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Capital Budgeting
For Technology

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Capital Budgeting for Technology Adoption in Telecommunications: The Case of Fiber

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1.0 Introduction

The transformation of the current public telecommunications network, presently dominated by copper facilities and a mix of analog and digital technology, to a future all-digital fiber optic network is by far the largest investment program ever faced by telephone companies. While the construction and use of digital network facilities has dominated the intercity or long-haul portion of telecommunications for some time, its introduction into the local exchange has only begun. The first local exchange digital switches and interswitch fiber links were installed in the early 1980's and still account for only a very small fraction of the total investment in local telephone facilities. However, there is now a sense of urgency on behalf of local exchange companies (LECs) to upgrade their networks with digital switches and fiber optic transmission paths. The reason for the sense of urgency can be summed up in a word--competition.

The intent of this paper is to address the most pressing question facing the LECs: What will be the cost, in both time and money, to deploy the new technology? Of course, this is a familiar question which has often been posed in the history of telecommunications. A good example of past major investment decisions is the adoption of electronic switching in place of mechanical and electromechanical technologies. However, the current decision to invest in digital fiber technology is unprecedented relative to decisions of the past, since it represents a major transformation of the network in a competitive environment. Every other major investment decision was made in a monopoly environment and the investment decision was therefore almost completely dominated by considerations of service quality, cost savings, and regulatory assurance of capital recovery.

At the present time, the technology adoption decision is driven by considerations of growth, market share, and the structure of demand. The preferred technology at the margin for switched network services is clearly digital fiber and this is often the choice of new LEC competition as well. LECs are alarmed by this, because--as with bypass problems of recent years--once customers move to an alternative network, they may be lost forever. In view of this, the LECs are doubly concerned, for despite the fact that basic voice telecommunications exhibits very slow growth relative to newer value-added and service markets, they also recognize that there is a high long-run opportunity cost associated with being other than the first to have fiber. Furthermore, a fiber deployment strategy is robust to many alternative rival strategies, such as satellite, radio, or coaxial cable.[1]

Given that LECs view aggressive fiber deployment as a strategic necessity, the next step is to plan for it by developing construction scenarios which are financially feasible given what is known about technology. It is with this that the present paper is concerned. Our preliminary conclusions based on the available data is that the LECs face a large capital shortfall in their efforts to aggressively pursue widespread deployment of fiber to homes and businesses. Under current market conditions and fiber cost levels, it appears that the LECs will require about $100B in new revenues beyond the internal cash flows over the construction horizon just to cover the costs of fiber for plain old telephone service (POTS) functionality. Advanced fiber systems providing for a wide range of new customer services would cost even more.

To raise sufficient funds, the LECs will likely have to expand into new lines of business (e.g. cable television), and borrowing in the capital markets, at least in the early construction phase, may be heavy. However, there does appear to be sufficient funds available to LECs to aggressively pursue and complete a hybrid fiber/copper network where fiber is deployed in network feeder plant and interconnected to existing copper and coaxial local distribution facilities. Even for an all fiber scenario however, $100B is not an enormous amount to raise over a reasonable construction interval that would cover at least ten years.

The current regulatory environment within which the LECs must make decisions to invest in new technology is seriously flawed and needs to change if investment incentives are to be economically motivated. Accounting rules, especially regarding depreciation, do not allow for reasonable matching of future cost and revenue streams for new technology and rational investment decisions using the standard calculus of net present value (NPV) are elusive. We strongly recommend depreciation accounting revisions.

Our analysis also makes a strong case for abandoning old fashioned rate-of-return rate base regulation in favor of alternative forms such as price caps. The current regulatory regime is fraught with incentives to create internal cross-subsidies and over-capitalization. In the "good old days" of fully regulated monopoly, there may have been some justification for the depreciation accounting methods, since sharing of total costs through cost-and-rate-averaging was the name of the game.

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[1] Fiber offers certain advantages regardless of other technologies, such as use of dielectric transmission media which is not sensitive to radio and electromagnetic interference, virtually unlimited bandwidth, and privacy. No other known technology currently under consideration provides for all of these.

In today's partially regulated environment, however, it is simply obsolete. With or without changes in accounting rules, price caps would effectively eliminate perverse investment incentives for new technology, thereby solving most of the problems we have identified.[2]

The next section will provide a broad overview of the current literature regarding the cost of fiber deployment and discuss the business and financial situation of the LECs. Section 3 provides a descriptive look at the capital budgeting decision, and section 4 presents the basic LEC accounting framework and discusses the financial incentives that affect capital budgeting decisions. Section 5 describes the financial data and analyzes future investment scenarios. Finally, section 6 summarizes the analysis.

2.0 Current Situation

An examination of current industry costs and revenues is necessary to prospectively evaluate various scenarios for technology adoption. To date, most research has concentrated on the engineering costs which are currently known for fiber technology and facilities. In a few cases, the costs of technology deployment are assumed to depend partly on the structure of demand. In particular, demand is usually assumed to affect unit costs of fiber capacity through volume or subscriber density production economies, or through "learning by doing." On the supply side, unit costs are assumed to decline because of improvements in fiber technology over the investment interval. Much use is made in existing studies of models of technological substitution such as the Fisher-Pry "S" curve. The early consensus from these studies (see figure 2.0) suggests that the technological substitution of fiber for copper in the public telco network should be complete around the year 2020.[3]

What has been largely ignored in existing studies is the financial capability of telcos to fund the investment program for fiber technology adoption and a discussion of the alternatives for financing the program. The purpose of the present analysis is to bring together for the first time the costs of a fiber technology investment program in conjunction with the operating cash flow to support it. The latter perspective has generally been missing.

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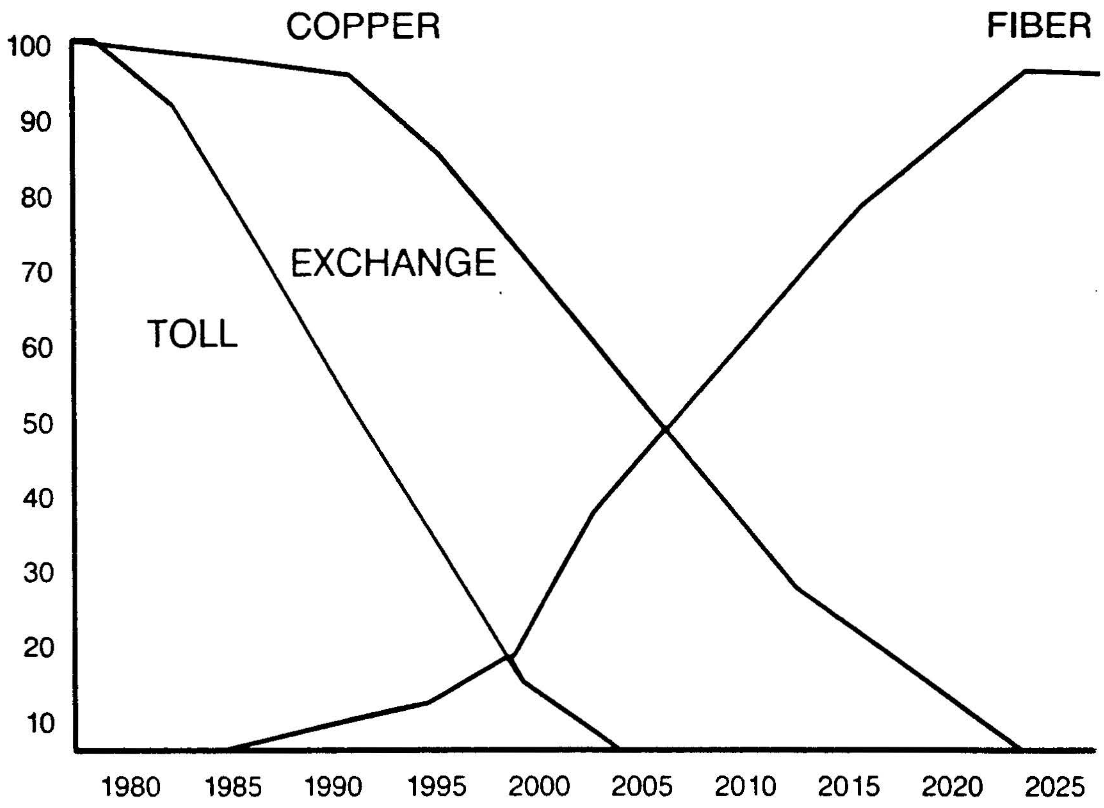
[2] For a more detailed discussion of incentives under price-cap regulation, see Egan, B.L., and W.E. Taylor, "The Economics of Ceiling Price Regulation," Bellcore, 1987.

[3] One recent major study is in Vanston, L.K. and R.C. Lenz, "Technological Substitution in Transmission Facilities for Local Telecommunications," Technology Futures Inc., Austin, Texas, 1988.

Figure 2.0



Source: Pacific Bell in Lightwave

2.10 Cost of Fiber Technology

Existing studies of the cost of fiber technology deployment in public telecommunications networks are based on engineering cost estimates, which vary widely, anywhere from $1,500 to about $20,000 per network subscriber. These figures imply a total cost of between $150B to $2 trillion for all subscriber lines. A brief survey of these existing estimates, on a subscriber-line basis, is given in Table 2.1 for a wide range of access line configurations and functionalities. At this early stage, none of the cost estimates can be dismissed out-of-hand since the estimates are extremely sensitive to assumptions regarding network architecture and the costs of devices and components. The most oft-quoted numbers are in the range of $1,500-$3,000 per subscriber for an all-fiber deployment scenario,[4] and these will provide the basis for our cost estimates.

In approaching the costs of technology adoption, it is important to distinguish between new installations and replacement of existing facilities. In the case of new installations, the marginal technology is usually preferred because of marginal cost advantages. However, for existing facilities the technology adoption decision is partly a replacement decision. This complicates the analysis as there are usually at least three alternatives for dealing with production from existing installations: (1) continue using and maintaining old equipment; (2) improve and upgrade old equipment to increase its original useful life at the margin; (3) replace all or part of old technology with new technology.

In choosing among these alternatives, it must be kept in mind that the total cost of new facilities--i.e., capital cost plus operating and maintenance costs--must compete with only the operating and maintenance costs of existing facilities.[5] The unit cost of capacity for each technology is important and is usually easier to evaluate for new capacity at the margin, since the largest component of long-run marginal cost of new capacity is up-front capital costs which are relatively straightforward to estimate. Such a comparison between copper and fiber access lines appears in figure 2.12, and indicates an economic crossover about 1992. This is based on costs only; revenue considerations could of course cause an earlier crossover.

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[4] However the studies use a variety of assumptions regarding technological advancement over time and those with cost numbers at the low end usually refer to prospective rather than current costs. For purposes of conservatism, we choose current costs or the high end of the range.

[5] For detailed discussion of the cost considerations when comparing new technology at the margin with existing plant, see Taylor, L.D., "On the Measurement of Marginal Costs," Draft 1988, and Telecommunications Demand, 2nd ed., Ballinger (forthcoming).

Table 2.1

The Cost of Fiber for Advanced Services

Study	Total/Sub	COE	%	Feeder	%
1.	2,000	78	3.90%	206	10.30%
2.	2,460	1,835	74.59%	15	0.61%
3.	18,100	6,820	37.68%	900	4.97%
4.	2,280	180	7.89%	700	30.70%
5.	7,500	NA		NA	

Notes:

1. Marvin Sirbu et al., "An Engineering and Policy Analysis of Fiber Introduction into the Residential Subscriber Loop", Department of Engineering and Public Policy, Carnegie Mellon University, 1987.
   Sirbu assumes widespread introduction of fiber in the 1995-2000 timeframe, using a switched double star architecture. Subscriber is served both by a CO and RT serving up to 1,000 subscribers. Other assumptions: The average cost drops as demand increases; $2,000/sub. is for new builds where 20% of the homes have fiber, 60% of those use new fiber services; all subscribers have access to ISDN lines. Fiber for feeder costs $0.10 per meter; the average feeder length is not given and does not include installation costs. Local loop/distribution is separated into two components, the RDU and the Subscriber premise.

2. M. Faroque Mesiya, "Implementation of A Broadband Integrated Service Hybrid Network", IEEE Communications Magazine, Vol 26, No. 1. January 1988, p. 34.
   Study assumptions: Switched double star architecture; no demand assumptions used and ISDN is in place and costs are sunk; at least two TV channels and voice/data via the ISDN BRI; 2,000 subs. per RT. Feeder cost ($15) only considers 1.5 km fiber line. Cost of modulating and multiplexing TV signal from the headend to the CO/RT not included. Switching costs include both CO and RT. Loop/distribution costs include "network termination unit" and a TV set-top unit. NTU provides interface for fiber pair and the CPE at sub. premise. NTU will cost $500 and the set-top unit will cost $110. Cost of the subscriber loop fiber is not included in the analysis.

3. United Telecom Technology Planning, "Fiber in the Subscriber Loop", February 1988, p.47.
   Study assumes new system build, switched double star with 1,444 subs. per CO. Each sub. may access 32 TV channels (one switchable). ISDN is assumed. Broadband switch provides 140 megabits to sub. Fiber length from CO to RDU is 20,000 ft. Includes installation costs. Study groups both subs. premise and the RDU cost under Loop/Distribution. RDU serves 288 subscribers. Dist. length is approx. 1,500 feet, drop is 150 feet. Cost/sub. for cable, splicing, connectors, and placement is about $1,107. Multimode fiber from RDU to the sub. premises and uses subscriber interface unit.

4. Testing Under Way: Fiber Comes Home." Data Communications, June 1987.
   Study is for target cost. No mention of component costs or other details.

5. Bellcore Estimates in "Outlook for Fiber-to-the-Home: Healthy But Cloudy," Lightwave, February 1989.

Table 2.11

The Cost of Fiber Access for POTS

Study	Date	Cost/Sub
Corning	1988	$4,600
	1995	$2,300
United Telecom	1988	$2,800
	1995	$2,000
BellCore	1988	$3,000
CTIS	1990	$3,100

Notes:

1. Corning Glass, Filing in FCC CC Docket #87-266: Telco-Cable Ownership, 1987, Attachment page 5.
2. United Telecom, "Fiber in the Subscriber Loop," p. 49.
3. "Outlook for Fiber-to-the-Home: Healthy But Cloudy," Lightwave, February 1989.
4. Center for Telecommunications and Information Studies, Columbia University.

The cost comparison in figure 2.12 only applies to new or replacement access lines and does not include the costs of new advanced electronic devices for two reasons. First, production cost data for components and devices do not exist. While some data on prototype costs are available, very rapid cost declines are expected as the technology advances over the next several years and beyond.[6] Secondly, it is easier to compare access line costs across technologies when only POTS functionality is assumed. A point that must be kept in mind is that technological progress implies additional device and component costs to augment existing copper facilities as well as to install new fiber or hybrid copper/fiber facilities. A failure of many existing studies is to directly compare fiber access line costs, including optical and electronic devices providing for advanced functionality, to costs of standard copper lines which only

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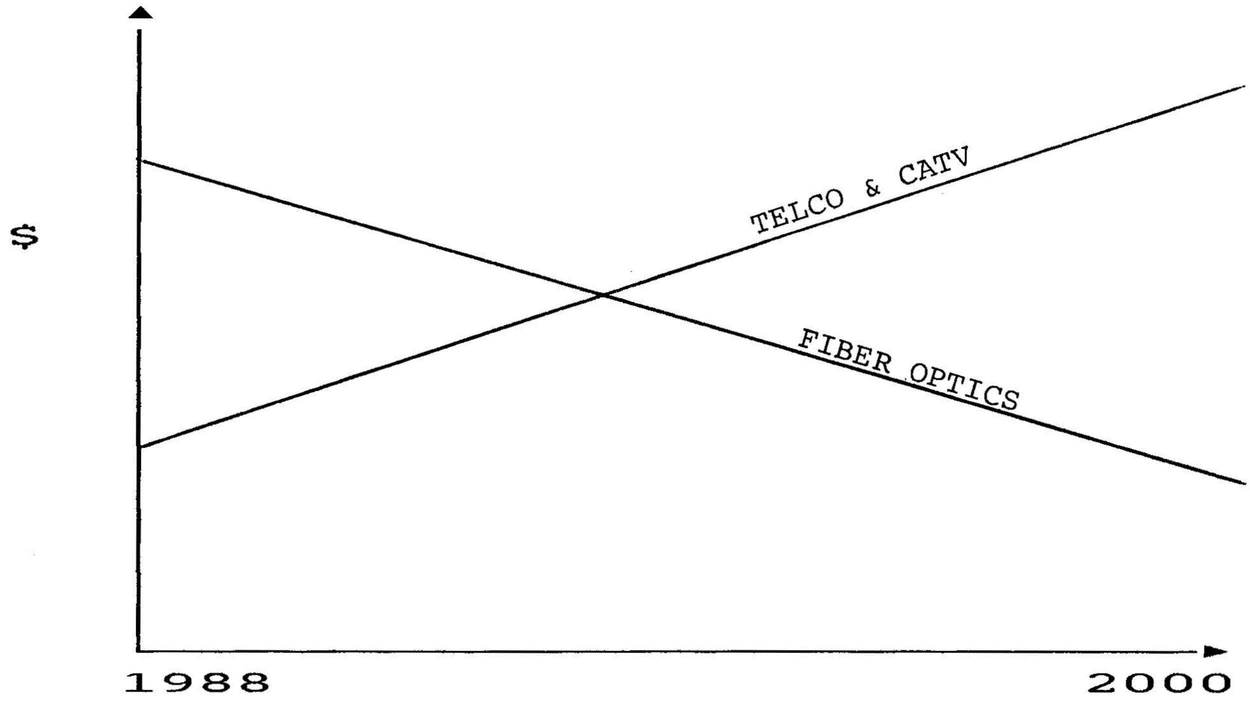
[6] Virtually all industry observers agree on this point and therefore it would be misleading to use prototype costs for such devices as optical/electronic converters, codecs, splitters, fiber muxes, connectors and interfaces. Rapid declines in high-quality fiber production costs and in labor intensive work, such as cable splicing and installation, have also occurred in just the last few years and will continue as the learning curve is extended.

Figure 2.12



provide POTS functionality. Table 2.1 provides estimates of fiber access line costs assuming POTS-only service is initially offered.

2.2 Financial Position of Telcos

In view of the substantial cost of fiber technology deployment, we now turn to an overview of the financial situation of the telcos. Figure 2.21 illustrates the total investment in assets of the telecommunications industry and its component parts. This breakdown is especially important when considering hybrid copper/fiber technology scenarios. The percentage of total network capacity which is currently fiber and digital is also indicated.[7] What is immediately clear is that only interoffice public network capacity has any significant fiber portion. Furthermore, as it has been advantageous for some time to deploy fiber in the interoffice plant, it is safe to assume that in the near future fiber facilities will represent the majority of interoffice capacity regardless of the outlook for feeder and local-distribution plant.[8] Similarly, long-haul interoffice switching capacity is already mostly digital and much transmission capacity is fiber.[9] Therefore it is safe to assume that the interoffice plant is not a limiting factor in the decision to deploy fiber technology in local networks. Thus, it is only the investment in fiber required for local facilities by LECs and other service providers which poses the investment decision with which we are concerned.

It is misleading to think of digital/fiber technology adoption as simply replacing the dollar value of embedded investment in older network technology shown in Figure 2.21, because the unit costs of capacity of the two technologies are different. However the embedded investment data does represent an important financial

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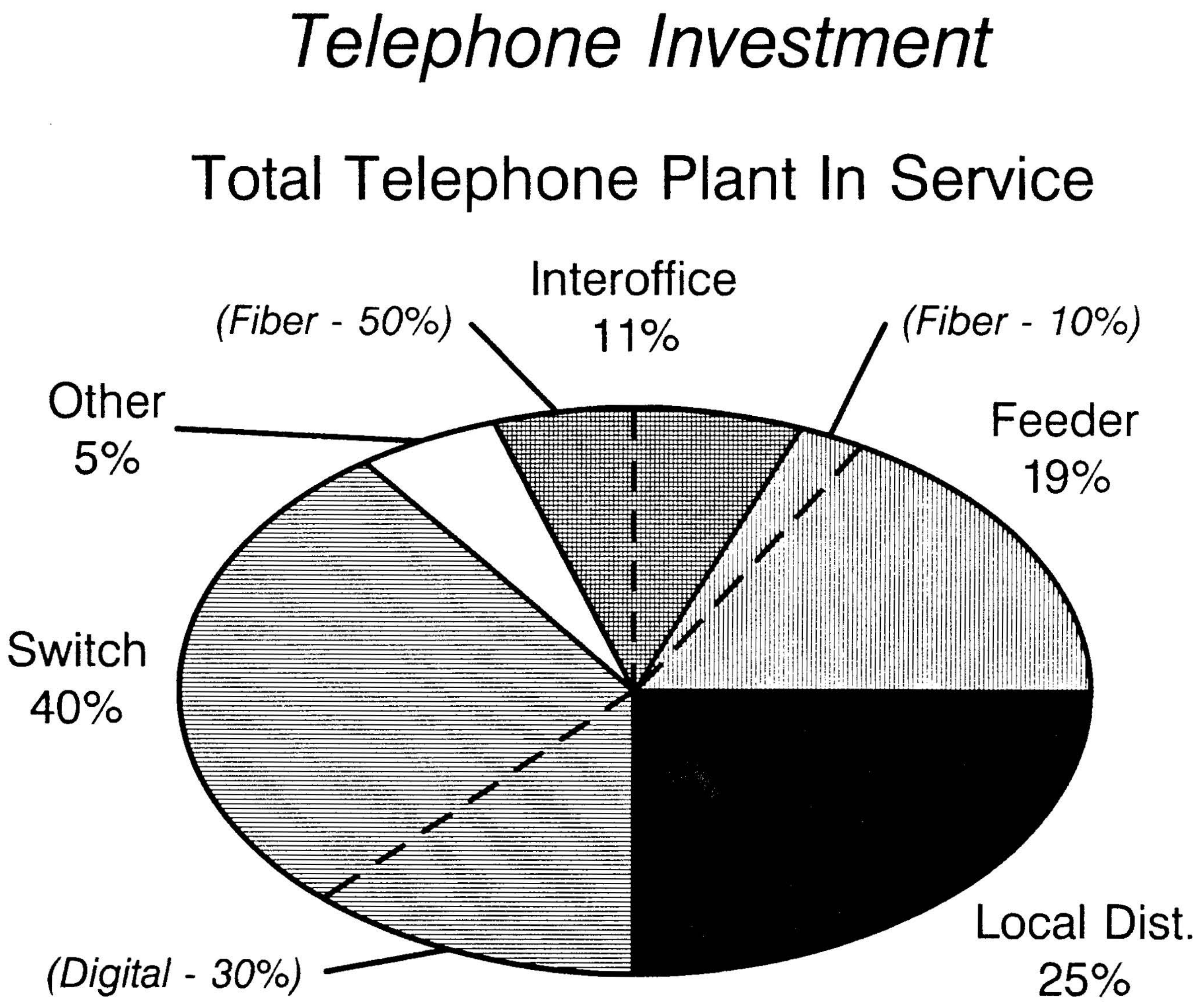
[7] There are many ways to view network capacity data and caution must be exercised especially regarding new digital fiber technology. Spare or excess capacity in telecom networks is normal as they are engineered for peak load. Capacity should be evaluated relative to actual and potential utilization since expanding capacity using digital fiber may only imply increasing speed of laser and electronic devices. This makes installed capacity of fiber versus copper or radio difficult to evaluate economically and most current measures simply use a more tangible, physical measure such as sheath miles of cable or circuit miles, even though capacity per circuit or sheath mile varies by technology. In a recent article it was noted that while installed fiber miles are only a few percent of copper, capacity is doubled; see Shumate, Paul W., "Optical Fibers Reach Into the Home", <u>IEEE Spectrum</u>, Feb., 1989.

[8] For a recent report on the use of fiber in telecommunication networks, see "Fiber Deployment Update," FCC, J. Kraushaar, February 17, 1989.

[9] As recently as 1980, the majority of AT&T toll plant was analog carrier (about 60%) and there was virtually no fiber. Today, the toll network is nearly all digital and much capacity is fiber. This is a good example of just how fast technology adoption can occur.

Figure 2.21



Telephone Investment

Total Telephone Plant In Service

part of the technology replacement decision since it is used and useful plant, the capacity of which will eventually be retired in favor of the marginal technology. The magnitude of existing plant investment affects the propensity of LECs to adopt hybrid technology deployment scenarios and this is not a factor for rival entrants. While embedded copper investment is a "drag" on fiber deployment by the LECs, it also represents a current cost advantage over potential rivals.

Figure 2.22 shows revenues and cash flow for the industry with a breakdown between IXCs and LECs. Current industry revenues are about $130B annually, of which about $40B is the IXC portion, with industry cash flow from business operations of about $40B- of which about $10B is IXC's portion. Thus cash flow from operations for all LECs is about $30B annually, of which nearly 2/3 is derived from annual depreciation charges, and the rest from net income.

Figure 2.23 gives recent industry revenue, subscriber lines, construction spending, and depreciation data. The relationship between the last two is key to the analysis that follows since most of the internal funds (or cash flow) available to support current spending for capital additions derives from depreciation accruals,[10] which have been growing rapidly. As is evident from Figure 2.23, telecommunications industry revenues have been increasing slowly (only 3% in 1988) and subscriber access lines even more slowly. The basic telecommunications business exhibits very sluggish growth relative to that for information and video services, yet cash flow and construction spending of telcos are at all-time highs. The reasons are revealing and interesting and are primarily a consequence of the way in which the telcos are regulated and the accounting procedures that this regulation imposes.

As to cash flows, the main drivers are low inflation rates, lower taxes, and higher depreciation rates. Depreciation rates have increased industry-wide about 50% since the Bell System divestiture. Throughout the 1900's, composite annual telco depreciation rates were steady at about 5% per year, implying an average useful life for telephone plant of about 20 years. Now AT&T's composite depreciation rates are about 10% and the LECs about 8%, implying an average useful life of about 12 years. These are very substantial differences and are indicative of the very significant and rapid changes occurring throughout the industry. In fact, on average, telco depreciation rates slightly exceed those of the unregulated cable television industry.
The importance of these data for the analysis is that cash flow to support capital additions is very high and this is a direct

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[10] For some background on the changes in depreciation rates, see FCC <u>Notice of Proposed Rulemaking</u> in CC Docket No. 87-447, October 5, 1987, and the references therein.

Figure 2.22

Industry Revenues And Cash Flow
(1987)

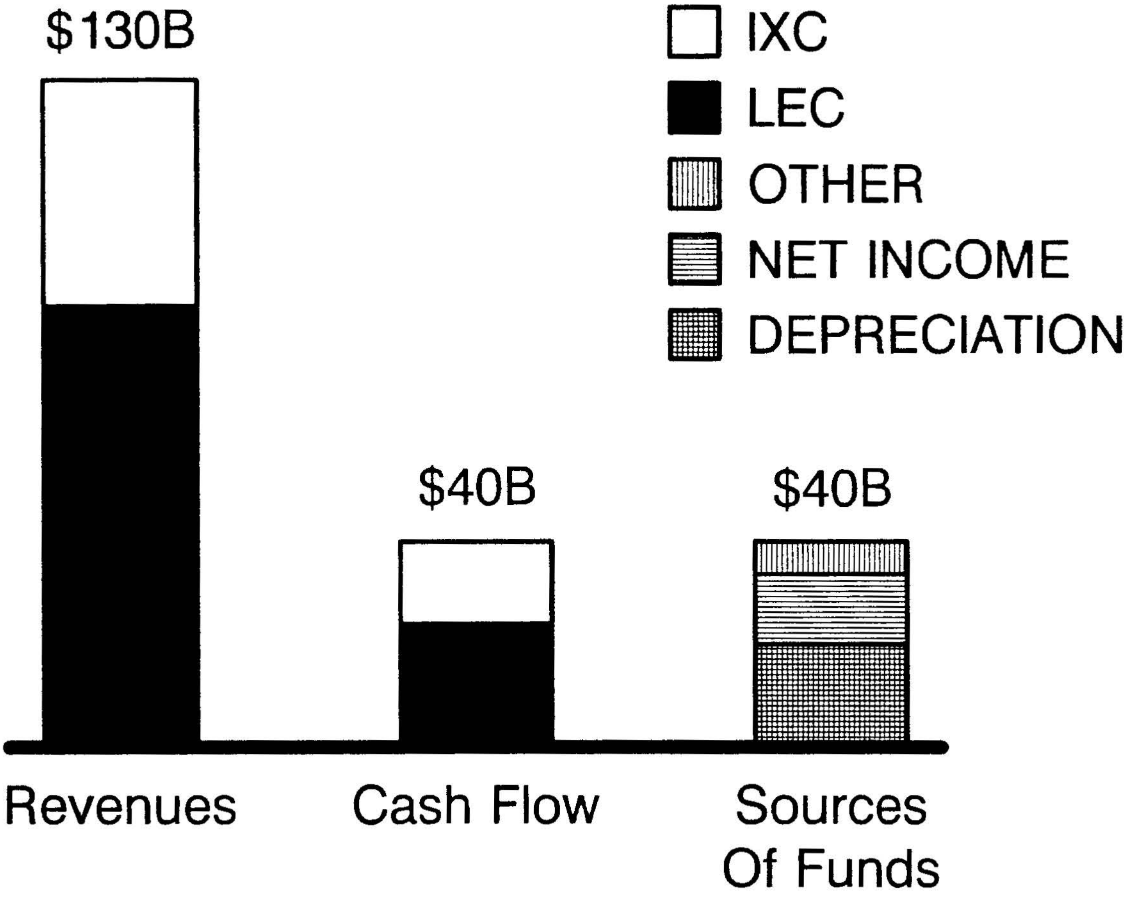
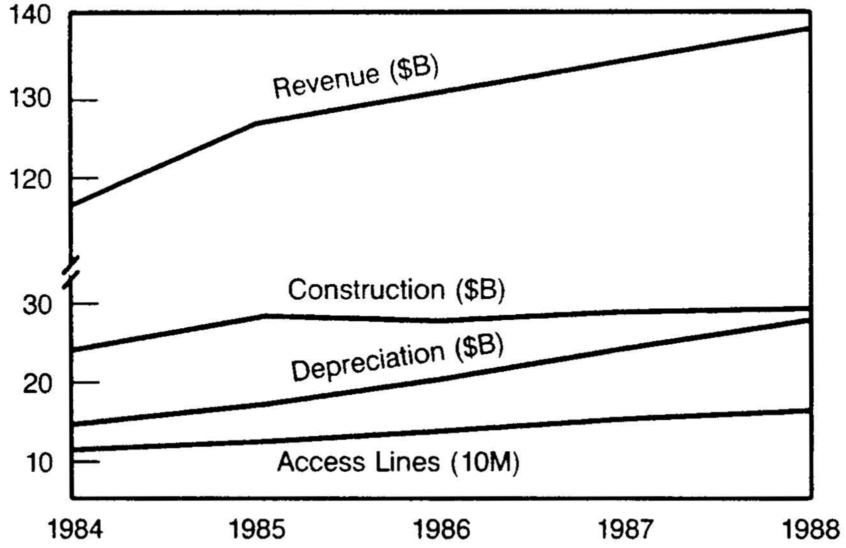


Figure 2.23

Industry Data

	Revenue	Access Lines	Construction	Depreciation
1984	$B 118	M 115	$B 23	$B 14
1985	127	118	26	16
1986	130	122	25	18
1987	134	125	25	20
1988	138	127	25	23



result of higher rates of depreciation and capital turnover. Much of this, of course, is making up for past regulatory problems which caused historical underdepreciation and a depreciation reserve deficiency that is currently being amortized.[11] Telcos spent over $25B in 1988 on capital additions, which compares with a net book value of total telephone plant of about $200B. Included were significant capital additions for digital network plant and fiber.[12]

Of the $25B of capital additions, industry depreciation contributed almost $23B, or about 90% of the total. Thus, for now at least, the competitive urgency to upgrade the telecommunications networks conveniently matches a healthy cash flow. But it is a situation that cannot be expected to continue, for the current high depreciation rates and shorter average service lives of plant will eventually cause the cash flow generated by depreciation to level off.

3.0 Telco Capital Budgeting

In this section, we provide a description of the telco capital-budgeting process. An understanding of how this process works is a necessary first step in developing a formal structure for analyzing how the LECs might be expected to convert to an all-fiber network. The telco capital-budgeting process utilizes a wide range of business decision criteria that are both economic and non-economic. An attempt is made to identify those criteria with the most impact on decisions to adopt and deploy new technology, where "new" is only loosely defined as that which is not typical of existing plant. Thus for LECs "new" technology is digital fiber.

Figure 3.01 shows how annual construction spending is being allocated and the extent to which new digital and fiber technology is used in the LEC switching and transmission plant. To avoid confusion in terminology, Figure 3.02 provides a stylized view of LEC telephone plant with clear demarcation points for switch (CO), interoffice, feeder, and distribution parts of the public network together with estimated percentages of total investment indicated for each. In recent years, the LECs have been adopting digital fiber technology in switching (both central office -- CO -- and remote terminals --RT) and interoffice transmission. Only a very limited investment is being

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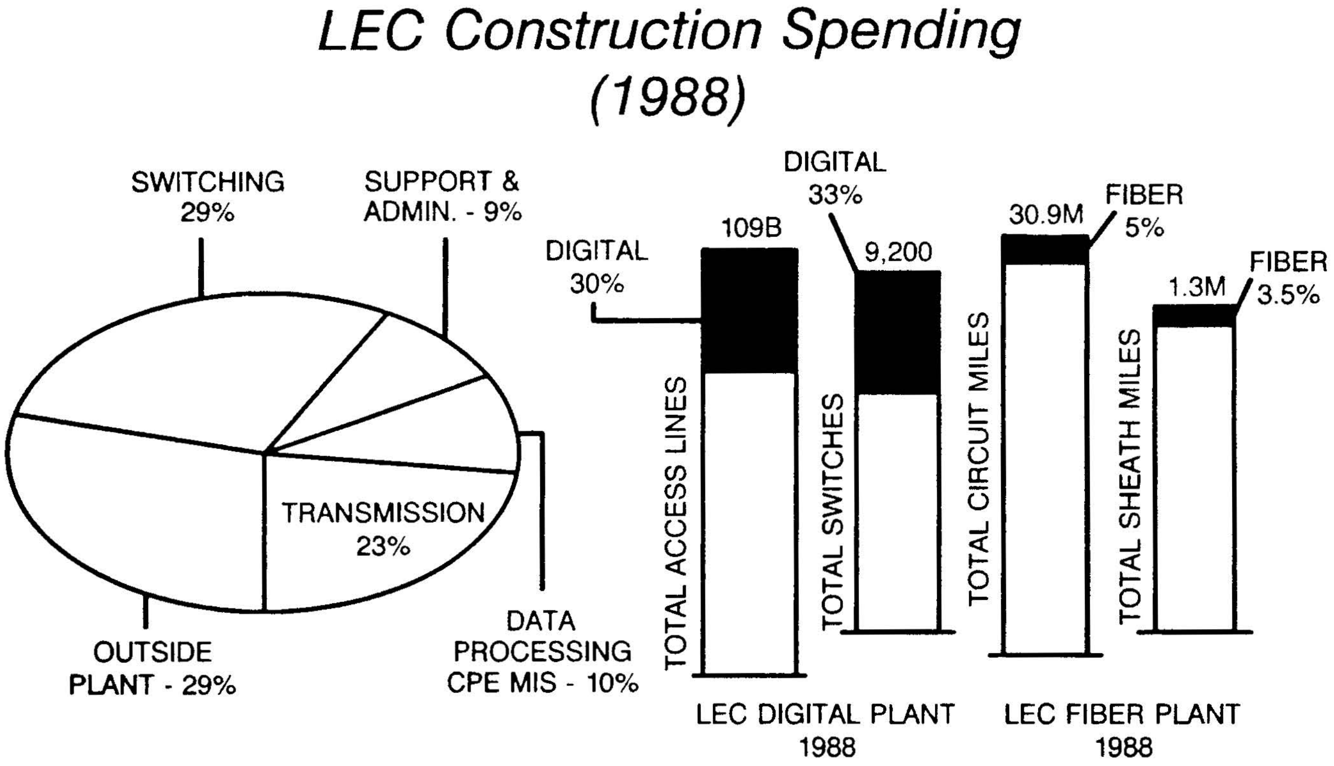
[11] For some background on the changes in depreciation rates, see FCC Notice of Proposed Rulemaking in CC Docket No. 87-447, October 5, 1987, and the references therein.

[12] For an analysis of telco capital budgets, see Telephony article, pp. 22-31, January 9, 1989.

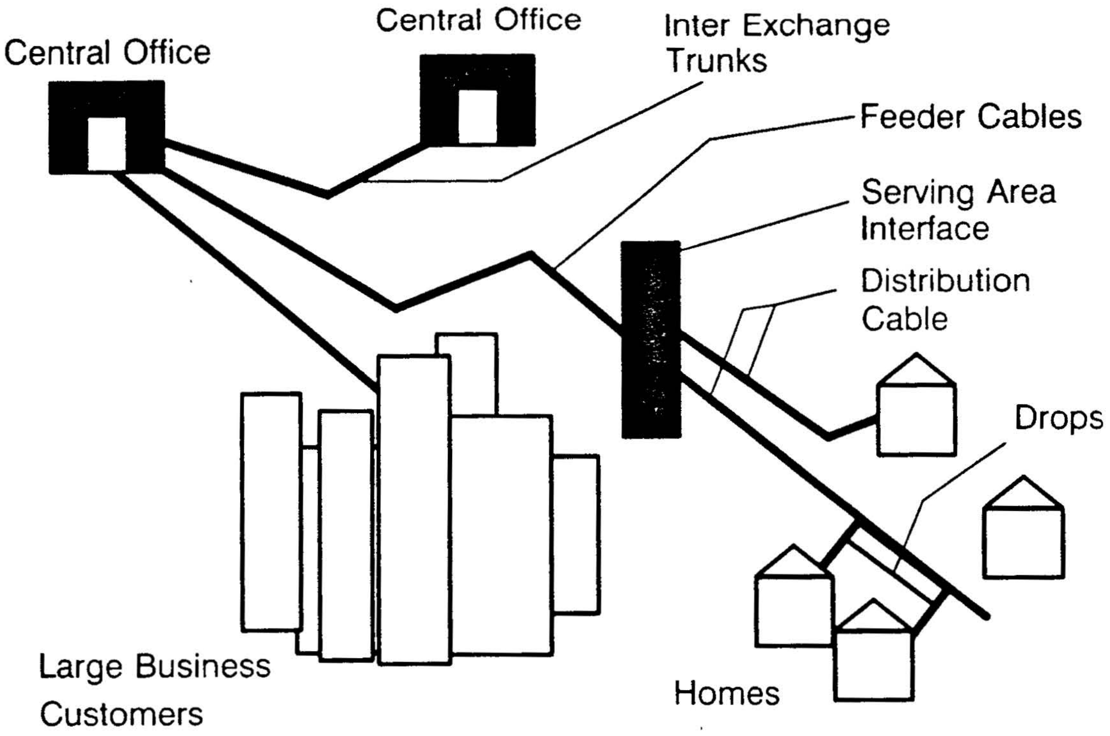
Figure 3.01



Sources: Telephony, January 9, 1989; FCC Fiber Report, February 1989; and FCC, Statistics of Common Carriers 1988.

Figure 3.02

Telephone Network



Percent Investment In:

Switch (CO)	40%
Inter Office	11%
Feeder	19%
Local Dist.	25%

pursued in the feeder plant and there is still no significant spending for digital fiber distribution plant.[13]

Based on current trends, however, it is safe to assume continued rapid adoption of digital and fiber technology in LEC switching and interoffice transmission plant. In fact, there are virtually no new analog switching and interoffice transmission facilities being installed in LEC plant. Therefore, the most important technology trade-off decisions affecting the LECs currently occur at the level of feeder plant where copper is still the technology of choice in most cases for both new and replacement facilities, while distribution plant is just beginning to be considered for digital fiber and this largely only for new construction.

3.1 The Annual Construction Budget

The LEC's annual construction budget is derived from a combination of bottom-up and top-down decision processes. Field personnel constantly monitor growth requirements, service quality, traffic levels, and local facilities performance at the local serving area level and put together a local budget based on desired projects in their respective service areas. The local capital budget is the sum of construction projects for plant replacement, growth, or maintenance expenditures which are capital-related and include upgrading and improving existing facilities to meet performance criteria. The LEC headquarters network staff adds all of these local budget requests and may alter them according to overall network planning criteria and goals. The total LEC network capital budget is then submitted to top management for approval.

At this point, LEC budget officers determine the internal funds available for the next fiscal year based on revenue and cash flow projections and compare these with the bottom-up request to determine if there are "new money" requirements. Invariably at this point, a sort of iterative give-and-take occurs to match spending to total funds available including new money requirements (if any). The process eventually settles on a number which is the budget for next year and these funds are allocated to local projects by the headquarters network staff. The total capital budget is thus a result of the combination of LEC engineering requirements and a financial dimension which is a combination of bottom-up and top-down processes.

3.2 Economic and Regulatory Incentives

Within the context of the observed LEC budgeting process lie some fundamental economic questions which affect the rate of technology adoption in the network. These include: What

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[13] See Esty, S.A., "Fiber Beats Copper in the Feeder Plant," Telephony, November 16, 1987.

determines which projects will be budgeted and which projects will not?[14] What is the cost of funds for the capital budget and how is this cost determined? What is the cost of "new money" and how does it relate to the cost of internally-generated funds? Finally, what determines how the total budget is finally arrived at? The answers to these questions require a thorough investigation of the nature of the capital budgeting process.

The decision of LECs to invest in new telecommunications technology involves a host of cost and demand factors which have increased in number and complexity since the AT&T divestiture. LECs are partially regulated, multiproduct firms whose production processes are characterized by high joint and common costs. They are also unique among large firms in that even though capital assets are fixed and immobile, the assets are widely dispersed. As shown in figure 2.21, almost half of network investment is in the form of local distribution plant. This provides some singular opportunities for flexible technology adoption strategies. In other capital-intensive industries such as auto, steel, and energy production, adoptions of a new technological paradigm involves major lump sum investments for large production facilities. This is in contrast with telecommunications for which the spatial distribution of network switching and transmission facilities is more flexible in allowing for selective upgrading and modernizing of facilities without major production interruptions. However, the slower the rate of network technology adoption in response to such fundamental changes as substituting analog copper for digital fiber does raise the cost of interworking of the two technologies during the transition phase. Nevertheless, it is very useful from a capital budgeting perspective to have the flexibility which relatively small and widely dispersed facilities provide.

It is much easier and less expensive to alter, postpone, or cancel a telephone network construction project in response to market conditions than it is to do so for (say) a nuclear power plant. The risk associated with future demand is also less because of much shorter lead times and greater flexibility in construction. Uncertainty is accordingly less likely to affect the overall decision to pursue adoption of new technology. The financial implications of reaching a "point of no return" in construction are less. "Half a switch" in terms of capacity is better than none at all, but half a nuclear power plant is not. The importance of all this for LECs is that it provides a certain amount of comfort, that should future cash flows fall short of expectations, heavy borrowing from external sources is not necessarily required at the risk of derailing overall investment

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[14] Individual construction projects are usually evaluated and funded based on NPV and pay-back type analyses using computer-based financial models such as the CUCRIT model originally developed by AT&T.

strategy. The bottom line is that no investment costs are sunk until actually committed.[15]

We now turn to the impact of regulation on telco investment. Traditionally the regulated LEC's investment in new network technology varied directly with demand growth, cost savings, or improvements in quality of service. In the post-war era, LEC growth was substantial and borrowing for construction was normal. It is only in recent years that sufficient funds for capital spending programs have been internally generated. The many factors which have contributed to this situation were mentioned earlier. LEC cash flow is at an all-time high and so is capital spending, and yet growth in lines and revenues is at post-war lows.

One is tempted at this point to ask, what is all this spending for? But this is not the right question since the data in Table 3.01 show the nominal answer. The questions that should be asked are why is all this spending occurring and is it economically justified? The answer to the first question is that recent levels of capital spending are occurring because cash flows are sufficient to support them and still meet shareholder demand for dividends, even with only nominal access line and revenue growth. However as indicated above, the healthy cash flow that LECs are currently enjoying are really short-term aberrations that have been caused by favorable changes in tax and depreciation rates.

Under rate-of-return regulation, there are only a few options for spending internally-generated cash flow, especially that part which derives from telephone plant depreciation. Depreciation rates have been adjusted upward primarily because of competition, which, among other things, has caused regulatory commissions to approve higher rates in order to amortize state and federal depreciation reserve deficiencies brought about by historical depreciation policies which held rates artificially low.[16] The options for spending the increased cash flows that these amortizations generate are not what they would be if LECs were not pervasively regulated in the telephone end of the business. Three options are to increase cash holdings, increase dividends, or reduce rates. These are not good short-run management strategies since dividend and tariff stability is a regulatory goal; besides, regulators constantly looking over management's shoulder may feel inclined or pressured by their political constituencies to take the situation as one of excess profits and penalize the LEC accordingly.

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[15] See Taylor, L.D., "On the Measurement of Marginal Costs," ref. ftn. 5.

[16] Ref. ftn. 10.

A fourth option would be to invest the funds in other lines of business and diversify. Again regulation discourages this, partly by rules of law and partly by affecting incentives. First, the capitalization structures and plans of LECs are regulated and for the RBOCs, the capitalization plans of new businesses must be approved by the MFJ Court and some state commissions unless the businesses are structurally (financially) separate from the telephone business. While the point in this case is moot, even if the LEC could legally fund new ventures from telephone operation cash flow, the "over-the-shoulder" effects of regulatory monitoring would probably prevent it from being a reasonable business option. There is a certain amount of "free" cash flow which is net cash flow after dividends and telco capital additions, and these funds in 1987 amount to 3.6% of total cash flow from operations.[17]

Given the regulatory and institutional environment within which the partially regulated LEC operates, the option with the highest payoff and least uncertainty is to invest the cash flow in new telephone plant. This is not only a use of current funds to provide for a return in the current period (since depreciation is an allowed expense for ratemaking purposes), but will replenish the rate base to prevent rate declines--and in turn total profit declines--in future periods. This observed phenomenon is due to stringent rate-of-return regulation and seems to set a floor on construction program spending in any given year. The available data bear this out. In fact, all major LECs tend to spend on annual construction an amount equal to its internal cash flow after dividends, regardless of demand for new lines and the level of revenues (which in some cases may even be declining). Smaller LECs, on the other hand, subject to much less regulatory and legal scrutiny, have not in recent years spent anywhere near the annual amount from telephone plant depreciation on new construction.

There is another significant investment distortion caused by rate-of-return regulation of a partially regulated LEC. Assume that a LEC is considering investing in network plant for basic service under the usual assumption that the return it will receive is equal to the allowed ROR of (say) 13%. Another option it may consider is to invest the same funds in another type of telephone plant, a portion of which is useful for providing both basic and new advanced services, and that the expected market return on the new services is much higher than the allowed or ceiling ROR. The LEC has no strong incentive to invest in the type of network plant which provides the highest market return since it is not allowed to earn more than 13%. Thus, the firm is more risk-averse than necessary or socially desired. Only weak or indirect incentives exist to invest in the advanced plant due

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[17] For RBOC cash flow data for 1987, see Industry Surveys for Telecommunications, June 16, 1988.

to LEC concern that if it does not, an alternative vendor of the new advanced service will come along and possibly cut into the LEC's basic business, or if the LEC believes that, at the margin, small gains in ROR are possible as regulators in the short-run cannot prevent it from achieving higher profits due to regulatory lag or if it is earning below the allowed return.

In a market-driven situation, a LEC which has a business planning priority for technology adoption and network modernization may rationally choose to begin a sinking fund for future construction which will later be spent as timing dictates. Yet, just because regulators only accept money spent in the current period for rate-making purposes, the opportunity cost to the LEC of applying current cash flow to a sinking fund is too high for this to be an attractive option.

The situation for the LECs is even more perverse when one examines the operating incentives created by the official depreciation accounting method itself. Not only are depreciation rates for each category of plant proscribed, but the composite average only is used for capital recovery and accruals to the reserve account. Therefore, an accurate portrayal of the source of net cash flows and matching of sources and uses of funds is impossible. While the age-old regulatory maxim of rate averaging would prevent meaningful rate/cost relationships anyway, rate averaging as a policy of social engineering is not a good reason to distort cost (depreciation) streams. In an era of the fully regulated monopoly, there may have been some justification for these depreciation accounting methods, however, in today's partially regulated environment, it is outdated. Cash flow may derive from old plant with no book value or from relatively new plant, but without knowing which can cause replacement or retirement decisions to be severely distorted. Business/residence and regulated/unregulated cost and revenue streams are confused and hard to identify. Internal cross-subsidies can also arise, for traditionally regulated services may be the source of funds for provision of new services and facilities in unregulated markets and vice-versa.

4.0 Depreciation Accounting

As suggested earlier, telco investment behavior is significantly affected by the methods of depreciation accounting that accompany rate-of-return regulation. This is because current and future-period cash flows of LECs are generally dominated by the depreciation allowances set by regulators. Although the cash-flow effects of these allowances have already been discussed, it is worth emphasizing exactly what these effects are. In the first place, depreciation is a large non-cash annual expense and represents almost 2/3 of LECs' cash flow from operations. These funds are the major source of internal capital available for funds are the major source of internal capital available for financing new construction, even though in theory they represent recovery of old capital, not necessarily funds for new capital.

In the second place, because of regulatory rules and the political and economic dispositions of regulators themselves, cash flows from depreciation generally must be spent in the year received or LECs risk two pernicious side-effects. The first is that current period earnings may appear excessive relative to the authorized accounting rate-of-return. The second potential adverse effect is that since the rate base declines by the amount of depreciation unless an equal amount is spent on current-period construction, future-period revenue requirements -- and in turn rates -- would be lower than otherwise. Such a perception is economically wrong because depreciation should be viewed first and foremost as legitimate capital recovery and only secondarily as a source of funds for plant modernization. Yet any attempts by LEC management to invest these funds elsewhere or return the recovered capital to shareholders would surely be viewed displeasingly by regulators and could result in lower profits for the firm. On the other hand, management is also not inclined to return the funds to ratepayers since this would set a bad precedent; also, it would not be sustainable and would accordingly not be consistent with rate stability.

As noted earlier, regulatory rules provide a further distortion to LEC investment incentives by curbing the use of sinking funds. When long-range business plans call for the deployment of a new production technology, as in the case of fiber, one reasonable approach to meeting the future construction spending requirements would be to establish a sinking fund. However, regulatory rules discourage such a fund, and this causes management to adopt non-economic strategies to salvage short-run profits and still find money to modernize. What we observe are requests to regulators to increase depreciation rates on existing plant, thereby decreasing book service life of that plant, and increasing cash flow available for modernization. This creates a cycle which is a self-fulfilling, albeit uneconomic, replacement of capital. This is a clear case of confusing apples with oranges, for average capital consumption rates should be uncoupled from the funding of new technology deployment. This is not to say that technological obsolescence is not a legitimate cause of shortened service lives of existing plant, only that availability of a new technological alternative does not necessarily force obsolescence of all embedded plant.

4.1 The Basic LEC Accounting Model

The following basic depreciation accounting model is useful for demonstrating the real-world financial aspects of past LEC investment decisions and for evaluating decisions prospectively.

The framework is illustrated in Table 4.1, which contains LEC accounting data for the post-divestiture years 1984-1988.

Table 4.1

LEC Investment ($B)

	(a) GPIS	(b) DR	(b/a) (%)	(a-b) NPIS	(c) DE	(c/a) CDR(%)	RETS	ADDS
1984	186	42	22.82	144	12	6.41	7	18
1985	201	50	24.72	151	14	6.80	8	20
1986	214	58	26.99	156	16	7.21	8	21
1987	222	63	28.12	160	18	8.01	9	20
1988	231	71	30.87	160	19	8.07	9	21

def.: GPIS - Gross Plant In Service (total communication plant)
DR - Depreciation Reserve (accumulated depreciation)
NPIS - Net Plant in Service
DE - Depreciation and Amortization Expense
CDR - Composite Depreciation Rate
RETS - Plant Retired
ADDS - Plant Added

The mechanics of the accounting process are as follows:

1. GPIS is the sum of original book cost of all past LEC telephone plant investment which has not yet been retired. As expected, GPIS exhibits steady growth. Original book cost is depreciable cost at the time the asset is purchased and is equal to: Original Cost - Salvage + Cost of Removal; where salvage and cost of removal are estimated at the end of the book service life of the asset.

2. DR is primarily the sum of historical depreciation expense accruals and other special adjustments such as amortization and unanticipated costs of asset removal. DR as a percentage of GPIS gives a snapshot of recovered capital as of the year in question. Notice that it is rising rapidly due to increases in allowed depreciation rates and amortization of past DR deficiency, where the deficiency is defined as the difference between the book DR and the theoretical DR. The theoretical DR is based on estimates of actual service lives through the use of plant mortality rates. The LEC book DR reserve is about 31%. For most competitive electronic/communications industries, it is much higher (usually between 40-50%) and for AT&T it is about 50%.

3. NPIS is the accounting rate base and is simply GPIS minus DR. Revenue requirements and in turn tariff rates are set based on the level of NPIS.

4. DE is annual depreciation and amortization expense. It results from multiplying GPIS by the regulatory-approved composite depreciation rate (CDR). CDR is a weighted average of depreciation rates of all categories of plant in service. As has been noted, the primary reasons for the rapid post-divestiture increase in DE are: (a) regulatory approval of shorter service lives for plant in service; (b) changes in depreciation accounting conventions; (c) amortization of DR deficiencies. Of course, DE and CDR cannot rise

forever or eventually DR will get too high relative to what regulators would accept or relative to the theoretical DR. Also, the service life of new plant at the margin would, at some point, exceed the average life of remaining embedded plant and the overall weighted service life would begin to rise again (and CDR will fall).

5. RETS is plant taken out of service (retired) at original book cost. Retirements reduce dollar-for-dollar both GPIS and DR accounts, hence if they occur at or after the end of assets' original book service life, they will have no effect on the rate base (NPIS). Because LECs use composite depreciation accounting, there is no gain or loss on asset retirements at the point of retirement.[18] Because there is no such thing in regulatory accounting as plant-specific depreciation expense or reserves, the implicit assumption is that "early" and "late" retirements cancel out. However, early retirements can in fact cause nominal increases in the rate base because the fixed CDR is applied to a smaller GPIS, lowering DR accruals and subsequently causing a slightly higher NPIS. This is but one of many distortions that can be caused by the composite depreciation accounting rules. Notice that in a steady (no growth, no inflation) operating business environment, RETS, DE, and ADDS would tend to equality and GPIS and NPIS would remain unchanged over time. Whereas plant retirement does not directly affect the level of the rate base (NPIS), a <u>write-off</u> does. Write-offs (asset devaluations) directly reduce GPIS dollar-for-dollar of the write-off, but DR is not affected, causing NPIS (GPIS minus DR) to be reduced.

6. ADDS is gross telephone plant additions also commonly called capital additions, construction, etc. For book accounting purposes, it is usually the depreciable part of original book cost (i.e. cost - salvage + cost of removal). ADDS increases GPIS dollar-for-dollar.

4.2 Distortionary Implications of Depreciation Accounting

The simple accounting structure of Table 4.1 yields a number of basic insights about the LEC operating environment and the distortions in investment incentives it creates for management. In general, the accounting and regulatory rules often give LECs incentives that are opposite to those that would emerge from an economic or market-based environment. Emulating the latter is, in theory, usually taken as a primary goal of regulation. LECs are constantly conducting a balancing act between depreciation charges, construction spending, and new finance requirements. In the 1970's, LEC growth was strong, depreciation charges were artificially low, inflation, interest, and tax rates were high (although they were substantially tempered by tax credits and deferrals), construction spending to meet growth was high and so were new finance requirements. Not only were there large rate increases but borrowing in capital markets was high, even with high interest rates. If there ever was a time to increase depreciation rates to a more economic level, the 1970's was the time to do it, but the regulators could not handle the short-run rate increases that this would have entailed. LEC telephone rates

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[18] For a review of the mechanics and principles of composite depreciation rate accounting, see Meigs, Walter B., <u>Intermediate Accounting</u>, p. 531, McGraw Hill, New York, 1978.

were rising rapidly throughout much of the 1970's and the political pressure faced by regulators did not allow for further rate increases. Despite the increased rate levels and low depreciation rates of the 70s, LECs did not generally earn the full allowed ROR.

In the 1980's, growth, inflation, taxes, and interest rates fell considerably, relieving pressure on rates and allowing for regulatory approval of increases in depreciation rates of over 50%. Some of the windfall from tax reform was used to "cover" new higher depreciation rates, among other things, instead of passing it through to ratepayers by reducing rates. In many states, a sort of three-way compromise was worked out (between the LEC, regulators, and consumer representatives) where a part of the tax windfall was passed on to ratepayers and part to the LEC. This resulted in healthy post-divestiture cash flows and no need for external borrowing for new construction, despite attractive interest rates. The upshot of all of this is low growth, yet unprecedented construction spending. Regulators would perhaps want to appear more progressive and try to adjust to changes in market factors as they occur; however, they do not always have the resources and information of the LEC at their disposal. As long as LEC investment spending in the public network does not bring pressure to increase basic rates, there is some presumption that things are working well and that the local phone subscriber will ultimately benefit from modernization. Recently, however, some state regulators have questioned the prudence of LEC investment activities; but it is the very system of regulation which may be encouraging suboptimal investment.

While this discussion at first suggests the conclusion that LEC capital spending is too high -- especially if it is for copper facilities -- this is not the correct implication since LECs are simply pursuing business interests under the incentive structure they face. Rather, in periods of healthy cash flow and when the future construction requirements for new technology are substantial, such cash flow should be allowed to be held in escrow to fund new construction as economics would dictate. For example, a very large program may be optimal to undertake in some given future year as timing dictates (e.g. when next-generation equipment is ready from manufacturers), and this is expected to require a very substantial sum of money accumulated over more than a year. However, LECs cannot create a sinking fund for regulatory purposes and may invest suboptimally, since it must spend cash flow in the year received. The last two decades clearly show how regulatory depreciation rates have adversely affected matching cash flows with spending needs. In other countries, such as Japan, where such strict regulatory and accounting rules do not exist, depreciation and borrowing rates are more market-driven and long-term planning is more rational.[19]

Even though current cash flow is high, LECs cannot be complacent, just because of increased depreciation rates and short-run decreases in taxes, growth, and inflation. The future does not bode well for LECs as growth and investment needs are likely to rise, just as depreciation rates level off or even begin to fall. AT&T spending and depreciation are already leveling off as its DR is now up to 50%; however, they were very aggressive to upgrade and digitize their long-distance network since divestiture, and therefore future construction and cash flows necessary to support it are reduced.

The LECs are still only about 30% digital in switching, and fiber in the loop plant is nominal. Heavy borrowing may be required just when interest rates appear to be rising. As we have seen, sinking funds are infeasible because regulatory accounting rules discourage them. In essence, funding technology adoption with increases in depreciation of existing plant is doing business planning with smoke and mirrors. Increasing depreciation increases current cash flow, but since it decreases the rate base dollar-for-dollar, it decreases cash flow in the future.

Another problem should be noted. Because of the use of composite depreciation rates, plant retirements do not reflect the underlying economics and cross-subsidies may abound but never be noticed. Much telephone plant is used and useful well after its net book value is zero, yet other plant is retired or taken out of service early. The books cannot show this, and plant with zero or low net book value in effect represents a cash cow which in some sense covers future period losses on plant which is prematurely retired. (Recall there is no book gain or loss on retirements when they occur.) This is an anomaly of composite depreciation-rate accounting which is perpetuated by rate-of-return regulation.

5.0 Data and Analysis

This section presents a first attempt to put the fiber technology adoption process in terms of the time and money required to do it. The accounting framework in Table 4.1 provides a top-down financial view of the process. The more detailed and complex technological substitution is an engineering process which is beyond the scope of the present exercise; however, some basic

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[19] For example, in Japan where telephone penetration is 98%, access line growth is very slow and telephone revenue growth is comparable to the U.S. Yet last year, NTT alone spent about as much as all RBOCs combined and has a DR of over 50% and still borrowed about a third of its construction budget to aggressively modernize. In the U.S., both regulators and Wall Street would be expected to react quite adversely to a situation like this.

engineering assumptions will be required. Although the analysis here is on a scale that is only useful for overall financial policy analysis, the fundamental economic implications have general applicability.

5.1 Fiber Access Line Costs

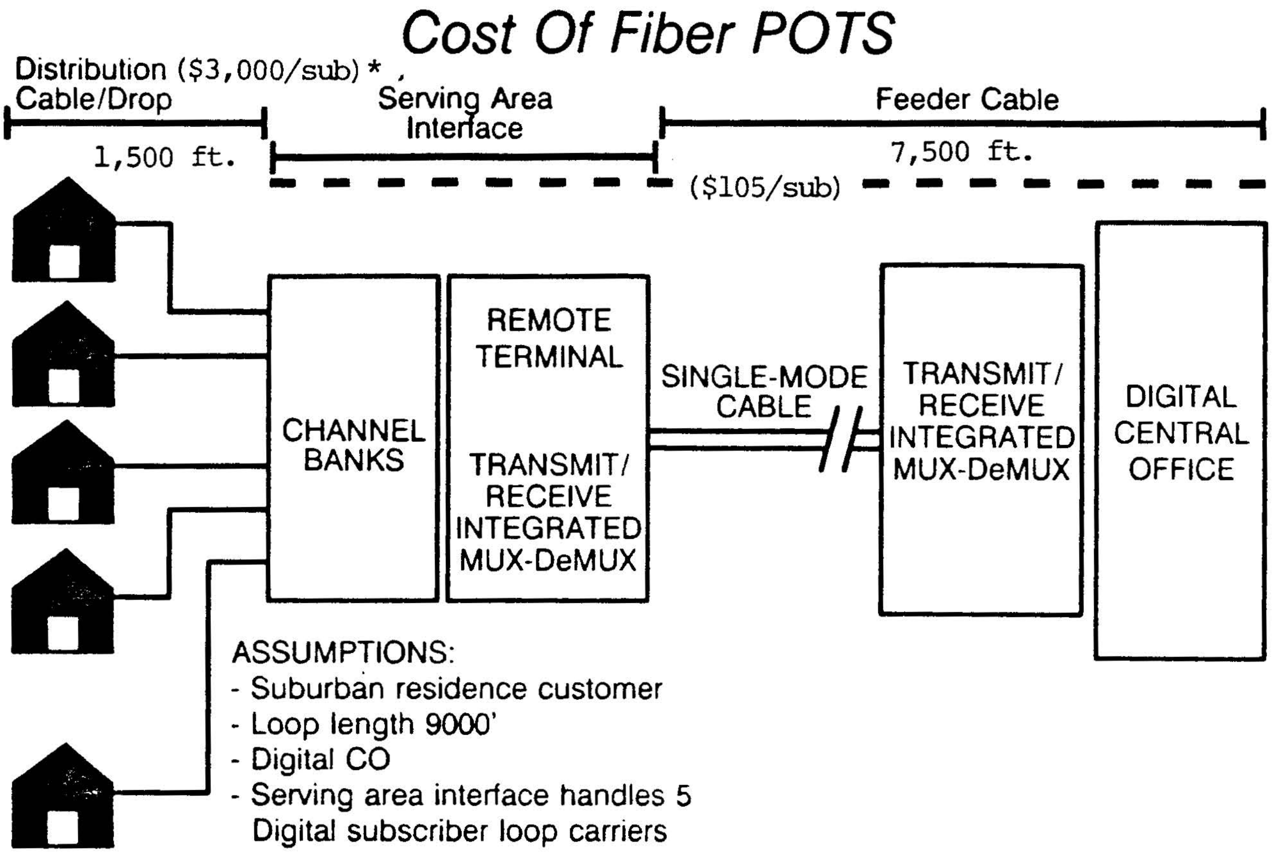
Currently, most major LECs face serious regulatory hurdles or are barred altogether from providing many new and enhanced digital communications services which fiber access lines would permit. This has caused many LECs to adopt a policy of basing initial fiber deployments on POTS only. The base-case assumption in this analysis is accordingly for POTS only.

Figure 5.1 shows our estimate of POTS fiber access line costs for a stylized residence network service configuration which could exist in the early 1990's and is considered a "target" subscriber for fiber installation. The figure represents a subscriber served by a digital CO, serving area interface and digital loop carrier. The total network cost per subscriber is assumed to be $3,100. This is the cost used throughout the analysis.

5.2 The Cash Flow Approach

Due to the number and complexity of engineering and cost assumptions-- the bottom-up portion of LEC capital budgeting-- we choose an aggregate top-down cash flow approach to begin examining the fiber technology adoption decision. LECs themselves are still considering a whole host of different fiber network architectures and no clear leader has surfaced in terms of network configuration. Thus the top-down cash flow approach provides the most descriptive LEC decision model, especially since short-run cash availability will tend to drive the process in the presence of long-run uncertainty. Two basic fiber deployment scenarios will be considered in the analysis to follow. First, an all-fiber access line scenario; second, a hybrid copper distribution and fiber feeder scenario. Even though initially only POTS functionality is assumed, an all-fiber scenario would obviously be capable of adding video services to the home at minimum additional cost. Similarly, in a hybrid fiber/copper scenario, interconnection of LEC feeder plant with local cable TV coaxial distribution facilities would allow for telco provision of passive (non-switched) video services to the home. In fact, this is the way many of the LECs are beginning to provide integrated services to the home. A prospective view of LEC industry revenue and cost streams will be examined with simple assumptions of sources and uses of funds to establish the amount of money required over time to adopt digital fiber technology.

Figure 5.1



Cost Of Fiber POTS

ASSUMPTIONS:
- Suburban residence customer
- Loop length 9000'
- Digital CO
- Serving area interface handles 5 Digital subscriber loop carriers

* Of the $3,000/sub, $900 = electronics
$2,100 = fiber link

Such large and long-lived construction projects like fiber technology adoption are best viewed in terms of net present value (NPV) of the expenditure stream, with the added twist that the expenditure stream is quite flexible and may allow for a pay-as-you-go investment philosophy. In these circumstances, downstream uncertainty is mitigated by incentives to invest whenever funds are available from internal sources, so that the initial go/no-go decision associated with classical NPV analysis can be circumvented. Other authors have viewed the LEC fiber deployment decisions as go/no-go decisions in NPV terms and often would reject the project on its face when total first costs from an engineering perspective are estimated to be large relative to the expected revenue benefits. This view is not appropriate since it is clearly not an all-or-nothing proposition for the LECs. Like Rome, public telephone networks are not built in a day. Looked at in this way, it is more a matter of timing and market expectations and strategy, whereby construction spending will be matched to cash flows from all sources depending on market assumptions. Should available capital not meet the decision-makers' business plan to implement fiber technology, the difference may be made up from establishment of a sinking fund. Sources of sinking fund cash include long and short-term borrowing, changes in depreciation rates and/or increases in revenues per subscriber. The investment situation is very fluid at the margin and no capital is sunk until committed and construction is largely postponable.

5.3 Revenues and Cost Recovery

Using $3,100 as current per-subscriber average cost, the total cost of fiber access is about $310B.[20] This is the cost stream to be spent over the construction interval which, as previously stated, will be determined by LECs ability to raise funds to support it. In the context of a classical NPV framework, over a ten year pay-back period with a 12% discount rate, the amount of money required would be over $40 per month per subscriber. While this might seem large, it should be viewed in the context of a household's total expenditure for electronic media/communications. On average, households currently spend about $100/month on all forms of electronic communications of which

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[20] ($3,100 x 100 million subscribers) = $310B. While there are only about 92M households, there are over 120M access lines; The difference is business lines and multi-line residences. It is much less expensive per line to provide fiber access lines to these subscribers, hence we assume 100M is reasonable. Of course, by the end of the construction interval, there will be more access lines; however, for convenience, we will not forecast growth of lines.

cable TV is about $30 and telephone about $45.[21]. Of this, the LECs only get about $25 per subscriber. Consequently, on the surface, it would appear that there are adequate funds for fiber construction, but existing LEC line-of-business restrictions temper this conclusion. If, for example, the POTS fiber deployment cost stream for LECs were to be $30B per year for 10 years, the current internal cash flow from existing services to support it is only about $20B per year, resulting in a significant new finance requirement.

However, in reality the $310B is not a large lump-sum payment which is committed to up-front. Rather, in every future year a portion is spent and therefore the cost stream is discounted similar to the revenue stream. Table 5.3 shows the simple depreciation accounting model of Table 4.1, with extrapolations of the data through the year 2000. The depreciation stream in Table 5.3 uses the most reasonable assumptions regarding prospective depreciation rates based on the recent available data.[22] The purpose of the data in Table 5.3 is to show how the future might look under a status-quo scenario of steady growth and spending trends. The depreciation stream is used to evaluate prospective cash flow in Table 5.31. The data in Table 5.31 show extrapolations of LEC internal cash flow through the year 2000 under an aggressive fiber deployment scenario. While the depreciation data in Table 5.31 come straight from Table 5.3, the expenditure for capital additions is much higher beginning in 1990 to reflect adoption of digital fiber technology in the network. The future capital expenditure stream totals more than the $310B required for fiber over the construction interval because additional capital-related maintenance and operating costs must also be incurred annually. We estimate such costs to be 15% of the total construction budget and have added them, making the total fiber cost stream $360B. One criticism of the cost stream used is that it implies the availability of a digitial CO for each subscriber line and therefore the stream of costs is understated. However we also use current (early 1990's) access line cost estimates and these will of course drop, perhaps substantially, by the last half of the 1990's, resulting in a lower cost stream. While refinements on both counts would seem called for, we must defer them, as well as others, to the future. The last column of Table 5.31 is the cumulative capital shortfall or new finance requirements.

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[21] The balance is over-the-air TV and radio. For a discussion of potential revenue sources, see Egan, B.L., "Towards a Sound Public Policy for Universal Broadband Networks," Columbia University, September, 1988.

[22] The FCC NPRM (ref. ftn. 10) predicts a theoretical depreciation reserve (DR) for telcos in 1990 of 37%. Assuming regulators continue to allow the LEC book DR to approach the theoretical DR then the depreciation data in Table 5.3 is an accurate portrayal of the base case for our analysis. There is some indication that regulators will approve even higher rates to allow the book DR to reach 40%. Notice we assume it to be capped by regulators beyond 1992 at 40%.

Table 5.3

Base Case

	GPIS	DR	%	NPIS	DE	CDR	RETS	ADDS
1984	186,043	42,450	22.82	143,591	11,930	6.41%	7,223	18,224
1985	200,845	49,650	24.72	151,196	13,650	6.80%	7,632	20,401
1986	213,927	57,729	26.99	156,194	15,650	7.21%	8,015	21,047
1987	222,395	62,540	28.12	159,855	17,820	8.01%	9,003	20,325
1988	231,177	71,357	30.87	160,233	18,650	8.07%	8,810	20,740
1989	243,107	81,197	33.40	161,910	19,449	8.00%	7,293	21,570
1990	257,383	93,352	36.27	164,031	20,333	7.90%	7,722	22,432
1991	272,094	105,964	38.94	166,130	21,223	7.80%	14,965	23,330
1992	280,459	112,222	40.01	168,236	18,230	6.50%	14,023	24,263
1993	290,699	116,429	40.05	174,270	18,895	6.50%	14,535	25,233
1994	301,397	120,790	40.08	180,607	19,591	6.50%	15,070	26,243
1995	312,570	125,311	40.09	187,259	20,317	6.50%	15,629	27,292
1996	324,234	129,999	40.09	194,235	21,075	6.50%	14,591	28,384
1997	338,028	136,484	40.38	201,544	21,972	6.50%	16,901	29,519
1998	350,646	141,554	40.37	209,091	22,792	6.50%	17,532	30,700
1999	363,814	146,814	40.35	217,000	23,648	6.50%	18,191	31,928
2000	377,551	152,271	40.33	225,280	24,541	6.50%	18,791	33,205

Assumptions:

1. GPIS (n+1) = GPIS (n) + Additions (n) - Retire (n).
2. Depreciation Reserve (n+1) = Depreciation Reserve (n) + Depreciation Expense (n) - Retire (n).
3. Depreciation Reserve capped at 40% in 1992.
4. Depreciation Expense (n) = Composite Rate (n) * GPIS (n).
5. Conposite rate is capped.
6. NPIS (n) = GPIS (n) - Depreciation Reserves (n).
7. Retire (n) = GPIS (n) x Floating Rate (to balance Depreciation Reserve)
8. Additions (n+1) = Addition (n) * 1.04.

Source: FCC Statistics of Common Carriers 1984, 1985, 1986, 1987.

For convenience of analysis, we have chosen not to forecast the growth of additional subscribers through the year 2000, which would make the capital spending requirements marginally higher. Also gross plant and annual depreciation would be nominally higher due to an aggressive fiber construction scenario. At the level at which this analysis is made, these are not material factors. Caution must be exercised in evaluating the accuracy of the data for any given future year. However, the totals are robust in the context of the simple model because, as previously stated, the

Table 5.31

Cash Flow for Local Exchange Companies Aggressive Fiber Construction
40% Depreciation Reserve

(figures in $ Millions)

	Net Income	Deprec.	Dividends	Capital Expen.	Financing	Cumulative Balance
1987	10,113	17,820	6,797	20,260	876	
1988	10,368	18,652	8,582	20,721	(283)	593
1989	10,731	17,259	8,882	21,500	108	701
1990	11,106	17,132	9,193	27,000	(7,955)	(7,254)
1991	11,495	17,891	9,515	28,000	(8,129)	(15,383)
1992	11,898	16,673	9,848	29,000	(10,278)	(25,661)
1993	12,314	17,305	10,193	29,000	(9,574)	(35,234)
1994	12,745	17,964	10,549	30,000	(9,841)	(45,075)
1995	13,191	18,651	10,919	31,000	(10,077)	(55,152)
1996	13,653	19,368	11,301	33,000	(11,280)	(66,432)
1997	14,131	20,211	11,696	35,000	(12,355)	(78,787)
1998	14,625	20,984	12,106	37,000	(13,497)	(92,283)
1999	15,137	21,789	12,529	40,000	(15,603)	(107,887)
2000	15,667	22,629	12,968	41,000	(15,672)	(123,559)
				360,000		

Assumptions:

1. Net Income grows 3.5% per year.
2. Depreciation taken from schedules where reserve is capped at 40% in 1992.
3. Dividends grow at 3.5% per year.
4. Capital Expeditures are cost of fiber POTS $360 billion total cost.

revenue and cost streams are flexible and investment in fiber is largely a pay-as-you-go activity. One can reasonably assume that changes in important factors such as inflation, interest rates, or growth will affect both cash flow from operations and capital spending alike, and this is our initial assumption. A more formal analysis would use a NPV framework and provide year-by-year details of discounted values of costs and revenues. Conceptually the discounting is straightforward and for present purposes there is nothing to be gained by forecasting discount rates.

5.4 Scenario Analysis

The last column of Table 5.31 implies new finance requirements over the construction interval of about $100B. This is the amount of cash flow required beyond that which is expected from internal sources. There are many possibilities to increase cash flow to cover the deficit. We will briefly examine three: (1) Debt financing; (2) Depreciation increases; (3) Revenue stimulation from new fiber services. Of course, any and all of these are likely to occur, but it is useful to evaluate each separately.

5.41 Debt Financing

The data in Table 5.31 show the annual amounts, in nominal terms, of funds which may be obtained through long-term borrowing. Assuming that regulators accept the effects of increased borrowing on the capital structure of LECs, the result will be to increase cash flow in the year borrowed, but decrease it in future years due to increased interest expense which must be covered from income. On the other hand, the average cost of capital is lower due to the effect of leverage (but at some point could increase because of greater business risk).

Table 5.41

Debt Financing
40% Depreciation Reserve

(figures in $ Millions)

	Financing Required	Debt Ratio
1987	(876)	41.73%
1988	283	41.00%
1989	(108)	42.20%
1990	7,955	44.78%
1991	8,129	47.35%
1992	10,278	50.26%
1993	9,574	52.70%
1994	9,841	54.97%
1995	10,077	57.00%
1996	11,280	59.22%
1997	12,355	61.33%
1998	13,497	63.40%
1999	15,603	65.54%
2000	15,672	67.44%

Table 5.41 shows the effect on LEC capital structure which occurs due to borrowing to finance fiber construction through the year 2000. On average, the ratio of debt to total capital from 1990 to 2000 is well over 50%, much higher than the current 40%. However, by historical standards, the borrowed amounts in real terms are not large and represent a feasible business option.

5.42 Increase Depreciation

Another option for increasing LEC cash flow to fund construction is to increase book depreciation. This has been occurring in the past, however at some point the book DR may exceed the theoretical DR and the wrong investment incentives can result. Many firms in the electronic/communications industries, however, have a higher DR ratio than the LECs (31%); in fact, AT&T is at about 50%. AT&T Communications is still rate-base regulated, and therefore this suggests that regulators may accept higher future DR ratios for LECs.

Table 5.42 shows the effect of increasing the rate of LEC depreciation reserve accruals and capping them at 50% in 1992. The new annual depreciation levels are sufficient to fulfill much of the new finance requirements for fiber construction through the year 2000. Of the original capital shortfall of about $100B, the LECs now only require $40B in new finance.

5.43 Revenue Stimulation

It is widely anticipated that revenues from new advanced telecommunications services will grow rapidly and be much higher than the levels assumed in our forecasts of cash flow from operations. Most of these new services will be able to be provided on existing LEC copper facilities as narrowband ISDN is implemented. However, to provide entertainment video service to the home, fiber is required. Early LEC tariffs for providing transport of local cable TV signals over coaxial cable or fiber indicate a willingness to pay on behalf of cable TV operators of about $8 per month per subscriber. We take this to be a reasonable target for new LEC revenues per subscriber by the year 1995. Obviously the growth in household revenues would gradually creep up to $8 per subscriber and we reflect that in Table 5.43 where cash flow is again evaluated to the year 2000. Initially cable TV signal transmission would usually occur on LEC coaxial distribution systems which were built, purchased or leased from others. There is no available data on the increase in LEC cost streams from this hybrid approach and we leave this for further research.

From the data in Table 5.43, it is clear that a favorable revenue stimulation scenario will substantially mitigate new finance requirements of fiber technology adoption, reducing it by about two-thirds.

Table 5.42

Cash Flow for Local Exchange Companies Aggressive Construction 50% Depreciation Reserve

(figures in $ Millions)

	Net Income	Deprec.	Dividends	Capital Expense	Balance	Cumulative Balance
1987	10,113	17,820	6,797	20,260	860	
1988	10,368	18,652	8,582	20,721	(283)	577
1989	10,731	25,526	8,882	21,500	6,030	6,607
1990	11,106	28,312	9,193	27,000	3,549	10,156
1991	11,495	36,733	9,515	28,000	11,220	21,377
1992	11,898	19,632	9,848	29,000	(6,614)	14,763
1993	12,314	20,349	10,193	29,000	(5,611)	9,152
1994	12,745	21,098	10,549	30,000	(5,557)	3,594
1995	13,191	21,880	10,919	31,000	(5,450)	(1,855)
1996	13,653	21,724	11,301	33,000	(7,259)	(9,114)
1997	14,131	21,972	11,696	35,000	(8,640)	(17,754)
1998	14,625	22,792	12,106	37,000	(9,425)	(27,180)
1999	15,137	25,467	12,529	40,000	(9,330)	(36,509)
2000	15,667	24,541	12,968	41,000	(10,808)	(47,317)

Assumptions:

1. Net Income grows 3.5% per year.
2. Depreciation taken from schedules where reserve is capped at 50% in 1992.
3. Dividends grow at 3.5% per year.
4. Capital Expeditures are cost of fiber POTS $360 billion.

Table 5.43

Revenue Stimulation
40% Depreciation Reserve

(figures in $ Millions)

	Increase in Monthly Revenue Per Subscriber	Change in Operating Cash Flow	Net Income	Financing	Cumulative Balance
1987			10,113	876	
1988			10,368	(283)	593
1989	0	0	10,731	108	701
1990	1	1,200	12,306	(6,755)	(6,054)
1991	2	2,400	13,937	(6,687)	(11,741)
1992	4	4,800	16,825	(5,350)	(17,091)
1993	5	6,000	18,614	(3,274)	(20,365)
1994	7	8,400	21,665	(920)	(21,285)
1995	8	9,600	23,624	356	(20,929)
1996	8	9,600	24,450	(482)	(21,412)
1997	8	9,600	25,306	(1,179)	(22,591)
1998	8	9,600	26,192	(1,930)	(24,521)
1999	8	9,600	27,109	(3,632)	(28,152)
2000	8	9,600	28,057	(3,282)	(31,434)

Assumptions:

1. There are 100 million access lines.
2. Revenue increases are per month.

5.5 Hybrid Fiber/Copper Scenario

Deployment of fiber in LEC feeder plant does not create a substantial difference in the base case financial scenario. We estimate the cost to be about $25B based on Figure 5.1. Based on this level of cost, fiber is assumed to be deployed in both LEC interoffice and feeder network plant and is interconnected to copper and coaxial local distribution facilities. This scenario creates no serious capital shortfall beyond that which would be implied from the base case analysis in Tables 5.3 and 5.31. Forecasted cash flows from internal sources are expected to cover the costs of this less aggressive technology deployment scenario.

6.0 Summary and Conclusions

Many estimates of the costs of fiber technology adoption in public telephone networks have been made and virtually every informed observer agrees that they are very high--to many, astronomical is the more proper term. In fact, the numbers are so high as to raise doubts about the private sector mustering the funds sufficient to deploy the technology in a timely fashion as part of the informatization of society. Indeed, the Federal Office of Technology Assessment and others have raised this concern relative to the international competitiveness of the American economy. Our primary conclusion from the present analysis is that there is adequate potential capital available to the private sector and that direct government assistance is not required. In fact, government intervention, like existing regulation, would likely serve only to distort market processes and, in turn, the investment incentives of otherwise competitive telephone companies and others.

Thus the deployment of fiber in the public telephone network is a matter of when, not if, and it is to this end that the analysis in the last section was focused. Based on current trends, cash flow to support aggressive fiber technology adoption is available over a reasonable construction interval (10 to 20 years). A cash flow analysis in a net present value framework is the appropriate tool to evaluate fiber technology deployment scenarios. At the broad policy level of analysis, the fiber technology deployment scenario is flexible from a capital budgeting perspective since it is largely a pay-as-you-go proposition. However, within the overall capital budget, individual construction projects require a much more detailed NPV analysis for relevant revenue and cost streams to locally determine optimal fiber technology deployment scenarios. We leave this for future research and view the present analysis as only a first-cut to address policy issues and make recommendations.

Our first recommendation is to change the methods of LEC depreciation accounting. The current approach is a sort of "black box" where it is not possible to obtain reasonable matches of historical or prospective cost and revenue streams, and this makes optimal capital budgeting for technology adoption elusive. Specifically, depreciation accounting should rely more on economic principles and be "de-averaged" by asset and service categories on the books. This would allow for proper matching of revenue and cost streams and recognition of gains or losses on assets and retirements as they occur.

The current accounting and regulatory rules which impose rate-base regulation cause further distortions for investment decisionmaking. Specifically, the cost of capital of internally-generated cash flow, which derives largely from asset depreciation, is not known and requires further research to identify. It lies somewhere between being above zero and the external market cost of capital, since the options for use of these funds is limited but is not singularly constrained.

The general solution to many of the uneconomic investment incentives caused by the current regulatory and accounting rules is to adopt price-cap regulation. The analysis provides a particularly strong case for this.

We would like to make clear that this is a first attempt to solve a complex puzzle and the research needs to be extended to be most useful in practice. First, very little is known about service demand in a digital fiber environment. On the cost side, we make the assumption that aggressive fiber deployment begins in 1990. The LECs in fact are currently involved in deployment of other major networks such as the so-called Intelligent Network and ISDN, both of which do not necessarily require fiber. We do not directly evaluate either of these as investment projects and leave this for further research. However, the analysis and conclusions remain robust within the context of the future finance requirements for fiber in LEC networks. While we assume that aggressive LEC fiber deployment begins in 1990, it could just as easily have been deferred until 1995 or 2000, under the assumption that ISDN is in place by then, with little effect on the overall conclusions.

In addition, the detailed financial effects of generating additional funds from borrowing in capital markets need to be worked out for each financing alternative. Lastly, an evaluation is needed of the LEC theoretical depreciation reserve in order to assess whether economic principles regarding plant retirements accurately reflect economic service lives.