Fiber to the Home: Public Policy/ Technology Conflict

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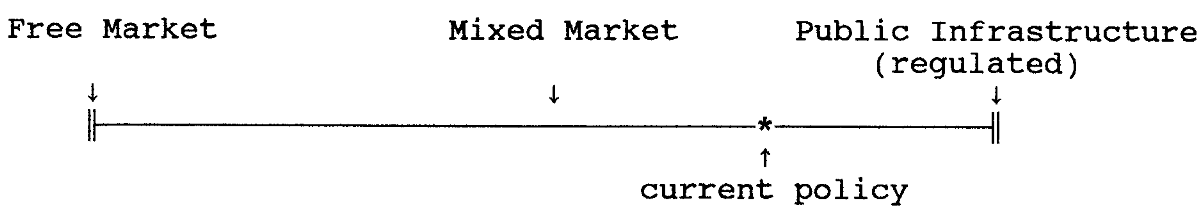
1.0 Introduction

With the growing linkage between computer and telecommunications facilities, discussion has turned toward the prospect of constructing large scale public information/communication networks. The concept of public Integrated Broadband Networks or IBNs is a manifestation of this grand vision which, in its purest form, would connect all households and businesses with high-speed digital fiber optic links. This article will place in perspective the public policy issues raised by the adoption of IBN technology. The public and private costs and benefits of IBNs will be discussed as well as the economic feasibility of deployment. We will discover that current public communication policy is misguided, and serves to reinforce the existing conflicts between free-market and public-infrastructure paradigms for technology adoption.

Figure 1 illustrates the range of possibilities for deployment of fiber-to-the-home. On the far left is the private free-market approach and on the far right, the public-infrastructure approach. The middle, or mixed market, represents equal emphasis. The current institutional and policy environment lies between the middle and the right on our diagram with regulated telephone utilities enjoying local monopoly status.

Figure 1
Fiber-to-the-Home Deployment Scenarios



The mixed-market approach creates a number of problems. First, in the absence of a clear policy direction, decision-making becomes risky or impossible. Will the laws change for example, and prohibit certain businesses from constructing IBNs? Second, the major firms, regulated and unregulated, must fight legal and political battles to protect their entrenched interests, causing serious delays in technology adoption. Finally, without clear policy goals, the potential for achieving an efficient

transition to technologically advanced public networks may be foregone as networks continue to become fragmented. This may result in inequalities in service where efficient, high-quality private networks will exist for those that can afford to build or access them, while a relatively low-quality high-cost public network will exist for everyone else.

Rate-base regulation and depreciation accounting rules currently favor telephone utilities, who represent the infrastructure approach to IBN technology adoption. Existing regulatory rules allow local telephone companies to increase their depreciation rates for existing copper plant which can then be recovered from subscriber rates. Cash flow from depreciation is then used to support digital fiber construction, which is also charged to the subscriber base. This is allowable under current regulations as a reasonable return on investment. Consequently, current regulatory rules favor deployment of fiber-to-the-home by telephone companies rather than by other kinds of businesses which cannot finance such large-scale construction in a rate-base-regulated environment. The time has come for policymakers to reassess the current situation with an eye toward changing existing regulatory structures.

Historically, the development of the communications infrastructure has been guided by standardization and regulation. The last several decades have seen increased competition, the growth of private networks, and the development of diverse standards and network protocols. All of these factors have served to fragment public communications into an array of subnetworks, each using quite different technologies, each optimized for the specific service application for which it was originally intended. America is currently at a public policy crossroads where free-market competitors are busy building private networks within an existing regulatory structure which may be outdated.

Current policy is inherently unstable and pits public and private needs against one another. We cannot enjoy the best of both worlds: a private market paradigm, where communications networks develop according to forces of supply and demand, and the public market paradigm emphasizing social costs and benefits. Public policy prescriptions for achieving these separate goals are quite different. If we continue the status quo however, we risk languishing in a world of inefficient technology, where public utilities, which enjoy monopoly status, "compete" with unregulated entrants. The resulting tug-of-war between entrenched interests, and their political constituencies, puts politics rather than societal issues at the forefront of the policy debate.

Our policy makers must decide whether IBNs are useful enough to the public to warrant the extensive costs involved in building them. This will depend, in part, on how they come to be constructed, through the natural market forces of supply and demand, or in a regulated environment, common carrier or otherwise. Each of these scenarios required a different strategy for the cost-efficient deployment of technology as well as a public policy designed to support the strategy. This paper contrasts private IBN deployment -- the market approach -- with the infrastructure approach of public IBNs. It is assumed that funding for the infrastructure approach will come from cross-subsidies using existing subscriber rates, not from public taxes.

The main conclusion from the discussion contained here is that only an infrastructure approach is likely to result in the timely deployment of IBNs. Without trying to determine whether the long-term benefits are worth the costs, it is simply noted that there are ample funds available in regulated markets to deploy IBN technology.

Deployment of IBN depends heavily on the social benefits one believes it offers. Despite uncertainty and disagreement regarding these benefits, America must plan for the future and make a choice, for the status quo alternative may be very inefficient. Unfortunately it is easier for politicians and policymakers to avoid these difficult choices, since public consensus on technical issues is elusive.[1] Nonetheless, the substantial social and economic risks which will result from doing nothing necessitate a well-formulated public policy.

2.0 Economics of Technology Adoption

Before considering investment models for fiber networks, the relative merits of the technology should be discussed vis-a-vis competing technologies. Digital fiber-optic networks can offer high quality, high-speed communications, with unique advantages such as: immunity to electromagnetic interference; security and privacy (public airwaves are not required and digital encryption is possible); low maintenance cost; and flexibility in application, since all transmitted signals can use a standard digital format. At present, different networks exist for the transmission of video, circuit-switched, packet-switched and private-line services. This is not an efficient use of distribution facilities because they are idle between transmissions. Further, multiplexing these services together using an all-digital signaling format avoids both the inefficiencies of channelizing incompatible analog and digital signals and the cost and quality problems of signal conversion.

There are other communication technologies competing with fiber, none of which have all the capabilities of fiber, but all of which offer cost advantages for various service applications. Examples include satellites, copper/coaxial cable, and radio. These technologies have been around for some time and have been optimized to provide basic communications services such as voice, data, and video transmission. Their success makes it difficult to undertake cost-effective deployment of integrated digital fiber technology.[2] Integrated digital fiber networks will one day offer lower overall costs than various combinations of the above technologies, but it is clear that non-fiber technologies are preferred at present for the more common applications.[3]

Recently, attention has recently been given to deployment of various hybrid networks, using fiber to augment wire, coax, and satellite or radio facilities, usually for long-haul, high-volume, shared applications such as telephone trunk lines. Fiber is cost effective in these situations and is often deployed in conjunction with existing local distribution networks. If such hybrid networks are successful, fiber-to-the-home is less likely to occur.[4]

Satellite

Satellite technology, including new high-powered Direct Broadcast Satellites (DBS), and Very Small Aperture Terminals (VSAT), are especially well suited for one-way, point-to-multipoint transmissions requiring very high bandwidth such as video and some data services. Under current cost conditions satellite technology is preferred over fiber and is expected to remain so for some time.

Wire/Coax

The vast majority of local distribution facilities use copper wire for telephony and coaxial cable for cable TV. Both are well suited for short-distance transmissions. However, their current cost advantages over fiber at the margin are disappearing and may be gone by 1995 for most new construction.[5]

Radio

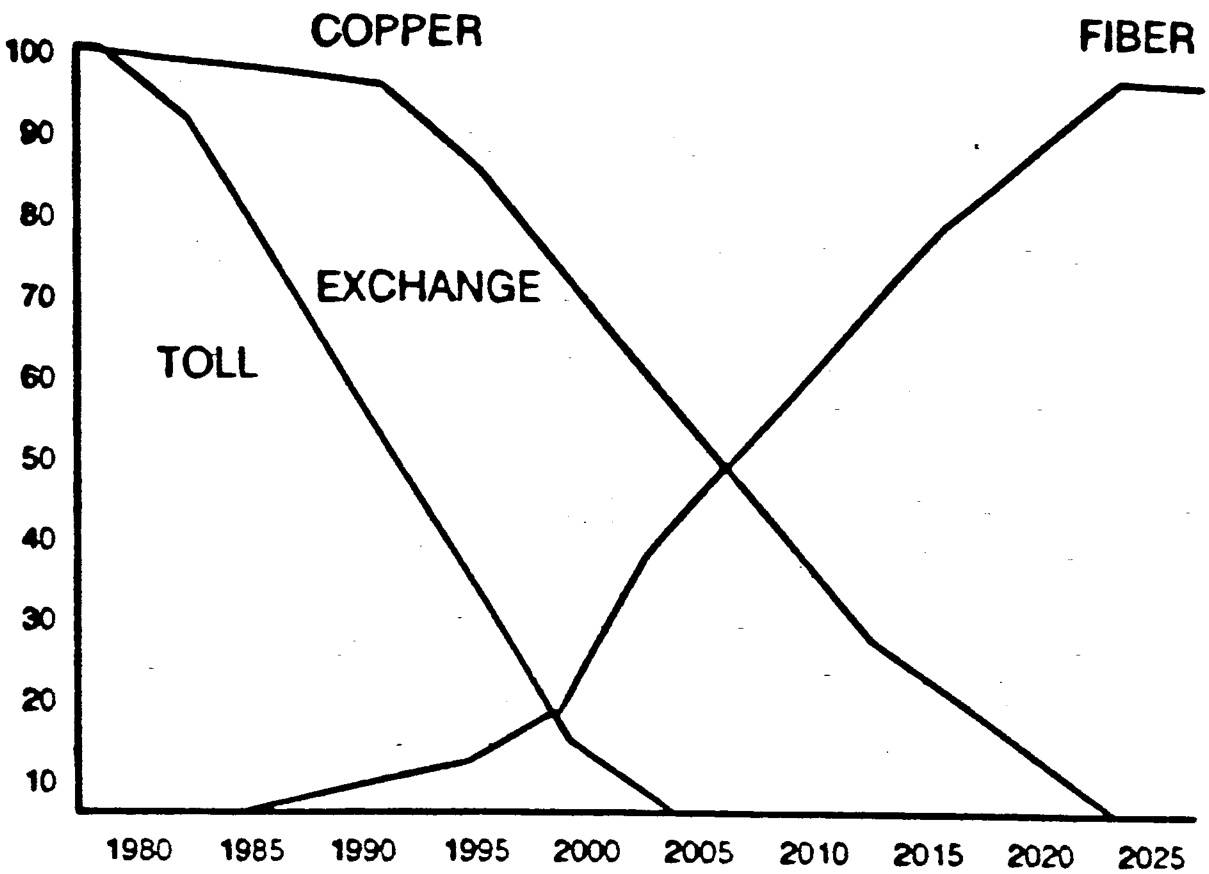
Analog microwave and cellular communications represent a small portion of the market today but digital radio, and especially digital cellular technology, are important advances. In the near future, digital radio may achieve prominence as a local distribution technology used to bypass local wireline facilities. Significant cost advantages plus the convenience associated with portability will help to spur diffusion of this technology.

To shed some light on the public policy conflicts created by technology, it is useful to review some investment models for deployment of new technology and to discuss their underlying assumptions. These are: (1) the Fisher-Pry "S" curve, (2) the cash-flow market model, and (3) the cash-flow model for partially regulated firms.

2.1 Fisher-Pry Models

A popular model for evaluating the time-path of technology adoption is the Fisher-Pry "S" curve. This model has significant empirical support and is based on a "production learning curve". A typical "S" curve for fiber technology adoption appears in Figure 2. This model assumes that initial engineering production cost advantages cause the new technology to be deployed and that, as time passes, these cost advantages become greater through further technical progress and "learning by doing" effects.[6] Eventually, only the newer technology is used and all others -- in this case, metallic facilities -- are phased out.

FIGURE 2



COPPER
FIBER
EXCHANGE
TOLL
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90
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70
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There are many problems with this approach. First, such models are risky since the time horizons tend to be quite long, and interim alternatives are not known ex ante. Second, the empirical support for the shape of the Fisher-Pry curve derives from prior success stories where there was a known preference for the technology in question. Only the shape of the time-path of diffusion was at issue. Third, the models are strictly supply-side, and may only register imperfectly the effects of changes in demand structures and the classical considerations of NPV models such as cash flow. Institutional and public policy considerations such as regulatory rules and tax policies are also ignored. Finally, the models' results are reminiscent of the oft-quoted economic prediction, "In the long-run we're all dead." Let us consider an example.

Assuming that fiber becomes cost-effective for new construction of local loops by the mid-1990s, it will presumably be installed in new housing construction, about two to three percent of the public network. At this rate, it will be a long time indeed before fiber-to-the-home is ubiquitous; basically corresponding to the time it takes to turn over the housing stock. The process might be accelerated as fiber became cost effective as a replacement for existing metallic loops as they wear-out. This might add another few percent per year. On the other hand, many metallic loops will last fifty years or longer depending on local conditions. Moreover, since existing loops represent sunk costs, maintenance and repair costs would have to be very high to justify burying a new fiber loop, even if the actual cost of the fiber itself were nominal. Labor and machinery costs for digging and installation are a significant one-time cost, especially in rural areas.

The conceptual elegance of the Fisher-Pry model should not lull one into accepting the inevitability of a forecast. The rate of adoption which most benefits society may be quite different from the simple Fisher-Pry model. The social costs of speeding up the technology adoption process must also be considered.

2.2 The Market Model

A market model of investment uses cash-flow analysis to determine whether or not to undertake a given investment project, based on the net present value (NPV) of future revenue streams. A similar model is called "Pay-back Analysis," wherein a project is ranked with others according to a desired capital recovery period. In both models, the expected future revenue stream is compared to the cost stream, adjusting for the time value of money. The project is accepted if there is a positive NPV. Management then decides whether to provide funding for the project.

An earlier paper by the author surveyed a number of studies of fiber-to-the-home and developed a cost stream for deployment.[7] The total expenditure required is approximately $300B for a basic fiber-to-the-home national network, with advanced systems, such as IBNs, costing even more. These estimates are consistent with a number of other recent cost studies discussed below.

Demand for existing communications services requiring digital fiber network facilities is very small, as most customer services are available over non-fiber transmission media. Little is known about future demand for broadband services and forecasting is very risky. Most existing studies show how broadband service demand and revenue to be too low to support the likely cost stream for an all-fiber deployment scenario. One recent MIT study indicated that market penetration of new video services would have to be very high to cover the cost of fiber-to-the-home; similar results were obtained in a Carnegie-Mellon study.[8] Market penetration takes time and, in any case, it significantly lags behind facilities construction, and seriously jeopardizes the financial viability of fiber-to-the-home model based on NPV. Hybrid scenarios -- where both fiber and metal are used -- are too numerous to be considered here, as fiber proves to be economical in portions of the public network, hybrid deployment will increase. This is already occurring in private markets, indicating that there is a standard business-case justification for it, especially in high-capacity shared-network-facility arrangements, sometimes referred to as fiber "backbone" networks. The final leg of local distribution, generally dedicated to a single subscriber, is where fiber is most difficult to justify on the basis of cost efficiency.

Based on current evidence, there does not appear to be a justifiable business case for deployment of fiber-to-the-home. There is no apparent risk/payoff scenario which would justify the decision to undertake largescale public IBN projects. Simple observation strengthens this point. While there are no significant competitors in the market for public local distribution networks, there has been significant competition among fiber optics vendors in toll markets since the early 1980s. Clearly, there is no current or near-term profit advantage perceived by vendors in offering local fiber access lines. The few competitive local fiber networks in major cities serve niche markets (private networks and bypass), making little effort to reach the mass market. A recent FCC study on deployment of fiber in densely populated metropolitan areas indicates that this market is still in its infancy.[9]

Vendors of local area networks (LANs) continue to invest heavily in metallic technologies for new installations. One recent industry estimate showed copper installations continuing to dominate the LAN market well into the 1990s, a period during which the industry is expected to achieve substantial market penetration.[10] In summary, not only is fiber-to-the-home difficult to justify in a market setting, but it may even take some time for it to succeed in shared local network applications.

2.3 The Regulated Firm Model

Regulated or partially regulated firms such as telephone companies operate under public service obligations and rate-of-return regulation, requiring the application of classical NPV analysis to be modified somewhat from the market model. The underlying business incentives faced by regulated telephone companies are very different from those faced by unregulated firms; the details of how such incentives affect investment decisions are provided in a recent article by the author.[11] The partially regulated telephone company invests in new technology to be able to compete for market share. It can do so whenever there is cash-flow available to make the investment and still meet shareholder demands for dividends. Under rate-base regulation, a company can earn a reasonable rate of return on new investment, paid for by revenue from current technology. Indeed,the incentive structure imposed by regulation encourages this. Much of the revenue stream is attributable to depreciation charges which are recovered in subscriber rates for regulated services. Depreciation, properly viewed, is first and foremost recovery of invested capital, <u>not</u> funds for new construction. The cash flow which derives from telephone company depreciation is, in theory, available for any number of uses including dividends, construction, price reductions or other investments. Because of incentives offered by rate-base regulation, telephone companies generally reinvest the funds in the regulated business as long as shareholder demand for dividends is met.

In a non-regulated environment, a firm desiring to upgrade and replace its plant facilities would normally have to consider increasing depreciation at the expense of net income. Telephone companies can avoid this problem since increases in book depreciation are allowed as expenses for ratemaking purposes <u>and</u> provide cash flow for new construction. New construction, in turn, enters the future rate base as a depreciable asset on which a reasonable return can be earned. A telephone utility expecting competition would want to adopt the technology with the lowest long-run unit costs -- such as digital fiber -- especially when it does not sacrifice short-term earnings.

In the past, telephone companies were expected to modernize plant in a way consistent with public expectations of high service quality and cost efficiency and, in turn, were allowed to earn a reasonable return from subscriber rates. This monopoly incentive structure determined the pace of technology adoption. The current incentive structure is quite different, as are the implications for technology adoption. As AT&T and the local exchange companies (LECs) face increasing competition, investment incentives must be based on considerations of the structure of demand, growth and market share, not simply on acceptable levels of service quality. The capital spending trends of AT&T and the LECs reveal an unprecedented effort to modernize their networks by adoption of digital and fiber technology, the technologies used by their competitors. However, regulated LECs are unique in that their earnings are not necessarily depressed by depreciation of existing plant and capital spending increases which may be recovered in subscriber rates. This is because there is a great incentive to spend the regulated-market revenues for new construction. The cash flow is high for several reasons: low inflation; low taxes; and higher regulatory allowances for depreciation. Other options include: allowing depreciation to reduce the rate base (and hence future earnings) by not plowing revenue back into new construction; reducing tariff rates; or returning cash-flow to shareholders. All of these options are clearly less desirable for a management concerned with increasing total profits.

Not only do non-regulated providers lack a rate-base, but high depreciation and interest on borrowing for construction seriously depress earnings. Moreover, telephone companies, as regulated firms, treat technology adoption primarily as a "pay-as-you-go" proposition.[12] Under such conditions, fiber-to-the-home passes the NPV test for rate-base-regulated local telephone companies. From a capital budgeting perspective, it is convenient to have the flexibility which a relatively small and widely dispersed set of network facilities provides. It is easier and less costly to alter, postpone or even cancel a given network construction project in response to market conditions than it is for a rival entrant starting from scratch. For telephone companies then, fiber implementation is a pay-as-you-go proposition not subject to the strict market cash-flow (NPV) model which requires a "go/no-go" decision. Given that telephone companies are public service providers, whether they like it or not, their incentive is to increase current and future-period cash flow through higher depreciation and construction. They will follow this course until it is no longer prudent to do so because of declining earnings and regulatory constraints, such as caps on prices or on depreciation reserves.

Data available since divestiture bears this out. Table 1 gives telephone company investment and financial data for 1984 through 1988. It shows a rapid rise in depreciation, high levels of construction spending, and steady increases in the rate base. Net income as a percent of revenues remains steady. (Revenues, operating cash flow and dividends are also shown.) In the theory of public utility regulation, total capital recovery is allowed, and the rate of depreciation determines its speed. Higher current-period depreciation charges should result in a lower rate-base and lower future-period charges, and vice-versa. However, if current-period depreciation charges are always reinvested in the regulated business, then higher current-period charges do not necessarily translate into lower future-period

TABLE 1

LEC INVESTMENT ($M)

	GPIS	NPIS	DR(%)	DE(%)	RETS	ADDS
1984	186043.0	143591.9	22.82	6.41	7223.4	18224.6
1985	200845.1	151195.7	24.72	6.80	7632.7	20401.2
1986	213927.0	156194.1	26.99	7.21	8015.5	21047.9
1987	222395.5	159855.0	28.12	8.01	9003.8	20325.7
1988	231177.3	160233.0	30.69	8.07	8810.8	20740.4

GPIS-gross plant in service
NPIS-net plant in service
DR-depreciation reserve/GPIS
DE-depreciation expense/GPIS
RETS-plant retirements
ADDS-plant additions

LEC FINANCIAL DATA ($M)

	Annual Revenues	Operating Cash Flow	Net Income	Deprec. Expense	Dividends	Capital Expends.	Debt Ratio (%)	Rate of Return (%)
1984	75303.0	23207.4	8587.6	11927.2	7910.5	18224.6	43.18	7.40
1985	82432.3	25938.2	9645.3	13647.6	5953.6	20401.2	42.19	6.80
1986	87578.0	27289.4	10104.8	15418.8	6320.7	21047.9	41.43	8.03
1987	91382.6	27301.3	10113.0	17804.0	6797.6	20325.7	41.73	7.79
1988	96128.5	28176.8	10368.6	18652.3	8582.4	20740.4	41.00	8.00

Debt Ratio - Long term debt/invested capital
Rate of Return - Net Income/invested capital

Source: Company Reports for 25 largest LECs (about 95% of market) charges. Total revenue requirements and profits are higher over time because of incentives caused by rate-base regulation. Recent data show that LECs' depreciation rates rose about 50% since the AT&T divestiture agreement and still the rate base continues to increase because of high levels of construction. This leads to a rise in total revenue requirements and profits.

Telephone companies are only partially regulated and competition is growing, giving them an additional incentive to protect market share. The best way for them to do this is to expand capacity by adopting those technologies with the lowest long-run unit cost of operations. This assures their ability to compete with rivals in growth and market share by cutting prices should regulations permit. Interestingly, this business strategy for long-run efficiency is similar to the Japanese approach, where aggressive capacity expansion occurs well in advance of future demand.

In terms of public benefits, however, this is a bad news/good news scenario. Even though perverse investment incentives may exist, telephone companies are able to invest in technology which is deemed socially beneficial, financing it with cash flow from the general subscriber base. Even though there is no compelling private business case for financing the rapid deployment of public digital fiber networks, there still may be enough money for it from current subscriber fees. This point should not be overlooked when establishing public policy. Those who believe that improving the communications infrastructure is of value to society wish to spread the attendant costs over a broad base of the population through taxes or tariff rates. Therefore, the use of telephone companies' cash flow from regulated operations to fund technology adoption, even when it is not profitable for a private company, may still be economically and socially justifiable.

3.0 Public Infrastructure versus Private Networks

The spectrum for the evolution of advanced communications networks is bounded at one end by an all digital, fiber-to-the-home, public network infrastructure and at the other by a highly fragmented, heterogeneous mix of private networks. The underlying public policy issue is whether fragmentation or unification of network subscribers will occur. Will there be "something" to plug one's private local network and equipment into? If there is no common infrastructure, will the private facilities interconnect efficiently? No one wishes the third alternative- fragmented networks without easy interconnection.

Where does fiber fit into all of this? Once in place, fiber offers limitless capacity with low or zero marginal cost for usage as well as the lowest long-term unit cost. The problem is that it is not currently used for most service applications and therefore, while it is optimal in the long-run, in the short-run it is preempted by other technologies because of their current cost advantages. Existing technologies are already installed and will last for a long time with only low unit operating costs when compared with the total cost of fiber installations. Technology adoption often progresses in suboptimal ways from society's perspective. It is often the product of business and political decisions which create pressure to use the technology which offers the greatest near-term net revenue opportunities. This classic business dilemma reflects the constant struggle between short- and long-term strategies. The infrastructure approach to public policy explicitly recognizes this dilemma, trying to stimulate rational long-term technology adoption strategies to valorize the public network for society's overall benefit.

Fiber exhibits no special short-term advantages over other local distribution technologies for the following reasons:

(1) there are no services which will provide the revenue to drive market penetration;
(2) there are too many successful services using other transmission media;
(3) there are no existing standards for installation and operation of fiber systems;
(4) competing technologies are developing which provide new high-bandwidth capabilities; and finally,
(5) an infrastructure approach requires too much time and organization to work in a free market setting.

4.0 Making a Choice

America is at a crossroads in its search for a viable communication policy and must decide whether to take into account the overriding public benefits of new technology not reflected in economic profit. The kinds of public policies which result from private (free-market) versus public (infrastructure) technology adoption scenarios are very different, and one or the other should be chosen. We cannot accept the status quo. If policymakers truly believe in the public benefits of communications, and that these benefits far outweigh the sum of private benefits (as is the case with our highway system) then public policy should foster this approach. If, on the other hand, access to information and communication is deemed to be largely a private good where benefits accrue only to those who pay for them (as in the case of personal computing); then public policy should foster a free-market approach.

The infrastructure approach to public policy assumes that private investment decisions based on NPV/pay-back analysis will not result in a fiber-to-the-home scenario and that private markets will not work to maximize social welfare in public communications. If this is the case, one available policy option is to continue to allow telephone companies, as public utilities, to invest cash flow, obtained from subscribers, in IBN technology. Given current market conditions and forecasts, fiber-to-the-home will easily pass the NPV test for regulated telephone companies. There appears to be enough cash flow from regulated operations to support an aggressive fiber infrastructure strategy. Total industry capitalization is under $200 billion, annual depreciation rates are just under ten percent, and annual construction spending runs at over ten percent. At existing basic rate levels, the financial health of the industry is very good even with unprecedented construction spending.[13] It is important to remember, however, that it is only the existing regulatory accounting rules which allow fiber deployment to pass the NPV test as a sound investment.

The infrastructure approach is a valorization of public communications; it promotes the development of new technology in hopes of creating a demand in the marketplace and it yields economic and social benefits far beyond those of a free-market approach.[14] Positive externalities provide the key to this approach, as demand ultimately feeds on itself, stimulating even greater productive activity. Those who support this approach cite historical precedents, where past progress in transportation and electronic communications technologies caused demand to take off well in excess of any credible ex ante predictions.[15] Current public policy languishes somewhere between the free-market and infrastructure approaches to technology adoption. Existing regulatory accounting rules for depreciation and rate-base regulation heavily favor LECs in the race to deploy fiber-to-the-home, and consequently the country is leaning toward an infrastructure approach. But many policy roadblocks remain for LECs, most notably restrictions on entering markets for many advanced communications services.

If policymakers wish to further the infrastructure approach to public communications networks, they should remove impediments to telephone companies and cable companies, both of which are infrastructure players, by proposing even higher depreciation rates, removal of business restrictions and the like. The infrastructure approach invloves at least partial regulation of infrastructure firms. This approach recognizes that public interference in the markets may restrict the product and service options that an otherwise competitive market may offer, but this is a small problem compared to the need for social benefits of infrastructure development. Cost-efficiency under the public infrastructure approach arises through technology-push by economies of scale and demand stimulation which results from compatability. To stimulate private efficiency under this scenario and to avoid future increases in cross-subsidies, new schemes for incentive regulation may be considered, such as changes in depreciation accounting rules, price-caps and the adoption of Open Network Architecture.

Cost-sharing is one regulatory feature generally recognizing net public benefits, which are presumed to be greater than the sum of private benefits, largely due to network externalities. The encouragement of industry standards is important. These should not be directly set by regulators, but the industry must be required to adopt some generic network and device compatability satandards that other firms may manufacture to. Relaxed operating restrictions may be implemented to allow for contribution from non-regulated lines of business to flow to the regulated infrastructure. Of course one potential problem here is cross-subsidies going the other way. A host of tax and investment incentives are also available, like tax credits or interest rate subsidies and loan guarantees to infrastructure firms. Some good examples are the Rural Electrification Administration and the Rural Telephone Bank. On the whole, the infrastructure policies are to stimulate cooperative public/private efforts for infrastructure development.

Policymakers who prefer a private-market approach to technology adoption, regard information and communications as benefitting only the private sector. The emphasis is on the competitive market paradigm. Public policy would discourage inefficient investment in public infrastructure by the LECs or cable companies. For example, one could de-average book depreciation reserves by category of plant use (e.g. business/residence) to allow for more accurate matching of asset revenue and cost streams, thus discouraging internal cross-subsidies between non-competitive and competitive lines of business. The decision to deploy FTTH would be driven by NPV in a business case setting. Market alternatives would abound with no central control. Cost efficiencies would depend on private innovation and struggle for competitive advantage. New market development would drive much of the innovation. Public policy would stress telephone company deregulation and eventually eliminate regulation as we know it, while being careful to continue policies which encourage industry cooperation on issues involving standards and interconnection. This would prevent LECs from subsidizing new technology adoption with revenue derived from regulated customers so as to compete with rival entrants. During the deregulation phase, activities of incumbent infrastructure firms would be limited to their public utility obligations and operations (rate-base). The private sector would receive tax and R&D incentives and perhaps some federal interest subsidies or loan guarantees, but these would be offered to all private firms on the same terms and conditions. Standards development would still be encouraged so that private firms have opportunities to take advantage of economies of scale in production and consumption due to compatability. Cooperatives of private firms may be allowed to expand the possible synergies of R&D talent or design and manufacturing capabilities to develop network prototypes. A sort of "Japanese Model" is encouraged where cooperation of firms is allowed, but other cooperatives will compete for business against them.

The business sector would regard such policies as a catalyst, suggesting that a "trickle-down" of new technology will occur to society's benefit. This is a questionable position since there have been past failures of supply-side trickle-down policies. Specifically, income and education gaps continue to grow under such policies and the risk is that the information/communication rich will get richer relative to the poor.

In summary, it is important that a public consensus be reached on the proper goals of communication policy, for the status quo alternative may be neither privately nor publicly efficient. In fact, it may further exacerbate the technology/policy crisis. IBNs may never have a chance if the political tug-of-war between the free marketeers and infrastructure faction leaves the country with no public policy.

ENDNOTES

1. The problem of forming a public consensus regarding socially beneficial investment projects which have potentially large positive externalities but which are also technically complex is discussed in D. Allen, "New Telecommunications Services: Network Externalities and Critical Mass," Telecommunications Policy, September, 1988, pp. 257-271; and in B. L. Egan, "Towards a Sound Public Policy for Universal Broadband Networks," Center for Telecommunications and Information Studies, Columbia University, Working Paper #282, September, 1988.

2. For a listing of categories of existing and potential electronic communications services and of the firms which provide them, see Table 2, in B. L. Egan, "Towards a Sound Public Policy for Universal Broadband Networks," Center for Telecommunications and Information Studies, Columbia University, Working Paper #282, September, 1988, p. 38.

3. Fiber is optimized for high-capacity two-way communication and can provide a wide range of services over a single access facility. Even at current installation costs, it is estimated that fiber-to-the-home is no more expensive than all of the existing technologies used to provide the current range of customer services. The problem of course is that these other technologies are cheaper in the present non-integrated environment.

4. For some discussion of hybrid fiber/metallic applications in local distribution, see "Fiber-to-the-curb gains status, might preempt home connection," Lightwave, June, 1989.

5. For some cost comparisons see the studies referred to in B. L. Egan and L. D. Taylor, "Capital Budgeting for Technology Adoption: the Case of Fiber," Center for Telecommunications and Information Studies, Working Paper #336, Columbia University, April, 1989, pp. 6-8.

6. A recent comprehensive study appears in L.K. Vanston and R.C. Lenz, "Technological Substitution in Transmission Facilities for Local Telecommunications," Technology Futures Inc., Austin, Texas, 1988.

7. See B.L. Egan and L.D. Taylor, "Capital Budgeting for Technology Adoption in Telecommunications: The Case of Fiber," Center for Telecommunications and Information Studies Working Paper #336, Columbia University, April, 1989.

8. See H.S. Elkinton, "An Analysis of the Residential Demand for Broadband Telecommunications Services," Draft, MIT, 1988 and M. Sirbu et al., "An Engineering and Policy Analysis of Fiber Introduction into the Residential SUbscriber Loop," Draft, Dept. of Engineering and Public Pulicy, Carnegie Mellon Univ., 1988.

9. J. Kraushaar, "Fiber Deployment Update," FCC Common Carrier Bureau, February 17, 1989, Table V.

10. Market Intelligence Research Company (1989) estimates that in 1993, 92% of LAN installations will be twisted pair (63%) or coaxial cable (29%) and only 8% will be fiber.

11. B.L. Egan and L.D. Taylor, "Capital Budgeting for Technology Adoption: the Case of Fiber," Center for Telecommunications and Information Studies, Working Paper #283, Columbia University, April, 1988.

12. Egan and Taylor, ibid.

13. Egan and Taylor, ibid.

14. For discussion of the value of connection to a broadband network, see the articles by Egan and Allen, (ref. ftn 1); and a recent article by T. Curtis and K. Means, "Market Segmentation and the IBN Policy Debate," Draft, California State Univ.--Chico, 1989.

15. For an historical perspective on social infrastructure investments see, R. J. Solomon, "Past and Future Perspectives on Communications Infrastructure," MIT, Draft, 1989.