged taps. Load coils normally aren't a problem since they aren't typically deployed closer than 18 kilofeet. If a line isn't "clean" then ADSL may not run properly. It is not a trivial matter for the large LECs to quickly diagnose the condition of their lines because they haven't had to monitor their lines this closely before. Voice services are much more tolerant of imperfect lines than ADSL services.

We Expect 8.7 Million Large LEC ADSL Subscribers By 2002

Our expectation is that ADSL deployment will begin to accelerate substantially in the second half of 1999 once standards have been set and plug and play is a reality. RBOC deployment announcements to date are more measured than they may seem. For example, USW may have installed ADSL equipment in 223 COs, but the initial DSLAMs installed have the capacity to deliver ADSL to a fraction—about 55,000—of the 5.5 million lines served by the COs. The same can be said for the other RBOCs. Of course, since ADSL capital is success-based to a great extent, capacity can be increased quickly by adding line cards in reasonably small increments.

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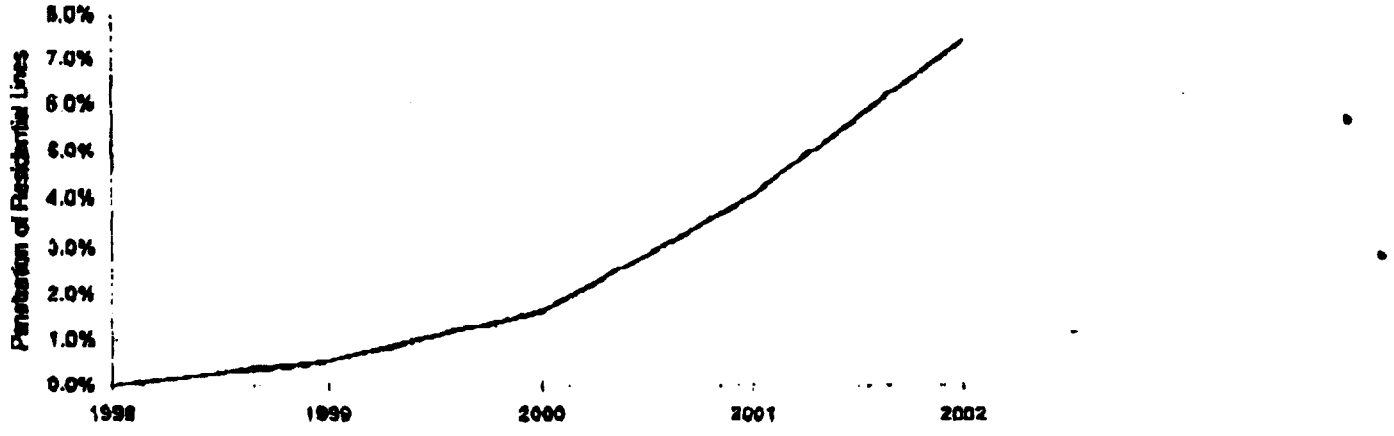
Exhibit 5. We Expect 7.4% ADSL Penetration Of Large LEC Residential Lines by 2002



Source: Company reports and Prudential Securities estimates.

Our company-specific analysis shows large LEC ADSL penetration starting out gradually from essentially 0% in 1998, rising to 0.6% by year-end 1999, 1.7% by year-end 2000, 4.1% by year-end 2001, and 7.4% by year-end 2002. We believe that a 7.4% penetration (Exhibit 5) by 2002 is reasonable given that the RBOCs today are experiencing much higher penetration levels of additional access lines (SBC's penetration is above 20%), many of which are used for Internet access. While some cannibalization of second lines by ADSL may occur, we don't believe the net income impact of ADSL will be reduced by such cannibalization since it may be the case that second lines used for Internet access are not as profitable as primary lines (see assumptions in Appendix 1). USW is the only RBOC which has publicly stated an ADSL subscriber target, which is "a couple of hundred thousand within a couple of years." We forecast USW to garner 250,000 ADSL subscribers by the end of 2000.

The following "top-down" analysis based on an aggregate U.S. view fits nicely with our company-specific analysis, we believe. The key assumptions are: the percentage of on-line households will rise from about 25% today to 45% in 2002; the percentage of on-line households with high-speed connections will rise from 2% today to 50% in 2002; one half of high-speed connections in 2002 will be ADSL connections; the large LECs will provide 70% of ADSL connections in 2002, with CLECs and smaller LECs

Table 7 We Expect High-Speed Data Connections To Grow Dramatically By 2002
(Millions of Households)

	1998	2002
Total U.S. Households	101	106
On-Line Households	26	47
-- percentage	25%	45%
Percentage of On-Line Households		
With High-Speed Connections	2%	50%
Number Of High-Speed Connections	0.5	24
Cable High-Speed Connections	Nearly All	12
Telco High-Speed Connections	Under 0.1	12
% of Telco High-Speed Connections		
Supplied By Large LECs	Nearly All	70%
Large LEC High-Speed Connections	Under 0.1	About 8.5

Source: Company reports and Prudential Securities estimates.

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Table 8. We Estimate That Current ADSL Architecture Delivers A 16% IRR Over 5 Years

Income Statement Per One Customer ($)

	Year 1	Year 2	Year 3	Year 4	Year 5
Monthly Fees	540	504	468	432	396
Installation	110				
Total Revenue	650	504	468	432	396
Order Fulfillment	250				
Customer Acquisition	200				
Cost of Modem	220				
Network Operating Costs	54	50	47	43	40
Retention, G&A	72	72	72	72	72
Depreciation	140	140	140	140	140
Total Costs	936	262	259	256	252
Pretax Income	(286)	242	209	177	144
-- Margin	-44%	48%	45%	41%	36%
EBITDA	(146)	382	349	317	284
-- Margin	-22%	76%	75%	73%	72%
Income Taxes	109	(92)	(79)	(67)	(55)
Net Income	(177)	150	130	110	90

Cash Flow Statement ($)

Net Income	(177)	150	130	110	90
Depreciation	140	140	140	140	140
Capex	(700)				
Cash Flow	(737)	290	270	250	230
IRR 16.0%					
Assumptions					
Monthly fees ($)	45	42	39	36	33
DSLAM Cost Per Customer	500				
Infrastructure Capex Per Customer	200				
Total Capex Per Customer	700				

Source: Company reports and Prudential Securities estimates.

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able 8. We Estimate That Plug and Play Architecture Lifts The IRR To 32%

ome Statement For One Customer ($)

	Year 1	Year 2	Year 3	Year 4	Year 5
onthly Fees	540	504	468	432	396
stallation	-				
tal Revenue	540	504	468	432	396
rder Fulfillment	125				
ustomer Acquisition	150				
ost of Uptake					
etwork Operating Costs	54	50	47	43	40
etention, G&A	72	72	72	72	72
epreciation	140	140	140	140	140
otal Costs	541	262	259	255	252
retax Income	(1)	242	209	177	144
- Margin	0%	48%	45%	41%	36%
BITDA	139	382	349	317	284
Margin	26%	76%	75%	73%	72%
Income Taxes	0	(92)	(79)	(67)	(55)
Net Income	(1)	150	130	110	90

Cash Flow Statement ($)

Net Income	(1)	150	130	110	90
Depreciation	140	140	140	140	140
Capex	(700)				
Cash Flow	(561)	290	270	250	230
IRR 31.8%					

Assumptions

Monthly fee ($)	45	42	39	36	33
DSLAM Cost Per Customer	500				
Infrastructure Capex Per Customer	200				
Total Capex Per Customer	700				

Source: Company reports and Prudential Securities estimates.

providing the remainder. This last assumption calls for a lower market share for the incumbents in ADSL than in basic local services in 2002. We believe that the incumbents will lose 35% of local services market share to CLECs by 2007 at a gradual pace, with market share loss of 15% to 20% by 2002. We have assumed a lower ILEC market share in ADSL than in basic local services since ADSL is a new service and both the ILECs and the CLECs are starting from zero market share.

We Estimate That A Single Customer Potentially Generates An IRR Of 16% Assuming Today's Technology

The foundation of our financial analysis is the return associated with a single customer (Table 8). We assume that the customer subscribes to ADSL for 5 years and that current architecture is used—that is, a splitter and truck roll are required. Our conclusion is that a single customer would generate an internal rate of return (IRR) of 16% over the five-year period. Due to up-front costs, the service provider loses money in the first year with an EBITDA margin of -22% and then turns positive over the remaining four years with EBITDA margins in excess of 70% each year.

We assume that ADSL revenues to the service provider are $45 per month in the first year and that there is an initial installation fee of $110. The $45 per month assumption is a blended figure and covers the ADSL service exclusively. That is, services that are delivered over ADSL, most notably Internet access, are not included. Our expectation is that the minimum ADSL bandwidths will cost about $25 per month with charges ranging up to several hundred dollars for higher bandwidths. The minimum charge of $25 per month plus about $20 per month for Internet access results in a total of $45 per month that we envision being competitive with cable modem offerings. Because we believe that competition from cable modems will increase as cable companies upgrade their networks, we assume that ADSL revenue per month declines from $45 in the first year to $33 in the fifth year.

One of the up-front costs is order fulfillment, which we assume to be $250. We believe that it costs an RBOC about $100 to fulfill an order for a POTS ("plain old telephone service") line. We use this as a basis and add $150 to reflect an hour and a half of a technician's time to reflect a truck roll to arrive at the $250 estimate. Another up-front cost is customer acquisition, which we assume to be $200. This is a relatively high cost starting out since ADSL service providers will need to spend money on initial marketing that educates the public. Over time as ADSL becomes popular the cost of acquisition can be expected to decline since some customers should call the service providers directly—a very low acquisition cost scenario. The last major up-front cost is the ADSL modem at the customer premises, which we assume to be $220. This assumption reflects current modem costs and we consider it to be conservative since modem costs will likely come down over time due to innovations from suppliers and economies of scale.

We don't believe that a 16% IRR is sufficient to motivate the large LECs to deploy ADSL aggressively. We believe that they have more attractive investment alternatives, ranging from investments in their core businesses to international opportunities. We believe that plug and play architecture, however, will generate returns more than high enough to motivate the large LECs to deploy ADSL aggressively.

Plug And Play Architecture Improves The IRR To 32%

Plug and play architecture raises our estimated IRR to 32% (Table 9) since the up-front costs are much lower. Our revenue estimates remain the same. The cost of order fulfillment drops because provisioning is much simpler and no truck roll is required. We estimate that the cost of order fulfillment drops to $125, which is still 25% higher than the estimated cost of fulfilling a POTS order, from our $250 estimate with current technology. We believe that the cost of fulfilling an ADSL order will remain higher than that of fulfilling a POTS order due to help desk costs as customers call to ask installation questions. We estimate that the cost of customer acquisition drops to $150 from $200 as the large LECs progress down the learning curve and as the public becomes more aware of the product. We estimate that the modem cost drops from $220 to zero since the modem will be built into the computer purchased by the consumer.

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Table 10. Our Aggregate Large LEC ADSL Model

Income Statement ($ Thousands)

	1999E	2000E	2001E	2002E
Recurring Revenue	169,817	610,950	1,520,388	2,894,868
Installation Revenue	60,068	108,207	211,752	265,292
Total Revenue	229,885	719,157	1,732,140	3,160,160
Order Fulfillment Costs	136,518	187,425	362,920	448,956
Customer Acquisition Costs	105,214	187,425	381,154	510,178
Modem Cost	98,283	112,455	-	-
Network Operations Costs	16,982	81,098	152,039	289,487
Retention and G&A	22,642	87,263	233,806	482,478
Depreciation	40,882	145,089	340,873	631,181
Total Costs	424,531	780,755	1,470,791	2,362,280
Operating Income	(194,646)	(63,597)	271,249	797,881
-- Margin	-85%	-9%	16%	25%
EBITDA	(153,764)	81,502	612,122	1,429,062
-- Margin	-67%	11%	35%	45%
Income Taxes	(73,966)	(24,167)	103,075	303,195
Net Income	(120,681)	(39,430)	168,174	494,686
Revenue Assumptions				
ADSL Customers, EOP (thousands)	599	1,837	4,660	8,742
Net Additions	546	1,249	2,823	4,081
ADSL Customers, average	314	1,212	3,249	6,701
Revenue Per Customer Per Month ($)	45	42	39	36
Installation Charge	$110	$85	$75	$65
Cost Assumptions				
Order Fulfillment Cost Per Customer	$250	$150	$125	$110
Customer Acquisition Cost	$200	$150	$135	$125
Cost of Modem	$180	$90	$0	$0
Capex Per Customer	$650	$550	$450	$400
Total Capex ($ thousands)	354,947	687,225	1,270,512	1,632,568
Depreciation Period (years)	5	5	5	5

Source: Company reports and Prudential Securities estimates.

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Table 11. We Expect ADSL To Increase The Aggregate Large LEC Net Income Growth Rate Starting In 2000
($Millions)

	1998E	1999E	2000E	2001E	2002E
Ameritech	2,603	2,844	3,264	3,607	3,987
Bell Atlantic	4,296	4,616	5,375	5,945	6,576
BellSouth	3,242	3,675	4,060	4,486	4,957
GTE	2,963	3,396	3,894	4,308	4,846
SBC	3,905	4,570	5,245	5,963	6,748
USW	1,517	1,841	1,754	1,875	1,981
Subtotal	18,526	21,041	23,839	26,194	29,049
-- Growth		13.6%	11.9%	11.3%	11.1%
ADSL	0	(121)	(30)	188	495
Total	18,526	20,921	23,300	26,382	29,588
-- Growth		12.9%	12.3%	12.2%	12.2%
Incremental Impact		-0.7%	0.5%	0.8%	1.2%

Source: Company reports and Prudential Securities estimates.

We Estimate ADSL Will Add 120 Basis Points To Large LEC Net Income Growth In 2002

Our analysis of the financial effect of ADSL on the large LECs in aggregate (Tables 10 and 11) is based on our individual customer analysis and on our total subscriber forecasts. In our aggregate analysis we assume that up-front costs migrate down as ADSL migrates to plug and play. We expect ADSL to increase the aggregate large LEC net income growth rate by 50 basis points in 2000, 90 basis points in 2001, and 120 basis points in 2002 after initially reducing the aggregate net income growth rate by 70 basis points in 1999. On a dollar basis, we expect ADSL to be dilutive to aggregate large LEC net income by about $120 million in 1999 and $40 million in 2000 before becoming accretive by about $170 million in 2001 and $500 million in 2002. U S West may begin to experience the financial rewards of ADSL sooner than its peers since it has been more aggressive in rolling out the service, but we don't believe that U S West's head start is substantial in the grand scheme of things. At this point, our belief is that the RBOCs will all pick up market share at about the same pace once plug and play capability is available. In our forecast, we expect U S West to gain market share a little faster than its peers in 1999, 2000, and 2001. By 2002, we estimate that all of the RBOCs will have reached equal penetration rates. In actuality some variance in large LEC ADSL penetration rates will almost certainly occur due to differences in marketing campaigns, percentage of ADSL-qualified loops, rural versus urban territories, and other factors. But at this early stage of the game we believe that all of the large LECs should be capable of achieving 7.4% penetration of residential lines by 2002. Once again, success in the small to mid-sized business market could provide upside to our numbers.

Returns Are Likely To Be Higher If Enhanced Services Are Included

While the 32% IRR associated with plug and play ADSL is attractive in its own right, it is important to keep in mind that the scope of our analysis is only the ADSL transport service. Additional services delivered over ADSL are not included. Most notably, Internet access is not included. We believe that carriers will potentially be able to provide a host of enhanced services, ranging from Internet access to e-commerce applications to virus protection software to applications yet to be invented. We believe that these enhanced services are likely to be significantly more profitable than the underlying ADSL service, analogous to the situation in the public switched telephone network

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(PSTN) today in which vertical services (e.g., Caller ID, Voicemail, Call Waiting) are much more profitable than basic local telephone service.

Up To 80% Of Telco Access Lines May Be ADSL-Qualified

There are certain qualifications that a copper pair must meet to run ADSL. The line must generally be 18,000 feet or shorter and be free of bridged taps. At present the line must also be a "home run." That is, the line must run from the CO directly to the customer. The percentage of lines meeting these criteria varies by RBOC but is typically in the 40% -60% range. We estimate that BellSouth and U S West are nearer to the low end of that range while the remaining large LECs are near the high end. Lines that are not part of a home run architecture are part of a remote architecture in which remote terminals (or digital loop carriers [DLCs]) are attached to COs. In this architecture the lines originate in the DLC rather than the CO and the connection between the DLC and the CO can be either copper (e.g., a T-1) or fiber.

ADSL currently does not work well with DLC architecture. It is not technically possible to serve a DLC-fed line from a digital subscriber line access multiplexer (DSLAM) in the CO. This means that a DSLAM must be placed out in the DLC, which increases capital costs. It can also be expensive to increase the capacity between the CO and the DLC to handle traffic from ADSL subscribers. Our visit to SuperComm revealed that ADSL vendors are working feverishly to solve the DLC problem, and we believe that an economical equipment solution will be available over the next 6-12 months (some vendors claim they are already there). Such a solution may involve a smaller DSLAM with fewer ports. We estimate that the percentage of ADSL qualified lines will increase about 20 percentage points per RBOC to between 60% and 80% once DLC-fed lines are included. In fact, for BellSouth and U S West, the percentage may increase more and enable them to reach about 80% of lines with ADSL.

ADSL Transforms A Single Twisted Pair Into Three Channels

ADSL technology creates three channels out of one twisted pair of copper: a high-speed downstream channel ranging from 1.5 Mbps to 6.1 Mbps, a medium speed upstream channel ranging from 16 kbps to 640 kbps, and a POTS channel. Thus, ADSL service does not require a second line. The POTS channel will function in the event of ADSL failure since it is split off from the digital modem by a filter. ADSL technology is enabled by placing electronics on either end of a twisted pair of copper. On the telco end is a device called a DSLAM, which resides in the CO. The line is plugged into a port on the DSLAM. On the customer end of the line is an ADSL modem. Also on the customer end is a splitter or filter which separates the voice services and data services.

Crosstalk Is An Important Factor In Performance

Copper pairs are bundled together in a cable binder. When the electrical signal being transmitted across one copper pair cross couples with the electrical signal of another copper pair; this is called crosstalk. Significant interference from crosstalk can occur if adjacent copper pairs are transmitting information at the same frequencies. The performance of ADSL is therefore affected greatly by the number of copper pairs in the same bundle that are transmitting at the same or similar frequencies.

The impact of crosstalk on the PSTN as ADSL is more widely deployed is the subject of much debate in the industry. The large LECs and equipment suppliers believe that crosstalk will be manageable as they implement ADSL. We assume that crosstalk will not materially limit the deployment of ADSL to our projected penetration of 7.4% of residential lines by 2002, but crosstalk could affect ADSL performance as penetration rises and the likelihood of multiple copper pairs running ADSL within respective bundles increases. One variable that could be impacted would be maximum loop length.

There are two types of crosstalk: near-end crosstalk and far-end crosstalk. Near-end crosstalk occurs at the CO, where numerous pairs come together. Far-end crosstalk

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occurs toward the customer end of the connection. Near-end cross talk is much more prevalent than far-end crosstalk since more copper wires are combined into bundles as they get closer to the CO. Each copper wire introduces a crosstalk component and the proximity of so many wires raises the likelihood of aggregated crosstalk. Conversely, far-end cross talk is less likely since the density of copper wires decreases as they get close to the customer since they typically branch off as they get farther away from the CO. The distinction between near-end and far-end crosstalk is precisely the reason that ADSL is an asymmetric technology. The downstream ADSL speed (into the customer) can be much greater than the upstream speed (into the CO) without causing crosstalk.

DSL Breaks The POTS Frequency Boundaries

PSTN guidelines limit transmissions to between zero Hertz and 3,400 Hertz and the fastest information rate within those guidelines is 53 kbps. DSL technology achieves much higher information rates by breaking through the 3,400 Hertz boundary. A bandpass filter called a splitter makes sure that all signals below 4,000 Hertz pass through unchanged, and the ADSL modem then adds frequencies higher than 4,000 Hertz that are used for data transmission.

ADSL's speed limitations are dictated primarily by crosstalk and by attenuation. Attenuation is the tendency of a signal to dissipate as it travels over a loop. Attenuation is caused by the length of the copper loop and the thickness of the copper loop. A thinner copper loop has more resistance and causes more attenuation. Telco copper loops are typically 1/24 or 1/26 of an inch in diameter, referred to as 24 AWG (American Wire Gauge) or 26 AWG. In North America 26 AWG is more common than 24 AWG, and most telcos use the thinner 26 AWG near COs to minimize space requirements and 24 AWG over long loops.

DMT Has Been Chosen As The Line Code Standard For ADSL

The ITU has chosen discrete multi-tone (DMT) as line code for ADSL. DMT uses many narrow-band, 4 kiloHertz (kHz) carriers ("tones" or "bins") that transmit in parallel. There are a total of 256 carriers and each carries a piece of the information. In full-rate ADSL, the range between 20 kHz and 130 kHz is used for the upstream data and the 140 kHz to 1,000 kHz is used for the downstream data.

ADSL.lite Eliminates The Need For A Splitter

ADSL.lite eliminates the need for a splitter at the customer premises by reducing the interference in the 0-4 kHz range to a point where an acceptable signal-to-noise ratio for voice calls is maintained (a splitter is still required at the CO). ADSL.lite accomplishes this by reducing upstream signal power, which is the primary cause of interference in the voice frequency range. Thus, the signal power in the 20 kHz to 130 kHz band is reduced. In practice, the signal power in the downstream band, 140 kHz to 1,000 kHz, must also be reduced and only 96 of the 256 carriers are used. This limits the maximum ADSL.lite downstream speed to about 1.5 Mpbs.

Appendix 1: Financial Analysis Assumptions

Our financial analysis is based on the following assumptions:

Single Customer Analysis

❑ Revenues:

Monthly revenue in year 1 is $45 for ADSL service. This is a composite revenue estimate since monthly charges will vary with bandwidth. We expect that the lowest bandwidth will cost about $25 per month and assume that about two-thirds of customers subscribe to the lowest bandwidth. We expect such a price point to be quite successful since it is comparable to the cost of buying a second phone line yet offers much higher bandwidth. Once ADSL is installed, the RBOC's cost structure on a customer-by-customer basis does not vary materially regardless of the bandwidth provided (of course, the appropriate trunking capacity must be in place). We assume that monthly revenue drops by $3 each year to $33 in year 5 due to increased competition from cable modems.

There is an installation fee of $110.

The customer is not charged for the modem. The cost of the modem can be considered to be part of the monthly charge. In actuality customers may have a choice between buying or leasing the modem.

❑ Costs:

1. Order fulfillment costs are $250 per customer. These costs include order processing, billing set-up and any physical work that has to be done. We expect the cost of order fulfillment to migrate down over time as the large LECs move down the learning curve of ADSL deployment. The floor on order fulfillment costs is probably $110-$125, which can be thought of as the $100 that it costs an RBOC to fulfill a POTS line request plus $10-$25 in added cost for help desk support.

2. We assume a customer acquisition cost of $200. This cost should also migrate down as the RBOCs educate their customer service representatives, salespeople, and the public about ADSL, which is a relatively complex product. For example, once ADSL becomes popular customers may call up the RBOC and request the service, in which case the cost of customer acquisition is very small.

3. The cost of the modem is $220. This is a current estimate and we believe that it will migrate downward as volumes increase.

4. Network operating costs are estimated to be 10% of revenues. We don't believe that significant incremental expenditures for a large LEC to operate ADSL once it's up and running will be required. Retention and G&A are estimated to be $6 per month.

5. Depreciation of capex is expected to be $140 per year, which is $700 depreciated over 5 years. The largest piece of the $700 in capex is comprised of $500 of equipment cost (primarily for the DSLAM) and is a current estimate with some built-in conservatism and we believe it has the potential to migrate downward due to volume increases and technological advances. The remaining $200 of capex is investment for general infrastructure improvement to enable ADSL to run throughout the network. We used the fact that U S West spent an estimated $45 million in such costs to enable the deployment of ADSL in 223 COs. The expenditures were for interoffice facilities (increased bandwidth), facilities preparation (e.g., increased power supplies at COs, reinforcement of CO floors, air conditioning in COs), tools and testing equipment (diagnostics, repair), and ATM switches (prior to its ADSL deployment, USW had about 40 ATM switches and added about 40 more). Beyond its initial ADSL deployment, USW estimates that the general infrastructure costs per incremental customer may be around $100.

Aggregate Analysis (Table 10):

❑ Revenue:

Revenue per customer starts at $45 per month in 1999 and migrates down to $36 per month by 2002. We believe that ADSL prices will come down as cable modems are more widely deployed.

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- Costs:

1. Order fulfillment costs drop from $250 in 1999 to $150 in 2000 to $125 in 2001 and remain at $110 in 2002. This reflects that fact that plug and play architecture will not require a truck roll.

2. Customer acquisition costs drop from $200 in 1999 to $150 in 2000 to $135 in 2001 to $125 in 2002.

3. Modem costs drop from $180 in 1999 to $90 in 2000 to zero in 2001 and 2002. This reflects the phasing-in of plug and play architecture, in which the modem will be inside the PC purchased by the consumer.

4. Capex per customer drops from $650 in 1999 to $550 in 2000 to $450 in 2001 to $400 in 2002.

5. Impact on additional lines: we believe that ADSL will result in a slowdown in additional line sales and also the cancellation of existing additional lines because many additional lines are used for Internet access. While this phenomenon may partially offset the incremental revenue from ADSL, we don't believe that it will materially offset the bottom line impact of ADSL.

We don't believe that an additional line used solely for Internet access is nearly as profitable for the large LECs as a primary line. In fact, in some cases such a line may be unprofitable. On the one hand, a second line is often already deployed and therefore when a consumer subscribes to it there is no incremental capital to be spent and no additional depreciation. On the other hand, an additional line used for Internet access is unlikely to subscribe to high-margin vertical services and it is unlikely to be used for long distance calls which generate access charge revenues.

Conclusion: We Expect ADSL To Help Maintain Strong Large LEC Earnings Growth

We believe that ADSL services represent a significant opportunity for the large LECs and that ADSL services will be an important part of their strategy to take advantage of the huge growth in the data services market. We believe that the large LECs will achieve 7% penetration of residential lines by 2002. The small to mid-sized business markets represent upside to our analysis. We estimate that ADSL services will increase the aggregate large LEC net income growth rate by 50 basis points in 2000, 90 basis points in 2001, and 120 basis points in 2002 after initially decreasing it by 70 basis points in 1999. We believe that successful deployment of ADSL will be a critical piece of large LEC efforts to maintain strong earnings growth as increased competitive pressures come to bear on all fronts of their business.