Ex. __ (AES-2)

BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elements, Transport and Termination, and Resale	)))))	DOCKET NO. UT-960369
In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elements, Transport and Termination, and Resale for U S WEST COMMUNICATIONS, INC.	)))))	DOCKET NO. UT-960370
In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elemetns, Transport and Termination, and Resale for GTE NORTHWEST INCORPORATED	)))))	DOCKET NO. UT-960371

ATTACHMENT 2

DIRECT TESTIMONY

OF

ALLEN E. SOVEREIGN

March 27, 1997

Technology Forecast

For

GTE Telephone Operations

Ray L. Hodges

Technology Futures, Inc.

September 1995

Introduction and Summary

The purpose of this report is to provide a technology forecast of the major categories of technology sensitive investments of GTE: Outside Plant, Circuit and Switching. These categories represent over 80% of GTE's total investment. In each category, tremendous changes are underway which are displacing the bulk of existing investment and making necessary continuing large amounts of new investment:

- *Outside Plant* -- The replacement of copper cable by fiber optics in the interoffice, feeder, and distribution parts of the outside plant. GTE's interoffice, feeder, and distribution cable Average Remaining Lives (ARLs) are 2.9 years, 7.4 years, and 9.7 years respectively.

- *Circuit Equipment* -- The adoption of Synchronous Optical Network (SONET) equipment will make essentially all of today's circuit equipment obsolete. The ARL forecast for GTE's circuit account is projected to be 3.7 years.

- *Switching* -- The replacement of various components of digital switching as well as major upgrades to existing digital switching, and the adoption of broadband switches based on Asynchronous Transfer Mode (ATM) technology. The ARL for GTE's digital switching is projected to be to be 6.9 years.

The following chart provides a comparison of Technology Futures, Inc. (TFI's) forecast for the industry and GTE:

TFI EQUIPMENT LIFE RECOMMENDATIONS

Technology	Recommended Industry ARL (1/1/95)	GTE Recommended ARL (10/1/95)	Corresponding Projection Life*
Outside Plant			
Interoffice Cable, Metallic	2.9	2.9	-
Feeder Cable, Metallic	7.0 to 7.8	7.4	-
Distribution Cable, Metallic	7.5 to 10.2**	9.7	-
Metallic Cable, Averaged	7.0 to 8.7**	7.0 to 8.7	14 to 16
Cable, Non-Metallic, All Types	-	-	15 to 20‡
Circuit Equipment			
Analog	2.8	2.8	6 to 9
Digital	3.7	3.7	8 to 9
Switching Equipment			
Digital	6.3	6.9	9 to 11§

*These are estimates for the industry average; some companies may have lower or higher projection lives. Note: The projection life is for the installed base not newly-installed equipment and depends on the particular distribution of plant a company has.

**Ignoring competition for voice services.

‡The 15-year projection life reflects risk due to competition.

§This is a reasonable range of projection lives for existing equipment that corresponds to the recommended industry ARL of 6.3 years. Companies with a shorter ARL may have a shorter projection life.

These lives are significantly shorter than those used in regulatory accounting. They reflect the realities of technological change and the need to provide advanced communications services. They do not, however, fully reflect the impact of competition on the economic life of equipment and, therefore, may still be too long.

These changes are not only being driven by advances in telecommunications technology, but also by the need for new communications services and the emergence of competition in the local exchange. These three drivers -- technology, new services, and competition -- reinforce each other and together increase the pace, magnitude, and importance of the adoption of new technology.

The new investment will not be placed "overnight," and, in fact, on an annual basis, the level of investment implied by our forecasts will be comparable to past levels of investment. This is largely due to the efficiency of the new technologies and the continuing decline in their costs. However, the pace of obsolescence and retirements of existing investment will exceed historical levels, leading to shorter lives for existing equipment and higher depreciation rates.

The forecasts presented herein are based upon GTE specific data compared to studies of industry data as recently published in *"Transforming the Local Exchange Network,"* L.K. Vanston, Technology Futures, Inc., 1994 Edition and *"Depreciation Lives for Telecommunications Equipment - Review and Update,"* L.K. Vanston and R.L. Hodges, Technology Futures, Inc., 1995 Edition. These forecasts are generally consistent with our earlier ones published in 1988 and 1989[1], with some adjustments to account for the intervening years of additional experience. Basically, the message is the same -- new technology continues to be rapidly adopted in the local exchange network -- although the overall pace of adoption is slightly slower than previously forecast.

Industry Focus

The forecasts for the U.S. Local Exchange Carriers (LECs) as an industry are a very important bench mark; however, since GTE is not identical to other LECs in the characteristics of its geography, customers, managers, and regulators, they may not adopt new technology in lockstep. Thus, the current levels of new technology adoption by GTE may differ from other individual companies and their future pace and levels of adoption are also likely to differ. However, in spite of some differences, all companies have similar technology profiles today, demonstrating that historically they have evolved in a similar manner. Further, all LECs, including GTE, are subject to the same basic drivers of technology change, new service requirements, and competition. Finally, all have access to the same technologies from the same set of vendors, their networks are

[1] L.K. Vanston and R.C. Lenz, *Technological Substitution in Transmission Facilities for Local Telecommunications* (1988); L.K. Vanston, *Technological Substitution in Switching Equipment for Local Telecommunications* (1989); and L. K. Vanston, *Technological Substitution in Circuit Equipment for Local Telecommunications* (1989) (Austin, TX: Technology Futures, Inc.).

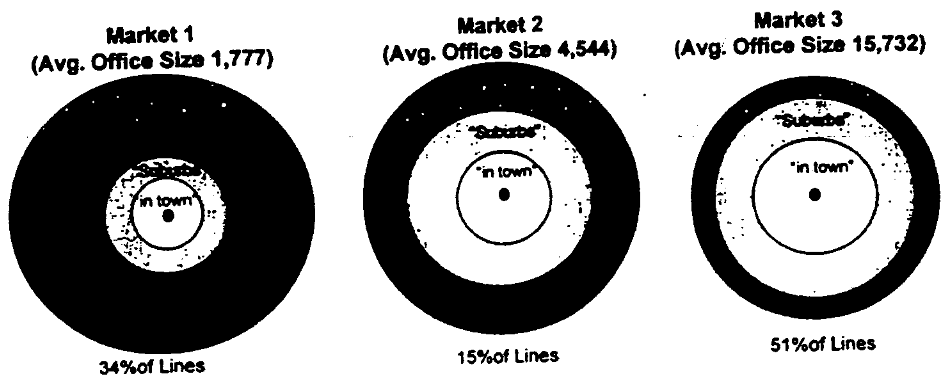
interconnected through national interexchange carriers, the same new services must be available on at least a national basis to be truly viable, and their competitors will often be competing on a national level.

In order to be successful, GTE will adopt new technology roughly in parallel with other LECs. Some companies will be faster than others--some will lead and some will follow--but the successful ones will complete the adoptions at about the same time. Thus, the industry forecasts are useful as a guide to the likely long-run pace of adoption for GTE as well as other individual companies. Also, while industry forecasts cannot take the place of detailed company plans, they can serve as additional input. This report utilizes both industry forecast and company plans to arrive at a specific forecast for GTE.

GTE Market Specific

GTE is somewhat unique when compared to the Regional Bell Operating Companies (RBOCs) or independents. The RBOCs are predominantly urban and the independents are predominantly suburban or rural. GTE has a cross section of markets that are highly urban, suburban and rural. The market conditions will be a factor in the timing of competitive entry and plant modernization in reaction to competition. GTE has developed market strategies for each of six market segments. The differences in the competitive environment and market strategies are reflected in the forecasts. For this report we have aggregated GTE's six market segments into three since this provides enough differentiation for our purposes without adding undue complexity. The physical characteristics of these market segments can be seen in Exhibit 1.

Exhibit 1
Market Structure Differences



All market types have similar demographic structures "in town, suburbs, and rural" but the make-up of each varies between Market Segments. Also the size of a typical office varies by Market Segment.

While the timing may be different, it is important to note that GTE will be facing increasing competition across all of its market segments. The major competitors will carry strong national brand names and strategies but local niche players will also compete. The new competitors will have significant cost advantages compared to GTE's embedded network and major market share and revenue losses in the voice market can be expected. The following outline summarizes GTE's competitive outlook:

- Cable television reaches over 90% of homes and even small companies intend to offer voice service soon. By 1998, competition can be expected in all market segments.

- Cellular coverage is already very extensive in all market segments, offering full-featured voice services. Existing cellular systems can be expanded to serve entire small towns and communities. Areas with obsolete equipment are very vulnerable.

- Introduction of Personal Communication Services (PCS) will intensify wireless competition and bring more potential competitors. While cellular has the capacity to serve entire small cities or towns, PCS combined with cellular will be able to serve everyone in the largest cities.

- Competitive Access Providers (CAPs) are already in Market Three and will target Market Two by 1996, and any large customers in Market One by 1998.

- Enhanced Specialized Mobil Radio (ESMR) will greatly expand its current dispatch service to include more business applications that are presently utilizing wireline services. They will primarily target customers that need to reach several users with the same information. This can be expected in Market Three in 1997 and in One and Two in 1998.

- Electric companies have placed considerable fiber in their networks and are now looking for partners to offer full communications services along with energy management. They are also looking to partner with PCS providers.

- Local Multipoint Distribution System (LMDS) or "cellular TV" at 28 GHz may compete for video services as well as telephony.[2] Density is an important economical factor so it will target the most dense areas first.

- Low earth orbit satellites are expected to be launched in 1997. This will be comparable to a worldwide cellular system but more expensive. It will compete with all high cost areas.

[2] Operation at 40 GHz, while technically feasible, may not prove to be economically feasible at this time.

- Very Small Aperture Terminals (VSATs) are already taking significant data traffic from the network from any area that has multi-location businesses, such as car dealers, Wal-mart, K-mart, etc.

- Digital Television (DTV) is exceeding all expectations in competing with cable and broadcast TV. This is additional competition for future video dialtone type services.

Methodology

The methodology underlying most of the forecasts presented here is *substitution analysis*. Substitution analysis is a technology forecasting technique that has been proven effective in projecting the adoption of new technology and the obsolescence of old technology. Substitution refers to the displacement of an established technology by a newer technology because the new technology provides substantially improved capabilities, performance, or economies. With substitution, technological superiority of the new technology -- not wear-out -- is the driver for replacement.

With substitution analysis, we examine patterns of technology substitution. The pattern is remarkably consistent from one substitution to another. The adoption of a new technology starts slowly because, when it first is introduced, a new technology is usually expensive, unfamiliar, and imperfect. The old technology, on the other hand, has economies of scale and is well-known and mature. As the new technology improves, it finds more and more applications; it achieves economies of scale and other economic efficiencies, and becomes generally recognized as superior. The old technology, because of its inherent limitations and falling market share, cannot keep up. The result is a period of rapid adoption of the new technology, beginning at 10% to 20% penetration level. This corresponds with a period of rapid abandonment of the old technology. Toward the end of the substitution , adoption of the new technology slows down again as the last strongholds of the old technology are penetrated.

Through experience, we have found a particular set of models, namely the Fisher-Pry model -- and its extensions, notably, multiple substitution models based on the same principles -- to be the most useful for forecasting.

Since the pattern of how a new technology replaces an old is consistent, we can apply the pattern to a technology substitution in progress, or one just beginning, to forecast the remainder of the substitution and estimate the end date for the old technology. We can apply substitution analysis even in cases where the substitution has yet to begin by using appropriate analogies, precursor trends, or evaluation of the driving forces.

Although no forecasting method is perfect, our experience with the model has been excellent. There are several factors that are not reflected in the Fisher-Pry model and must also be addressed in our forecasts:

- The rate of substitution often increases in telecommunications when the new technology captures 80% to 90% of the installed base, leading to an earlier final retirement date than forecast by the Fisher-Pry model.[3]

- Never before have new technologies in all areas of the telephone network been so mutually supportive as are fiber optics, SONET, and ATM.[4] This synergy will tend to accelerate the adoption of each.

- Although Fisher-Pry applies to both regulated and competitive industries, the pace of substitution tends to be higher in competitive industries. Thus, as competition increases in the local exchange market, we would expect the rate of substitution to increase faster than predicted by the Fisher-Pry model.

The cumulative result of these factors is to make the overall rate of change somewhat faster than forecasted here.

Estimating Technological Impact on Investment

The traditional method for estimating depreciation lives is to examine mortality data for older vintages and assume that all vintages will experience the same age-dependent characteristics. For example, if 60% of the units of a particular technology that were installed in 1983 were still in service in 1989 (six years later), we would assume that 60% of the units installed in 1990 would still be in service in 1996 (again six years later). (This greatly over-simplifies, but captures the basic idea.) The assumption of age-dependent retirements reflects a situation where wear-out or breakdown drives the replacement process. Under this model, new technology (or perhaps a new unit of old technology) replaces old only when the old technology wears out or breaks. This is an accurate model for many situations; for example, it reflects the way most companies replace motor vehicles.

However, today, technological obsolescence is the major driver for retirements in telecommunications. Substitution analysis captures the dynamics of technological obsolescence in a way that traditional mortality cannot. For example, Exhibit 2 plots the vintage survivor curves for crossbar switching. These are similar to normal survivor curves except that a separate investment life cycle is shown for each vintage of equipment. Note the "avalanche effect" between 1975 and 1980. During this period, all vintages experienced sudden and simultaneous retirements as electronic switching was rapidly adopted. This period corresponds to the period of rapid adoption of the new technology in the substitution pattern.

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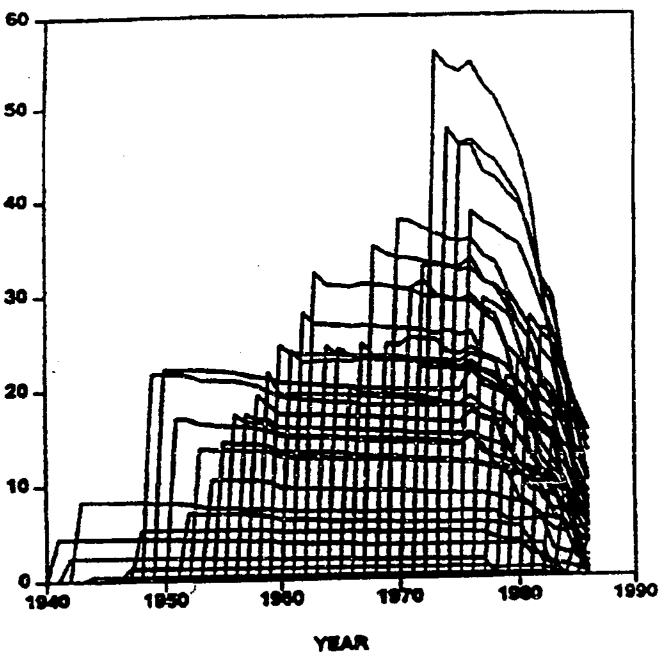
[3] R.C. Lenz and L.K. Vanston, *Comparisons of Technology Substitutions in Telecommunications and Other Industries* (Austin, TX: Technology Futures, Inc., 1985).
[4] For example, digital transmission was introduced in the early 1960s, but digital switching was not introduced into the local exchange network in significant quantities until the early 1980s.

Exhibit 2

Vintage Survivor Curves

1940-1985 Crossbar Vintages

Plant in Service (Million Dollars)



Source: Bellcore

Using historical data, a substitution analysis performed as early as 1970 would have predicted the avalanche that started in 1975. Given the relatively low retirement rates prior to 1975, standard mortality analysis would not account for it until after the fact. History is repeating itself now. Using substitution analysis in the mid-to-late 1980s, TFI predicted the avalanche that is burying the Analog Electronic Switching account today.

One can also see from the avalanche curves that, when technological obsolescence is the major driver for retirements, there is no such thing as a constant service life. Equipment purchased late in a technology generation will have a much shorter life than equipment purchased earlier. Further, the expected service life of equipment purchased late in the cycle is roughly the same as the average remaining life of existing equipment. These observations are contrary to mortality-based depreciation, but they reflect reality.

Also note that very large amounts of investment were made in the old technology very late in its life cycle, even after the new technology was available. This behavior can result from several factors including (1) the need to maintain existing equipment and service levels, (2) restrictions on the availability of the new technology, (3) high relative costs for the new technology in its life cycle, and (4) an inherent bias toward existing technology. The point here is that recent investment patterns in the old technology is a poor guide to the likely adoption of new technology, even in the near future.

Although the application of substitution analysis to depreciation can be very sophisticated, and even combined with mortality methods, we have taken a very simple approach here in estimating industry equipment lives from our technology forecasts. Basically, we use the percentage adoption curve to estimate a percent-age survivor curve from which we estimate an ARL.

Our ARL estimates do not take explicit account of the impact of competition on depreciation lives. First, as noted in the previous section, the substitution analysis underlying the lives does not reflect the growing levels of competition in the local exchange. Second, in this study, we have not estimated the impact of falling prices and falling LEC market shares on the economic value of remaining assets.

Data Sources

GTE specific data is based on company plans, financial reports, and inputs from GTE's planners and engineers.

Industry data for the study was published in *Depreciation Lives for Telecommunications* and *Transforming The Local Exchange Network* and was taken from Automatic Reporting Management Information System (ARMIS) reports to the FCC and TFI files. This information was supplemented by equivalent data received from other companies that do not make ARMIS reports. For a historical perspective, we also used data collected by TFI from the industry for the 1988 and 1989 studies.

Data for the GTD-5 switch was obtained from GTE engineers and from GTE records and reports. The percentage of investment of the categories was determined from an analysis of work orders.

Technology Forecasts

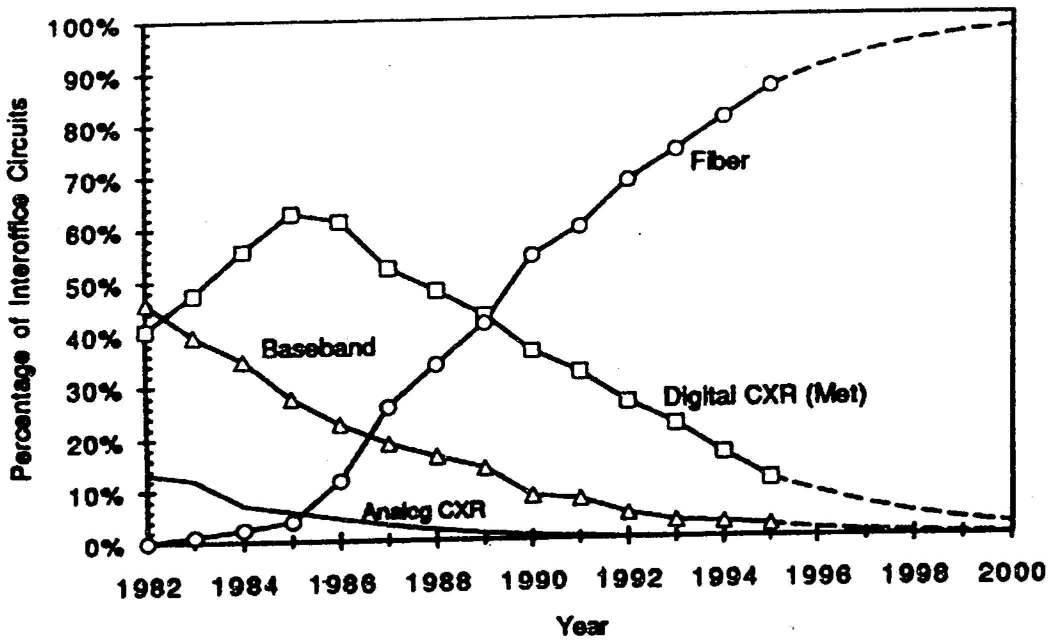
Outside Plant-Interoffice Cable

At year-end 1993, the LEC industry interoffice plant was 96% digital and 74% fiber, as measured by circuits in use.[5] Thus, there is relatively little metallic investment still being used in the interoffice environment. Almost all new investment is fiber and the metallic carrier share has declined steadily.

Exhibit 3 shows the percentage of interoffice circuits served by each major technology. TFI's forecast for the adoption of fiber, and the displacement of non-fiber facilities is based on a multiple substitution analysis of historical data through year-end 1993 and planning data through year-end 1995. The historical and planning data is shown by the hollow markers. Digital carrier (metallic) peaked as a percentage of total circuits in 1985 at 63%, 23 years after its introduction. Fiber, in contrast, reached 69% penetration in 1992, just ten years after its introduction. By 2000, 98% of circuits are forecast to be on fiber. GTE has 70% of its interoffice circuits on fiber as of year-end 1994 compared with 80% for the industry. However, in its major markets it is in line with the industry. In one such market, Florida, 100% was achieved in 1992. GTE presently has fiber in almost all interoffice routes (over 95%). Most remaining non-fiber interoffice applications are for residual uses such as alarm and test circuits. These will be phased out during the late nineties as the cost of maintaining metallic facilities out-weigh the cost of switching to fiber. We expect GTE to catch up with the rest of the industry and reach 100% in the 2000 time frame. For Interoffice Copper the ARL is 2.9 years. See Exhibit 4.

[5] To be more precise, these units are "equivalent voice-frequency circuits in use," although they are usually just referred to as "circuits." For example, a voice frequency copper circuit on two or four wires counts as one circuit. Each voice frequency equivalent circuit in use on a carrier system is counted as one circuit. Both switched and dedicated circuits are included. For data services, each 64 Kb/s is considered to be equivalent to one circuit. Thus, a leased DS1 line (1.544 Mb/s) is counted as 24 circuits.

Exhibit 3
Interoffice Technology Shares



Source: Technology Futures, Inc.

Exhibit 4
Interoffice Copper Cable Survivors

Year	% of Circuits on Copper Cable	% of 1994 Investment Surviving
1994	19.5	100.0
1995	13.6	69.9
1996	10.1	51.8
1997	7.2	37.0
1998	5.1	26.2
1999	3.6	18.3
2000	2.5	12.8
2001	1.7	8.9
2002	1.2	6.1
2003	0.8	4.2
2004	0.6	2.9
2005	0.4	2.0

Average Remaining Life (as of 1/1/95) = 2.9 years

Source: Technology Futures, Inc.

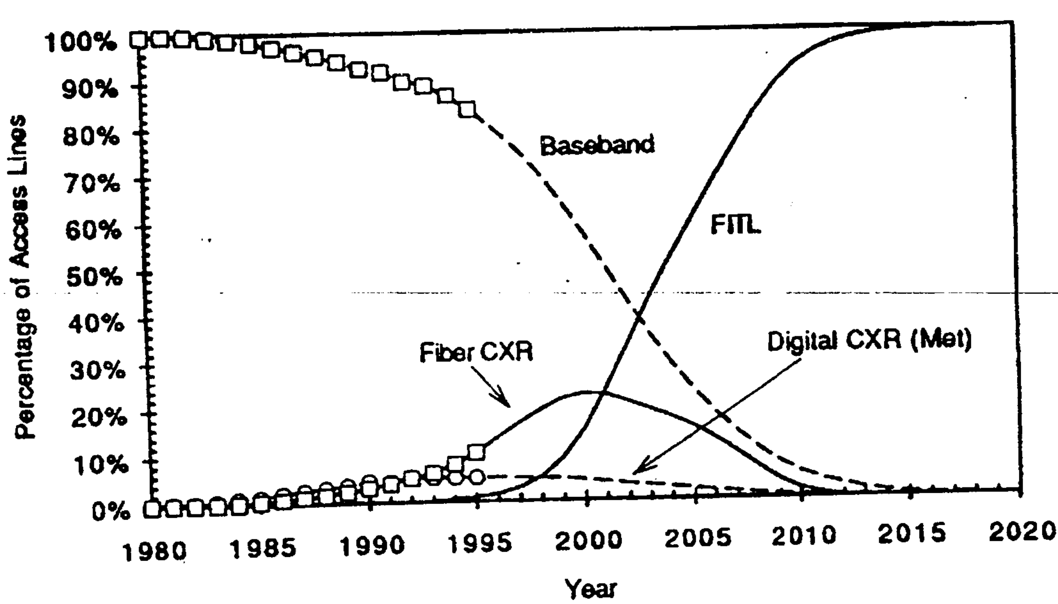
Outside Plant- Feeder Cable

In the feeder plant, Digital Loop Carrier (DLC) facilities have been displacing copper pairs for over 15 years. Both metallic-based and fiber-based DLC systems are being adopted, although fiber DLC systems are beginning to dominate.

Exhibit 5 shows the LEC industry percentage of access lines served by each of the major technologies. The forecast is based on a multiple substitution analysis of historical and planning data, shown by markers. By the end of 1993, 11.2% of access lines were served on DLC systems. Between 1995 and 2000, conventional fiber-based DLC will continue to grow, reaching peak at about 23% of access lines. This period will also see the rapid growth of "Fiber in the Loop" (FITL) systems. After 2000, FITL systems are forecast to rapidly displace all other types of feeder technologies, serving 50% of access lines by 2004, 90% by 2010, and essentially all access lines by 2015.

GTE currently has approximately 13% of its access lines on digital carrier and approximately 8% on fiber which is about the same as the industry. The industry forecast may be seen in Exhibit 5 (note: FITL). GTE's ARL for feeder copper cable is 7.4 years which is the middle of the range for the industry. This is based on Market Three (51%) being early and Markets One and Two (49%) being similar to the middle scenario. See Exhibit 6.

Exhibit 5
Feeder Technologies—Percentage of Access Lines



Source: Technology Futures, Inc

Exhibit 6
Metallic Feeder Survivors

Year	[illegible]		[illegible]	
	Metallic Pct of Feeder Access Lines	**Pct of 1994 Investment Surviving**	**Metallic Pct of Feeder Access Lines**	**Pct of 1994 Investment Surviving**
1994	83	100	83	100
1995	80	96	80	96
1996	75	90	75	90
1997	70	84	70	84
1998	64	77	64	77
1999	58	70	58	70
2000	51	61	51	61
2001	44	53	44	53
2002	37	44	37	44
2003	30	36	26	31
2004	24	29	15	18
2005	19	23	9	10
2006	15	18	5	6
2007	11	14	2	3
2008	9	10	1	2
2009	7	8	1	1
2010	5	6	0	0
2011	4	4	0	0
2012	3	3	0	0
2013	2	2	0	0
2014	1	1	0	0
2015	1	1	0	0
Average Remaining Life= (as of 1/1/95)		7.6 years		7.0 years

Source: Technology Futures, Inc.

Outside Plant-Distribution Cable

We use the term FITL to refer to any architecture that extends fiber to an area of no more than several hundred customers; the last link to the customer may be on copper pairs, coaxial cable, fiber, or wireless. There are a number of architectures that are under consideration or are being planned. A true consensus has yet to emerge on a single FITL architecture. Continuing changes in technology, costs, regulation, business relationships, market forecasts, and market share assumptions probably mean consensus will be arrived at only gradually. Whatever architecture is chosen, it will displace the vast majority of copper investment.

Our analysis of distribution facilities for the LEC industry includes three scenarios for the adoption of FITL. Each of these scenarios is based on composite forecasts of the demand for wideband and broadband digital services. The "early" scenario assumes that fiber is deployed rapidly to meet the emerging demand for new wideband services at 1.5 Mb/s or similar data rates. The "late" scenario assumes that wideband services are deployed on copper pairs using interim copper technologies such as Asymmetric Digital Subscriber Line (ADSL) and High-speed Digital Subscriber Line (HDSL), and that fiber is not rapidly adopted until the demand for broadband services (45 Mb/s and above) emerges. The "middle" scenario is an average of the early and late scenarios.

Exhibits 7A and B show forecasts for the demand for wideband and broadband services from TFI's recent *New Services Study*.[6] Also shown is the required fiber deployment under the early and late scenarios, respectively. The relationship between deployment (which determines service availability) and demand is derived from a prior TFI analysis of the historical availability and adoption of four television-based services.[7] Exhibit 8 graphically illustrates the averaging process used to obtain the middle scenario for the other two.

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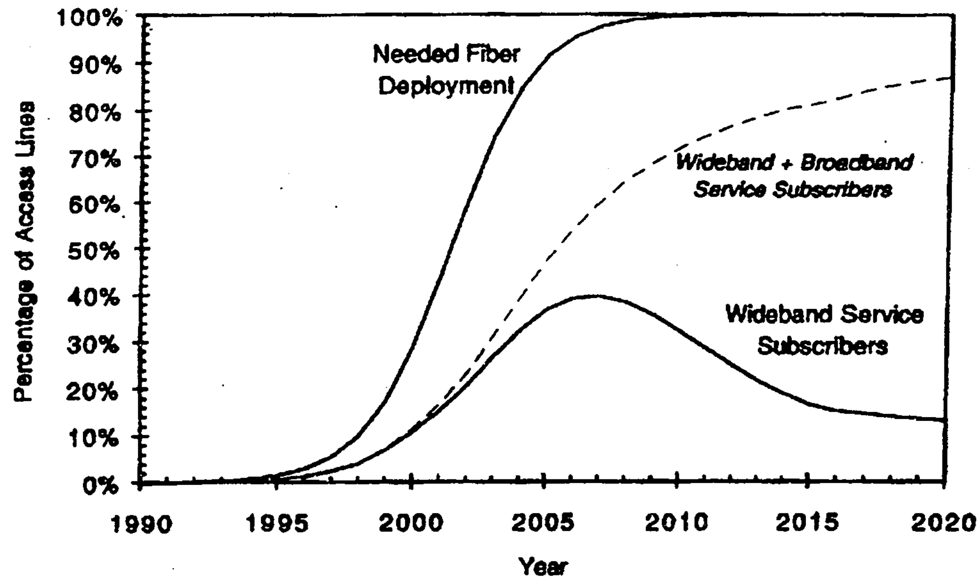
[6] L.K. Vanston, W.J. Kennedy, and S. El-Badry-Nance, *A Facsimile of the Future: Forecasts of Markets and Technologies* (1991); L.K. Vanston, El-Badry-Nance, W.J. Kennedy, and N.E. Lux, *Computer-Based Imaging and Telecommunications: Forecasts of Markets and Technologies* (1992); J.A. Marsh and L.K. Vanston, *Interactive Multimedia and Telecommunications: Forecasts of Markets and Technologies* (1992); B.R. Kravitz and L.K. Vanston, *Local Area Network Interconnection and Telecommunications* (1992); L.K. Vanston, J.A. Marsh, and S.M. Hinton, *Video Communications* (1992); L.K. Vanston, J.A. Marsh, and S.M. Hinton, *Telecommunications for Television/Advanced Television* (1992); and L.K. Vanston, *New Telecommunications Services and the Public Telephone Network* (1993) (Austin, TX: Technology Futures, Inc.).

[7] Vanston, Marsh, and Hinton, *Telecommunications for Television/Advanced Television*, pp. 123-144 and Vanston, *New Telecommunications Services and the Public Telephone Network*, pp. 45-52.

Exhibit 7A

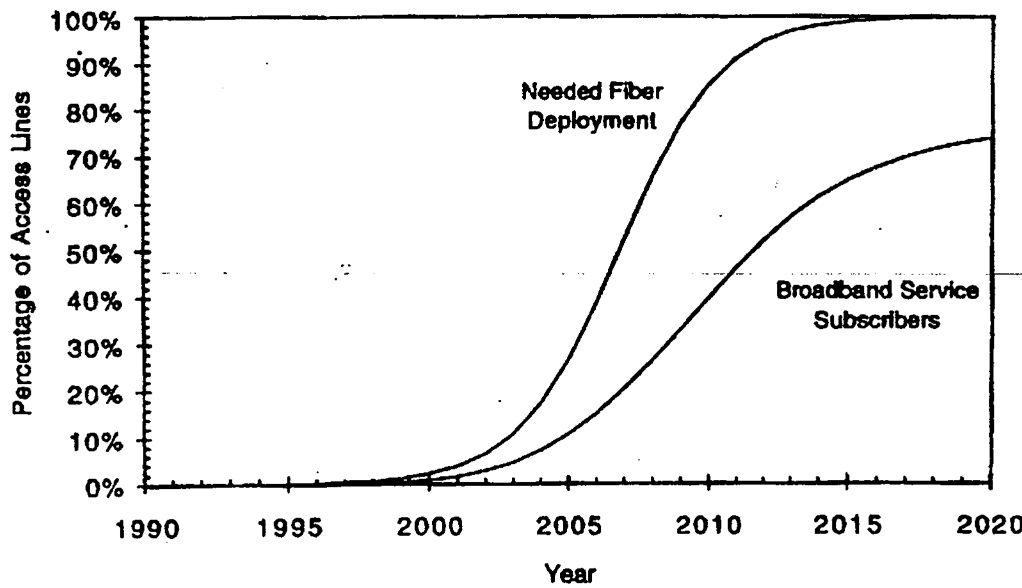
Distribution Fiber to Meet New Services Demand



Source: Technology Futures, Inc.

Exhibit 7B

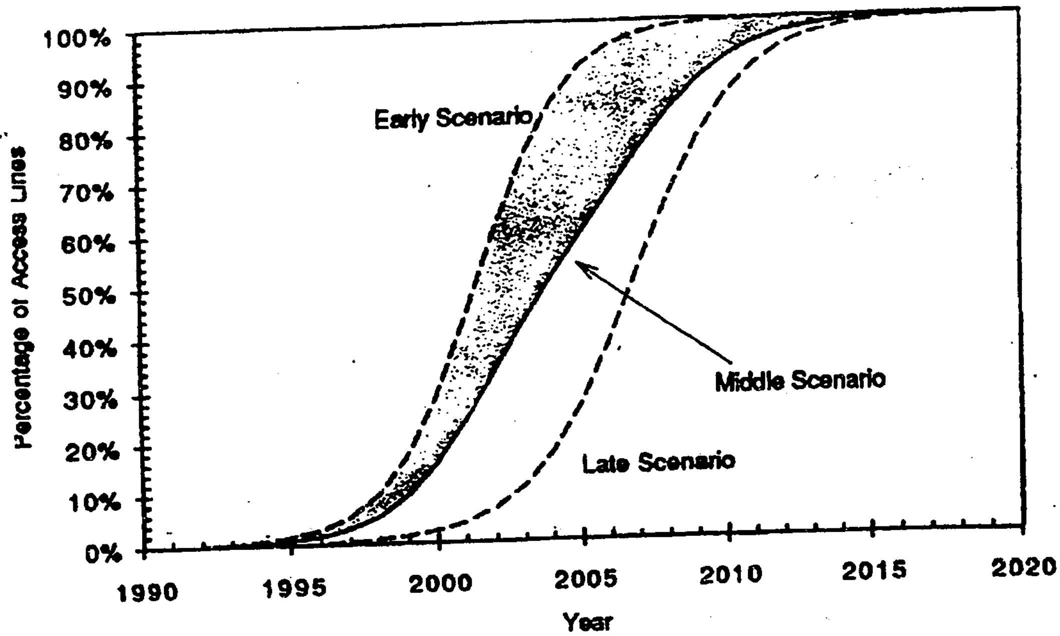
Distribution Fiber for Broadband Services



Source: Technology Futures, Inc.

Exhibit 8

The Adoption of Distribution Fiber—Three Scenarios



Source: Technology Futures, Inc.

The middle scenario represents a balancing act for the LECs. If they overinvest in upgrading copper, they risk entering the next century with an obsolete network after having sunk large amounts of money into equipment to enhance the copper technology. On the other hand, they cannot get fiber to everyone simultaneously, and, even if they could, it might not be the best plan financially. The middle scenario avoids the two extremes, with wideband services being provided on copper in the early years, then migrating to fiber as demand increases and costs continue to fall.

Adopting fiber more slowly than in the middle scenario would require too large an investment in ADSL/HDSL and divert excessive resources away from the preferable, long-term technology -- FITL. With the competition deploying more efficient technology and offering higher-quality services, this would be a dangerous course. For this reason, we believe that the middle scenario implies the maximum rational deployment of interim technologies and that the late scenario is not a reasonable choice.

However, this does not mean that the middle scenario is necessarily the best choice either. For companies that want to realistically compete in the provision of standard cable television services, as opposed to what has been called VCR-quality interactive services, the early scenario is better. Also, regardless of cable television services, many companies will adopt fiber strategies that will be much closer to the early scenario because, given the increasingly competitive nature of the industry, this is a less risky strategy. For these reasons, we believe that the likely industry FITL adoption pattern will fall between the early and middle scenarios.

Based on GTE's market strategies, it is likely that its Market Segment Three will be an early adopter since it faces the earliest and most intense competition. Segment Two will be near the middle scenario and Segment One a late adopter since they will not face competition as soon. GTE's ARL for Copper Distribution Cable is 9.7 years compared with the industry middle scenario of 10.2 years. See Exhibit 9.

Exhibit 9
Distribution Copper Survivors

Year	Early Scenario: Pct of Access Lines Fiber	Early Scenario: Pct of Access Lines Copper	Early Scenario: Pct of Copper Lines Surviving	Late Scenario: Pct of Access Lines Fiber	Late Scenario: Pct of Access Lines Copper	Late Scenario: Pct of Copper Lines Surviving	Middle Scenario: Pct of Access Lines Fiber	Middle Scenario: Pct of Access Lines Copper	Middle Scenario: Pct of Copper Lines Surviving
1994	0.8%	99.2%	100.0%	0.1%	99.9%	100.0%	0.4%	99.6%	100.0%
1995	1.4%	98.6%	99.3%	0.1%	99.9%	99.9%	0.8%	99.2%	99.6%
1996	2.8%	97.2%	98.0%	0.2%	99.8%	99.8%	1.5%	98.5%	98.9%
1997	5.2%	94.8%	95.5%	0.4%	99.6%	99.7%	2.8%	97.2%	97.6%
1998	9.6%	90.4%	91.1%	0.7%	99.3%	99.3%	5.2%	94.8%	95.2%
1999	17.0%	83.0%	83.6%	1.3%	98.7%	98.8%	9.1%	90.9%	91.2%
2000	28.4%	71.6%	72.1%	2.2%	97.8%	97.9%	15.3%	84.7%	85.1%
2001	43.4%	56.6%	57.0%	3.8%	96.2%	96.3%	23.6%	76.4%	76.7%
2002	59.8%	40.2%	40.5%	6.4%	93.6%	93.7%	33.1%	66.9%	67.2%
2003	74.2%	25.8%	26.0%	10.7%	89.3%	89.4%	42.4%	57.6%	57.8%
2004	84.8%	15.2%	15.4%	17.2%	82.8%	82.9%	51.0%	49.0%	49.2%
2005	91.5%	8.5%	8.6%	26.6%	73.4%	73.5%	59.0%	41.0%	41.1%
2006	95.4%	4.6%	4.6%	38.7%	61.3%	61.3%	67.1%	32.9%	33.1%
2007	97.6%	2.4%	2.4%	52.4%	47.6%	47.7%	75.0%	25.0%	25.1%
2008	98.7%	1.3%	1.3%	65.7%	34.3%	34.3%	82.2%	17.8%	17.8%
2009	99.3%	0.7%	0.7%	77.0%	23.0%	23.1%	88.2%	11.8%	11.9%
2010	99.7%	0.3%	0.3%	85.3%	14.7%	14.7%	92.5%	7.5%	7.5%
2011			0.2%	91.0%	9.0%	9.0%	95.4%	4.6%	4.6%
2012			0.1%	94.6%	5.4%	5.4%	97.3%	2.7%	2.7%
2013			0.0%	96.9%	3.1%	3.1%	98.4%	1.6%	1.6%
2014			0.0%	98.2%	1.8%	1.8%	99.1%	0.9%	0.9%
2015			0.0%	98.9%	1.1%	1.1%	99.5%	0.5%	0.5%
2016			0.0%	99.4%	0.6%	0.6%			
Avg Remaining Life (as of 1/1/95)			7.5			12.8			10.2

GTE ARL

	Market Segment 1	Market Segment 2	Market Segment 3	Total
Percent	51%	34%	15%	100%
Composite Contribution	3.8	4.3	1.5	9.7

Lives for Fiber Cable

Although there continues to be significant technological improvements in fiber optic cable, it is not yet clear how much of today's single-mode fiber will be replaced when superior technology becomes available. Much of the multimode fiber installed in the early days of fiber has been replaced with single-mode fiber. With such a historical precedent, we cannot rule out technology-driven replacement of fiber cable. However, except for the multimode to single-mode transition, upgrades to existing fiber systems have concentrated on the associated electronics. For this reason, we did not apply the same type of substitution analysis that we did for the other accounts. This is not to say, however, that fiber investment will have especially long lives.

As identified by GTE Labs and Bellcore, there are four major factors impacting fiber lives: technological obsolescence, topological obsolescence, mechanical degradation, and optical degradation. Technological obsolescence is to be expected even if the successor technology is not obvious today. We have already seen one generation of fiber optics be replaced, as multimode fiber made way for single-mode fiber. Also, manufacturers continue to improve the basic properties of fiber such as flexibility, strength, clarity, transmission quality, reflectivity, refractivity and durability. Topological obsolescence is where the location, routing, sizing, or architecture of a fiber installation later proves wrong. Finally, fibers eventually will crack or "go dark" with age, causing degradation in transmission capability. Although more careful fiber specification and installation has improved fiber lives, eventual wear-out is still a factor.[8] Putting these factors together, the best available technical judgment indicates that the projection life of fiber should be 20 years and that anything more puts the recovery of capital in jeopardy.[9]

Because of competition, any investment in the local exchange network now has an element of risk. The investment and accounting communities must reflect this risk in evaluating assets.[10] Although, from a technological viewpoint, a projection life of 20 years is appropriate, there should be a downward adjustment for the risk factor. Obviously, the appropriate amount involves some judgment that strays from the realm of both mortality analysis and technology forecasting, but five years may be a reasonable adjustment. Thus, a life of 15 to 20 years is recommended, depending on whether the risk factor is considered.

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[8] The physical properties of fiber are very different from those of copper, and their physical lives are affected by different factors. Thus, historical copper lives provide no guidance in estimating fiber lives.

[9] C. M. Lemrow, Corning Glass Works, "How Much Stress Can Fiber Take?," Telephony (May 23, 1988):82. Also, Bellcore Technical Advisory Committee, Generic Requirements for Optical Fiber and Optical Fiber Cable, Issue 8 (TA-NWT-000020, December 1991), p. 2.

[10] Competitive risk was addressed by Moody's Investors Service (see Telecommunications Reports [December 6, 1993]:5) with its warning: "In addition, it says the trend toward telephone companies entering each other's local exchange markets through alliances with cable TV operators and the prospect of new wireless services have increased the competitive risk at the local loop level 'significantly.' Telco's debt ratings 'are likely to be downgraded as a result.' " The same risk to the telco's debt is faced by the telco's assets.

Digital Circuit Equipment

The lives of current digital circuit equipment will be impacted by SONET equipment, along with other technology deployments. SONET will impact virtually all existing circuit equipment, including all but the most current (SONET upgradeable) digital and fiber optics terminal equipment. Our industry forecast for SONET adoption implies that, before 2005, essentially all currently-deployed digital circuit equipment will have been replaced by SONET equipment. Analog Circuit equipment not directly replaced by SONET is already obsolete and will be replaced within the same time-frame or earlier. This will be discussed following the SONET driven forecast.

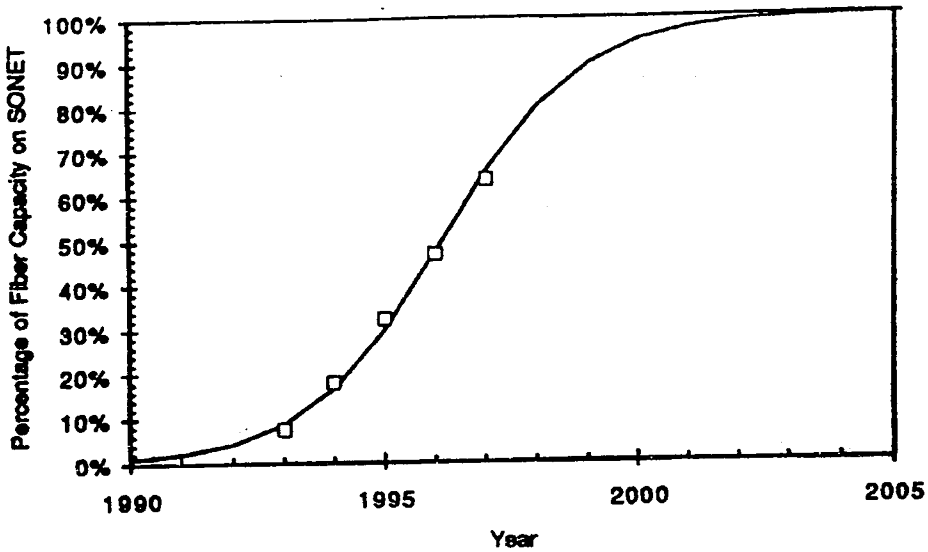
SONET is a new format for organizing information on a fiber optics channel that recognizes the need for integrating different types of traffic on the same pair of fibers. Among its many advantages are standardized optical and electrical interfaces to which all suppliers must adhere. Another is that an individual information stream on a fiber channel can be efficiently separated from the rest of the information on the channel. With a SONET add-drop multiplexer, any signal can be extracted with a single piece of equipment, without breaking down the whole signal. SONET add-drop multiplexers are already cost-competitive with asynchronous equipment, and soon will be commodity items that are integrated into almost every piece of circuit (and switching) equipment. This will render redundant much existing circuit equipment, including digital crossconnects and multiplexers.

Further, with SONET, carriers can mix-and-match circuit equipment so that they can use different manufacturers' equipment. This, of course, provides operational and equipment savings, as well as more competition among manufacturers which results in lower prices. Later on, SONET interfaces will be built directly into switches, leading to even more equipment savings. Next Generation Digital Loop Carrier (NGDLC) systems will directly link to switches through SONET interfaces. From the same unit, some channels may be connected to other switches or facilities using a built-in SONET add-drop multiplexer. Circuits could be transferred from one switch to another instantaneously. This will give carriers much more flexibility when it comes to dealing with switch manufacturers. SONET will benefit customers as well as carriers. In addition to the inherent economic benefits of a more efficient network, SONET will provide greater reliability through its support of fiber ring architectures and enhanced response time and flexibility in provisioning new channels.

Our SONET forecasts are based on fitting the Fisher-Pry substitution model to planning data for the period 1993 through 1997 from nine LECs. Exhibit 10 shows the forecast of the percentage of interoffice fiber capacity on SONET, along with the planning data. From the planning data, about 50% of interoffice fiber capacity is expected to be on SONET equipment by 1996. By 2000, 95% of interoffice capacity is expected to be on SONET and 100% by 2005. It is projected that GTE's Market 3 will be 100% SONET by 2000 and Markets 1 & 2 by 2005. Therefore, GTE's interoffice SONET equipment adoption is in line with the industry.

Exhibit 10

Adoption of Interoffice SONET Equipment

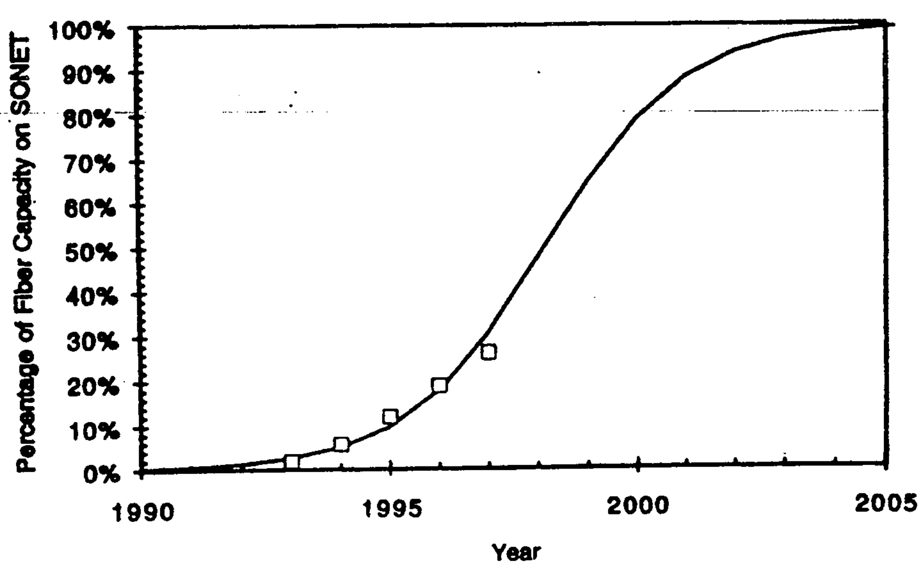


Source: Technology Futures, Inc.

Exhibit 11 shows the analogous forecasts for the percentage of loop fiber capacity on SONET. Based on TFI's industry studies, SONET adoption in the loop is expected to lag adoption in the interoffice facilities by about two years, reaching 50% adoption by 1998 and 95% by about 2002. Since GTE's interoffice SONET plans are in line with the industry as well as their FITL plans, its expected that their SONET adoption in the loop will be very close to the industry forecast.

Exhibit 11

Adoption of Loop SONET Equipment



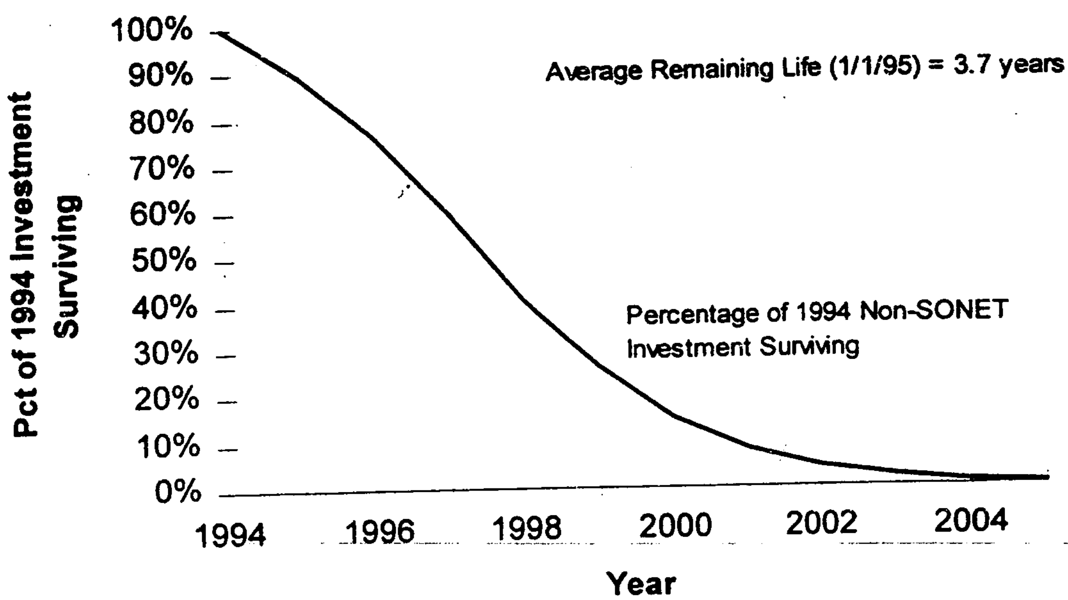
Source: Technology Futures, Inc.

Remaining Lives for Non-SONET Digital Equipment

The ARL for non-SONET digital circuit is based on combining the interoffice and loop forecast. Exhibits 12 and 13 show, in graphical and tabular form, the percentage survivor curves of non-SONET circuit investment in place at year-end 1994. The survivor curve is the average SONET adoption for all types of circuit equipment shown in Column 6 of Exhibit 14. The analysis yields an estimated ARL of 3.7 years. Since GTE's average adoption of SONET is about the same as the industry, GTE's ARL for non-SONET digital circuit equipment should be 3.7 years. See Exhibit 13.

Exhibit 12

Non-SONET Circuit Equipment Survivors



Source: Technology Futures, Inc.

Exhibit 13
Non-SONET Circuit Equipment Survivors

Year	Pct of Equipment Not on SONET	Pct of 1994 Investment Surviving
1994	88.5%	100.0%
1995	79.0%	89.3%
1996	67.6%	76.4%
1997	52.9%	59.8%
1998	36.3%	41.0%
1999	23.0%	26.0%
2000	13.3%	15.0%
2001	7.1%	8.0%
2002	3.7%	4.2%
2003	1.9%	2.1%
2004	0.9%	1.0%
2005	0.5%	0.6%
Average Remaining Life = (as of 1/1/95)		3.7

Source: Technology Futures, Inc.

Exhibit 14
Adoption of SONET Equipment Summary--
Percentage of Equipment on SONET

Year	Interoffice Transmission Equipment	Fiber DLC Equipment	Metallic DLC Equipment	Digital Crossconnec & Multiplex Equipment	Average for All Circuit Equipment
1993	7.5	2.5	2.5	5.0	5.0
1994	18.1	5.0	5.0	11.5	11.5
1995	32.4	9.7	9.7	21.0	21.0
1996	46.9	17.8	17.8	32.4	32.4
1997	63.6	30.6	30.6	47.1	47.1
1998	80.1	47.2	47.2	63.7	63.7
1999	89.6	64.5	64.5	77.0	77.0
2000	94.8	78.7	78.7	86.7	86.7
2001	97.5	88.2	88.2	92.9	92.9
2002	98.8	93.8	93.8	96.3	96.3
2003	99.4	96.9	96.9	98.1	98.1
2004	99.7	98.4	98.4	99.1	99.1
2005	99.9	99.2	99.2	99.5	99.5

Source: Technology Futures, Inc.

In addition to SONET, there are other drivers that will render existing digital circuit equipment obsolete:

1) D-channel banks have been and will continue to be replaced by digital crossconnect systems, as well as by integrated interfaces to digital switches. The adoption of digital switching is near completion for GTE with only its very rural central offices non-digital, and the predominate remaining use is for private line services which are presently declining and face competition.

2) Terminal equipment and repeaters are displaced when fiber optics systems are deployed. Our forecasts indicate that for the industry the interoffice network will also be all fiber by 2002 as will GTE.

3) Central office Digital Loop Carrier (DLC) terminals are being replaced by integrated DLC interfaces to digital switches, which also eliminate the need for line cards on the switch. For the industry, we expect that 65% of DLC systems will be integrated by 1997, compared with 43% today. This means that up to 60% of existing Central Office Terminals (COTs) will be obsolete by then. Since GTE is already over 90% digital switching, most remaining COTs are obsolete and soon will be retired.

There is a large class of digital circuit equipment-namely D-Channel banks, T- 1 terminal equipment, and CO-DLC equipment-that is largely obsolete, will have very short remaining lives, and be retired in the 2000 time frame. The exact impact can't be calculated from the data available, but inclusion of these factors would lower the life estimate for digital circuit equipment below the 3.7 years suggested by SONET adoption alone.

Analog Circuit Equipment

Other circuit investment not directly affected by SONET is voice frequency (analog) equipment which is being used for special services and backup to inter-office message trunks. Retirements of much of this equipment such as loop extenders and other conditioning equipment began in 1992 for GTE with a very concerted effort and will continue until all of the analog circuit is no longer required and has been retired. Also, special services growth is diminishing and will be subject to competition. GTE's ARL for this equipment should be no longer than TFI's industry forecast for analog circuit equipment which is 2.8 years.

Digital Switching

GTE has 59% GTD-5, 24.5% NTDMS, 11.5% 5ESSs, and 5% SCDCO and VIDAR. This report will address only the architecture and generic switching issues for the three major types (GTD-5, NTDMS and 5ESSs). The 5% VIDAR and SCDCOs are essentially obsolete and can remain in service in only extremely low growth areas with little demand for new services.

The three main types of digital switches use a modular architecture, meaning that individual modules can be replaced to take advantage of new technology. Modular upgrades can be used to increase capacity, improve performance, or add new features and capabilities without having to completely replace the switch. The analysis of technological change, obsolescence, and retirements in digital switching is more complicated than with analog switching because modular upgrades and partial (or interim) retirements must be forecasted.

Digital switching, being relatively new, has experienced relatively few modular change-outs so far for the industry. However, our forecasts indicate that we are entering a period of significant interim retirements for digital switches. GTE, having been a leader in deploying digital switching, has already experienced some retirements of earlier technology.

Existing Digital Switches

The major functional components of a digital switch are the following:

- *Central Processor/Memory-* This is special purpose computer equipment that provides the "brains" of the switch.
- *Switching Fabric-* This provides the very basic function of a switch which is making the connections between incoming and outgoing communications channels.
- *Trunk Interfaces-* These connect the switch to interoffice transmission facilities leading to distant switches.
- *DLC Line Interfaces-* These connect the switch to Digital Loop Carrier (DLC) facilities in the loop plant.
- *Baseband Line Interfaces*[1]*-* These connect the switch to baseband copper loops dedicated to individual customers. (Traditionally, these provide analog POTS service,

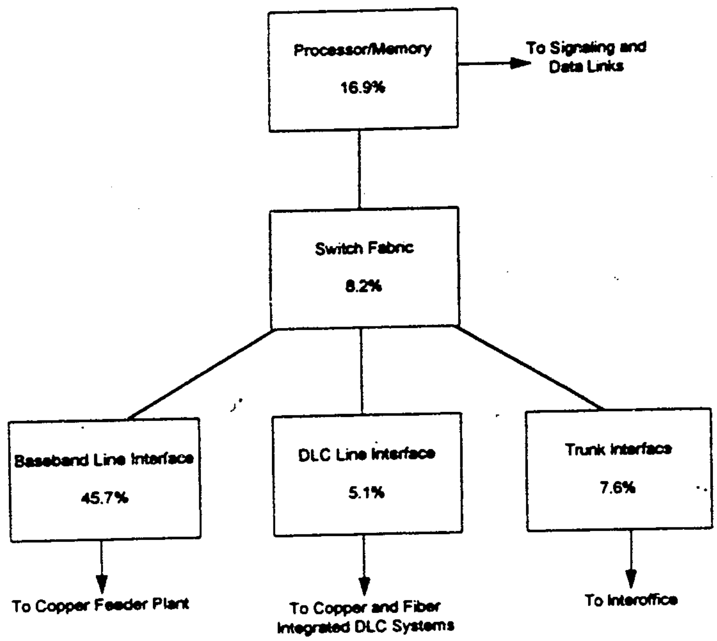
[1] Technically, baseband refers to signals that are not multiplexed or modulated, where the conductors carry the signal for only a single channel. Here, we extend the definition slightly to include services such as narrowband ISDN which involves several channels from the same customer on a single copper pair.

but this category includes equipment providing baseband digital services such as the narrowband Integrated Services Digital Network (ISDN).

- *Shell-* This is the common equipment, such as some cabling and power equipment, that is not modular and will last the life of the switch entity.[2]

Exhibit 15 illustrates how these components make up GTE's digital switching.

Exhibit 15
GTE Switching Architecture



Source: Technology Futures, Inc.

Forecast

GTE is different from the rest of the LECs in that the majority of their digital switching is GTD-5. TFI's previous industry studies did not include analysis of GTD-5s since they only represent a small fraction of the industry total. For this GTE specific report, an analysis was made to breakout the major components of the GTD-5 and then a GTE specific composite was developed as shown below in Exhibit 16.

[2] In some cases, it may include the physical housing of switch components, but often these are replaced along with the components.

Exhibit 16
Digital Switching - Component Analysis

Component	% Investment GTD-5	GTE Weighting	%Investment DMS	GTE Weighting	% Investment 5 ESS	GTE Weighting	GTE Composite
Processor/Memory	11	0.068	24	0.062	32	0.039	16.9
Switching Fabric	10	0.062	5	0.013	6	0.007	8.2
Trunk Interface	8	0.050	17	0.021	4	0.005	7.6
Line Interface	56	0.348	41	0.106	45	0.054	50.8
Shell & Misc.	15	0.093	13	0.034	13	0.016	14.3
	100	1.000	100	1.000	100	1.000	100.0

Source: Technology Futures, Inc.

The modularity of the digital switch creates interim retirements of the components that are upgraded. At the end of the life of a switch entity, most of its components will have been replaced at least once. Our approach to forecasting digital switching lives is to divide the switch into the major components described above and to project the life for each component. Then, a composite life is calculated by weighting the component lives by their percentage of switch investment. This analysis yields a composite Average Remaining Life (ARL) of 6.9 years as of 1/1/95 for GTE. Exhibit 17 summarizes the process.

Exhibit 17
GTE Digital Switching - Modular Retirement Analysis

Component	GTE % of Investment	Key Drivers	ARL (years)	Composite Contribution (years)
Processor/Memory	16.9	Life Cycle	5	0.845
Switching Fabric	8.2	Life Cycle & ATM	8	0.656
Trunk Interface	7.6	IO SONET + 2 yrs	4.5	0.342
DLC Line Interface & Baseband Line Interface	50.8	Feeder SONET + 2 yrs & DLC, FITL, & Dig Services	6.3	3.2
Shell & Misc.	14.3	ATM Architecture	13.3	1.888
Composite	100	GTE Composite ARL= (as of 1/1/95)		6.9

Source: Technology Futures, Inc.

The following observations are key to understanding the role of modular change-outs:

1) The shell is a very small part (about 10%) of the switch investment.

2) The processor/memory and line interfaces represent, by far, the greatest portion of switch investment, comprising at least 65% of the investment in the switch.

3) The investment in the switch fabric is minimal (about 5% to 10%).

4) Trunk interfaces are a relatively small part of switch investment, never exceeding 17% for the industry.

The component lives shown in Exhibit 18 were estimated by a combination of methods. The processor/memory life was based on a 1992 analysis of first generation purchases and retirements for Northern Telecom switches.[3] The switch fabric life was based on our forecast for the integration of ATM into existing switches, as well as more near-term change-outs. The trunk interface and DLC line interface lives are based on SONET adoption forecasts presented above, with a two-year lag added to account for the delayed impact on switching. The life for the largest component, analog line interfaces, was based on forecasts of the adoption of integrated DLC and FITL, as well as the impact of new digital services, including narrowband ISDN on non-DLC access lines.

The shell, which comprises about 10% of the investment, is the only part that is not modular and will last the life of the switch entity. The shell will be retired when Asynchronous Transfer Mode (ATM) switches dominate the public network. Because its percentage of the switch investment is small, the life of the shell has little influence on the composite lives of existing switches.

See Exhibit 18 for development of the ARL for each component.

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[3] L. K. Vanston, B. R. Kravitz, and R. C. Lenz, Average Projection Lives of Digital Switching and Circuit Equipment (Austin, TX: Technology Futures, Inc., 1992). Prepared for the United States Telephone Association (USTA).

Exhibit 18
Percentage Survivor Curves for Modular Categories of Digital Switching

Year	Processor /Memory	Switching Fabric	Trunk Interface	DLC Line Interface	Baseband Line Interface	Shell
1993	100.0	100.0	100.0	100.0	100.0	100.0
1994	100.0	100.0	100.0	100.0	100.0	100.0
1995	90.0	93.8	100.0	100.0	96.3	100.0
1996	80.0	87.5	88.5	96.0	91.5	100.0
1997	70.0	81.3	73.0	89.8	84.0	100.0
1998	60.0	75.0	57.4	82.7	74.4	100.0
1999	50.0	68.8	39.3	75.2	65.1	100.0
2000	40.0	62.5	21.5	53.8	51.8	99.9
2001	30.0	56.3	11.3	36.2	39.1	99.8
2002	20.0	50.0	5.6	21.8	28.3	99.2
2003	10.0	43.8	2.7	12.0	19.6	97.7
2004	0.0	37.5	1.3	6.3	12.7	93.6
2005	0.0	31.3	0.6	3.2	7.9	84.8
2006	0.0	25.0	0.3	1.6	4.5	69.9
2007	0.0	18.8	0.1	0.8	2.5	51.2
2008	0.0	12.5	0.1	0.4	1.3	33.6
2009	0.0	6.3	0.0	0.2	0.7	20.4
2010	0.0	0.0	0.0	0.1	0.4	11.9
2011	0.0	0.0	0.0	0.0	0.2	6.8
2012	0.0	0.0	0.0	0.0	0.1	3.8
2013	0.0	0.0	0.0	0.0	0.1	2.2
2014	0.0	0.0	0.0	0.0	0.0	1.3
2015	0.0	0.0	0.0	0.0	0.0	0.7
Pct of GTE Investment	16.9	8.2	7.6	5.1	45.7	14.3
ARL= (1/1/95)	5.0	8.0	4.5	6.3	6.3	13.3

Source: Technology Futures, Inc.

Switching Equipment--The Next Generation

The next major switching generation, ATM switching, is optimized to handle all types of traffic on the network efficiently and quickly. Today's digital switches use time division multiplexing to connect continuous streams of digitized voice or data at 64 Kb/s for the duration of a call. This is efficient for low speed, circuit-switched applications such as voice, but it is unusable or inefficient for high-speed digital applications, especially those with bursty (non-continuous) traffic characteristics. ATM switches, on the other hand, use small fixed-length packets, called cells. Unlike conventional packet switches, ATM switches do not introduce significant signal delay (because of the simple cell structure) which means they can be used for continuous, real-time applications such as voice and videoconferencing. However, since ATM uses packet switching, it is also good for bursty data traffic. The ability to handle all types of traffic, at all variable data rates, not only makes ATM an efficient switch, but it is also ideal for networked multimedia applications that use all types of communications.

A few ATM switches are currently being implemented by GTE in the local exchange network to serve data traffic. ATM is also being installed in private data networks and in premises networks. As more voice, image, and video traffic is added to the existing traffic on all types of networks, severe performance problems are going to emerge, and ATM switching provides the optimal solution. True public ATM networks will have to wait until internet working standards are finalized. Nevertheless, within a decade, the same standardized, high-performance switching protocol will dominate public networks, private networks, and premises networks, seamlessly integrating all types of communications. GTE will offer frame relay or switched multimegabit data services (SMDS) to accommodate customer's specific needs, but ATM is the switch of choice as the long term solution.

Exhibit 19 shows our forecast for the percentage of access lines served by ATM switching. This forecast assumes that, with its initial application limited to data services, ATM does not reach 1% of access lines until the end of 1996, but that, thereafter, ATM is adopted at the same average pace as digital switching was. The ATM access lines before 1997 are expected to provide private and semi-public data communications services and video dial-tone services provided from a local headend. After 1997, when ATM switches incorporating internet working standards are widely available, ATM switching will expand its role in the public network. This will enable the rapid growth of ATM forecast for the late 1990s and beyond.

Exhibit 19

ATM Switching—Percentage of Access Lines

Year	Digital Switching (All Types)	FITL	ATM Switching
1993	68.0%	0.2%	0.0%
1994	76.1%	0.4%	0.1%
1995	80.6%	0.8%	0.6%
1996	86.1%	1.5%	1.0%
1997	90.2%	2.8%	1.7%
1998	94.8%	5.2%	2.7%
1999	97.3%	9.1%	4.5%
2000	98.6%	15.3%	7.2%
2001	99.3%	23.6%	11.5%
2002	99.6%	33.1%	17.8%
2003	99.8%	42.4%	26.5%
2004	99.9%	51.0%	37.5%
2005	99.9%	59.0%	50.0%
2006	100.0%	67.1%	62.5%
2007	100.0%	75.0%	73.5%
2008	100.0%	82.2%	82.2%
2009	100.0%	88.2%	88.5%
2010	100.0%	92.5%	92.8%
2011	100.0%	95.4%	95.5%
2012	100.0%	97.3%	97.3%
2013	100.0%	98.4%	98.3%
2014	100.0%	99.1%	99.0%
2015	100.0%	99.5%	99.4%

Source: Technology Futures, Inc.

The first ATM switches in the public network are separate switches that are overlaid on the existing network. Next will come ATM as a separate switching fabric in existing switch architectures. ATM switches are incredibly fast, have tremendous capacity, and have a low cost per unit of bandwidth. As the cost gets even lower, it will become more economical to switch voice on ATM than on traditional switching fabrics. Once certain conditions are met, voice traffic will begin to migrate to ATM, and narrowband fabrics will be retired. Eventually, not just the narrowband switching fabric, but the entire switch entity will be retired. After all, today's digital switch architectures were not optimized for ATM, and they will eventually run out of steam like electromechanical and analog electronic switches have.