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ABSTRACT

The purpose of this report is to assess the viability of developing commercial computer communications networks to provide communications services to the deaf community on a nationwide basis. Access to this network is considered for existing Baudot/Weitbrecht Telecommunications Devices for the Deaf (TDDs) and ASCII terminals with Bell modems. The basic communications needs of the deaf and the potential market for a Deaf Network and Associated Services are defined. Examination of key concepts used to determine the commercial feasibility of DNAS, including supply and demand considerations and subsidy mechanisms, is followed by a review of current telecommunications provisions for the deaf, particularly Deafnet, a computer-based communication demonstration system. After discussing factors involved in a national commercial vendor-based framework for DNAS with special consideration of tariff design, the commericial performance of DNAS as it might be offered to a specific target population is evaluated. Preliminary commercial feasibility estimates are given for three alternative tariff structures and two supplier cost models. The study indicates that DNAS is likely to be commercially viable in the long term, although initial subsidies will be required. An appendix discussing the shift to cost-based pricing in the telephone industry, a glossary, and 26 references are also provided. (ESR)

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A NATIONWIDE COMMUNICATION SYSTEM FOR THE HEARING IMPAIRED:

STRATEGIES TOWARD COMMERCIAL IMPLEMENTATION

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Final Report

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I INTRODUCTION AND BACKGROUND

A. Introduction

It is now technologically possible to provide communications services for the totally deaf and for those whose hearing is less severely impaired. Computer communications networks will enable hearing-handicapped people to communicate at distances; for those without serious hearing difficulty, this is a simple matter of picking up the telephone. SRI International (formerly Stanford Research Institute) has been actively involved in studying this potential for a number of years and has operated a successful test-bed computer communication network for the deaf, called the Deafnet, that has allowed communication between subscribers in three metropolitan areas[1].

The purpose of this report, prepared by SRI International for the Department of Education (ED) and the National Telecommunications and Information Administration (NTIA), is to assess the viability of developing commercial computer communications networks to provide these communication services to the deaf community on a nationwide basis. The combined service that we describe (denoted DNAS--deaf network and associated services) would allow access by existing terminals used by the deaf as well as more modern terminals and also provide as much intercommunication between deaf and hearing as possible. It is recognized that a completely text-based system as described here may fill a necessary communication need for the deaf, but would continue to be a novelty for the hearing. Of course, the computer-communications industry is rapidly expanding and, as more businesses and individuals obtain the ability to communicate in this manner, the deaf will benefit. For that reason intercommunication would be limited and the service may still be mainly a deaf communication medium. The goal is initially to provide limited services and as pervasive access as economically possible with the intention of adding

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other services as they mature (such as text to voice and voice to text conversion).

B. Background

1. Communication Needs and Difficulties of the Deaf

Telephones ring. Radios play. And televisions from coast-to-coast deliver their daily fare of canned laughter, evening news and talk-show quips to 80 million U.S. homes. As the majority of twentieth century men and women try to cope with the din of what futurist Arnold Toffler has termed "information overload," it is easy to forget that almost ten million Americans are deprived of their hearing to a significant degree and, thus, of a vital key that would allow them access to large and critical parts of the social network.

The degree of social deprivation experienced by the deaf and hearing impaired varies to some extent with the time at which their handicap was acquired. For example, the prelingually deaf--those individuals who become deaf before learning to speak--often have severe problems in language acquisition, which affect not only their ultimate ability to speak but to read and write as well. Individuals who have become deaf after acquiring basic literacy have less severe problems, but, like some 4.4 million senior citizens with a significant hearing loss, they too suffer a handicap. Indeed, senior citizens are more likely than other members of the deaf community to reject hearing aids or other equipment which could help to alleviate their handicap.

Table I-1

ESTIMATES OF HEARING HANDICAPPED POPULATION IN THE U.S.

Age	Total General Population	Hearing Impaired	Significant Bilateral Loss	Prevocationally Deaf
Under 5 Years	16,344,000	70,000	43,000	6,000
5 to 14 Years	34,938,000	665,000	298,000	67,000
15 to 24 Years	42,474,000	1,159,000	366,000	72,000
25 to 44 Years	62,707,000	2,837,000	850,000	75,000
45 to 64 Years	44,497,000	4,479,000	1,993,000	100,000
65 Years & Over	25,544,000	7,020,000	4,437,000	158,000

The estimates in Table I-1 were prepared by the Office of Demographic Studies, Gallaudet College. They were derived by obtaining 1980 population figures from the U.S. Census Bureau and then applying the prevalence rates for hearing handicaps reported by Schein and Delk [2] in <u>The Deaf Population of the United States</u>. The authors define the "hearing impaired" as individuals with any degree of hearing loss; "significant bilateral losses" as substantial difficulty hearing in both ears; and the "prevocationally deaf" as those persons who lost their ability to hear and understand speech prior to 19 years of age. The particular group that is of concern in this report are those that cannot use the telephone (even with amplification) because of their handicap. That group is not specifically defined in Table I-1 but is contained in the group with significant bilateral loss and contains the prevocationally deaf. That this group is not precisely defined underscores the difficulty in determining this type of population statistic. The FCC has defined the "telephone limited" group rather broadly as follows[3]:

> "Throughout the United States approximately 6 percent of the population is handicapped by various degrees of deafness [2]. These range from the 400,000 who are totally deaf, unable to hear any

sound of any intensity to the 10,800,000 whose hearing is impaired to the extent that they require a hearing aid. There are 800,000 who cannot understand any kind of speech unless it is amplified to a medically dangerous level."

Regardless of how or when they acquired their handicap, the deaf and hearing impaired need to interact with one another and with the larger society. In short, they need in some way to compensate for the social tool which they lack. In the broadest sense, this study seeks to explore ways in which advanced telecommunication and computer technology can serve as the key that will open the social network to those Americans, and to define "packages" of services which can be provided today.

Telephony and broadcasting, two of the older telecommunication technologies, already have transformed the dynamics of our social networks. From over 98 percent of U. S. residences we routinely use the telephone to apply for jobs, make dinner reservations, sell used cars, buy new clothes and bank. Similarly, sixty-seven percent of all Americans rely on television as their principal source of news and information. Indeed, broadcasting's ability to report events as they are taking place has rendered obsolete at least one former function of the newspaper. Whether some type of computer will equally pervade our homes is not yet clear, but if one should, it offers excellent communication potential for the deaf.

One of the most frustrating aspects of deafness is the pervasive sense of dependence surrounding so many of these activities and functions. There are few artifacts of modern civilization that underscore this dependence as frustratingly as does the telephone. If one needs a plumber, a tow truck, a plane reservation, a cab, or a pizza, the hearing person thinks nothing of his dependence on the people involved or on the instrument he uses to summon them; neither would the deaf person, if this summoning were possible. But it is not--and on every one of these occasions a hearing person must be found and, somehow, asked "Will you please call for me?", with each such request adding to the feeling of helplessness and frustration. Few people can afford a permanent secretary, and it would be a very unusual person who would always be instantly available to respond to a deaf friend's calling needs. Although there are service centers where volunteers make calls in response to teletypewriter (TTY) requests, this does not alter necessity of such interposition. The deaf person is constantly aware of this. He is also aware that even the TTY-to-voice centers are sometimes ill-staffed or too poorly funded to provide adequate support or sufficient hours of operation.

A deaf person wanting to make use of the telephone is confronted by a great many stumbling blocks. A hearing person in a telephone-oriented society may have difficulty fully understanding the psychological effects of such blocks, but there are some areas of activity, such as employment, in which the practical consequences are obvious. The primary reason the telephone offers such an advantage to the hearing worker in comparison to his deaf counterpart is the vast difference in the amount of energy required for a hearing person's telephone call compared to the effort a deaf person must expend on writing a letter or transporting himself from one place to another in order to communicate. With pure information becoming a more and more valuable commodity, the deaf person becomes more and more severely handicapped by his inability to use the telephone.

Deafness entails a multitude of incompletely understood factors, and there is no single panacea to be found. However, there is no reason that the deaf, as well as the hearing, should not benefit from the great advances in communication that the telephone has spurred. Indeed, it is singularly appropriate that this benefit be provided by a further development of the very technology on which the telephone is based, i.e. electronics.

2. Early TTY Network for the Deaf

The explosion in modern telecommunications technology has proved to be both a blessing and a curse for the deaf and hearing impaired. Since the beginning of the century, telephone and radio have created greater isolation for the deaf as society shifted to audio telecommunications for more and more of its social transactions. Although the deaf can often read, write, and speak, how are they to use classified newspaper ads to buy or sell a couch, to apply for a job, or to call in sick once they have been hired? How do they contact their fire department, doctor, or friend in an emergency? How do they learn of storm warnings or accidents that snarl rush-hour traffic?

To solve some of these problems, deaf individuals now operate Baudot/Weitbrecht Telecommunications Devices for the Deaf (TDD) which use the telephone network and specially adapted teletypewriters. In 1964 Robert H. Weitbrecht,* a deaf engineer, developed the modem (modulator-demodulator) acoustic coupler that could be used to convert the electrical signals used by the TTY into audible tones that can be transmitted through the direct-dial telephone network. This pioneering effort provided the deaf population with their own telecommunication access for the first time, several years before it became commonplace for computer terminals to be used with phones (which started with the specification of the "Bell 103" standard modem). At the time Weitbrecht was developing his modem, the only source of inexpensive teletypewriters was the surplus generated as the telephone and telegraph systems replaced their older, obsolete equipment with newer and much more expensive devices. Since the deaf have a significantly lower average income than the hearing population, their leaders chose to support a system utilizing that surplus equipment. Such TTY installation, equipped with an acoustic coupler, could be purchased for as little as $300.

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* For a complete description see Robert H. Weitbrecht, United States Reissue Patent RE 27,595, March 6, 1973, based upon Robert H. Weitbrecht, original United States Patent 3,507,997 which was filed August 22, 1966 and issued April 21, 1970.

Although the decision to standardize on these surplus teletypewriters (which used the "Baudot" 5-level character code) made it possible for people of average income to afford a TDD, it had the unavoidable result of making the deaf TDD network incompatible as a whole with the newer devices being produced for the computer and communication industries. These use the "ASCII" character 8-level code. These character set differences coupled with the differences in the Weitbrecht modem signaling characteristics (compared to the standard Bell modems) and the slow, cumbersome typing of the old TTYs limited the effectiveness of these early pioneering efforts which originally were intended to give pervasive communication capabilities to the deaf.

The deaf population consequently became isolated from the rapidly expanding world of computer communications, a situation that today effectively precludes them from making use of new low-cost terminals, couplers, and automatic answering devices; it denies them the compatibility necessary to access computer systems (which provide personal communication services such as electronic mail) and prevents them from interacting with approximately three million 8-level terminals in use throughout the world today.

In many situations, a deaf person away from his TTY needs some kind of portable device to enable him to make an essential telephone call without having to rely on a possibly uncooperative or unavailable hearing person. Currently, no low-cost truly portable device exists to fill these needs. It is difficult for the hearing person, who takes the telephone so much for granted, to imagine the manifold complications that arise from this dilemma.

3. The Possibility of Computer Communications

Today's more than 40,000 Baudot TDD's are primitive devices, indeed, when compared to the three million ASCII computer terminals now in use. Faster and more reliable, the ASCII terminals offer more features for the money. More important, the ASCII standard is used almost exclusively in the ever-growing number of computer communication systems.

Recent scientific advances, however, are creating new, even more sophisticated communication systems which could alter society's use of existing technologies. Electronic mail systems (EMS)*, for instance, may be more efficient than the telephone for handling some types of social transactions. As Nobel laureate Joshua Lederberg has observed, the merging of telecommunications and computer technology into electronic text systems is "expected to increase the thoughtfulness of communication, the return of literacy in the efficient and precise use of language, and to enhance...discourse in many other ways [4]."

Electronic text systems may have at least one other significant consequence: as they develop and proliferate, they could provide important new opportunities for members of the deaf community to interact both with other hearing impaired individuals and with society at large.

What some have called the "telecommunications revolution" is due to remarkable progress in developing semiconductors, computer systems and new transmission services. As such progress continues, the merging of communication and computer technology will accelerate, bringing with it a new array of sophisticated electronic text services.

There are, for instance, thousands of electronic mail systems already operating in the United States. These range from small community bulletin boards Systems (CBBS) serving home computer hobbyists to large national networks for commercial users. Many corporations routinely use their own or others' computer systems for both inter- and intra-office mail. Meanwhile, CompuServe and The Source have been especially aggressive in developing the home computer market, offering customers a variety of services--including electronic mail. CompuServe alone has more than 12,000 subscribers with access to its electronic mail service.

* In this report, we use the terms "electronic mail systems" and "electronic text" to refer to computer-based technologies. We do not include telegraph, telex, or TWX.

How can the benefits of these new services be captured for the deaf? The growth of the home computer market, which is expected to take place within the next 10 to 20 years, may offer the most promise for the deaf and hearing impaired. Indeed, the deaf may be regarded as those members of the home computer market who are most likely to benefit from such services.

Our experience with the Deafnet demonstration program in San Francisco, Washington, D.C. and Framingham, Mass. has supplied ample evidence that the deaf are eager and effective users of the message and mass communications service that can be provided by EMS. Deafnet links the deaf to one another by allowing them to send personal messages and to publish an electronic newspaper containing information about captioned films, signed lectures and other events which commercial publications often do not carry. In addition, the network offers the deaf access to a database of information from schools, libraries and other public-service institutions.

Most important, the demonstration has offered the deaf valuable exposure to new technologies, while giving researchers fresh understanding of the users' needs. The research has shown, for instance, that EMS for the deaf should have features which are also suitable for the broader market. In particular, the system should be easy to operate and affordable, with charges based more on the services used rather than time spent on the system.

4. Difficulties in Implementing Computer Communications

The full potential of electronic text services for the deaf community will not be realized until several transitions are completed. First, the telecommunications industry itself is not only growing rapidly, but is also in the midst of a massive restructuring due to the Federal Communications Commission's (FCC) decision in its Second Computer Inquiry [5]. Computer Inquiry II (as the FCC's decision is often called) will deregulate large parts of the industry, including AT&T, which will be allowed, for the first time, to offer sophisticated

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computer communications on a fully competitive basis, provided it does so through a separate subsidiary.

Although such deregulation may generate new industry competition and superior products at lower prices, Computer Inquiry II probably will bring with it a shift to cost-based pricing; thus, consumers will be forced to bear more and more of the actual cost of the individual services they use. This is especially true for local telephone service, which is now subsidized to some degree by long-distance revenues. In other words, local customers will be much less likely to pay a flat monthly rate; instead, they will be charged for actual transmission time they use. This type of pricing could create substantial problems for deaf users, who may spend more time reading and writing on a system because of their language disabilities.

Second, as the communications industry grapples with internal restructuring, it will, at the same time, be struggling to penetrate a marketplace that may resist some of its newest products and services. To put it differently, the industry will be trying to manage the diffusion of its innovations throughout society. This process of innovation diffusion could be especially difficult for members of the deaf community, who often are isolated from, self-conscious about, or otherwise reluctant to use new telecommunications devices.

Finally, as part of this general process of innovation diffusion, the deaf will be facing still another change that is even more directly relevant to their immediate concerns: the technological transition from outmoded Baudot teletypewriters used exclusively by the hearing impaired to ASCII-standard terminals used in computer communications systems. As our earlier research has shown, the cost of converting existing TTY's can be as high as purchasing new ASCII systems. What, then, is to be done with existing equipment or to encourage the deaf to purchase the new terminals?

These and other questions may ultimately be resolved by policy-makers at both the federal and state levels. Many state public service commissions, for instance, now require telephone companies to lease Baudot-standard TDD's to deaf customers on request. Some state commissions have required or encouraged telephone companies to provide service to the deaf at reduced rates. How will such commissions handle the impact on the deaf of the telecommunications industry's shift to cost-based pricing, or the deregulation of all terminal equipment?

In trying to respond to the needs of deaf citizens, federal and state governments must be aware of the broader technological transition now facing the deaf community. Whether it be policymakers in agencies and commissions or deaf individuals and vendors working in the marketplace, someone will select a technology, and someone will distribute it to an as yet undetermined number of users.

The transitions now facing the telecommunications industry, its customers and, particularly, its deaf customers raise a host of problems and possible solutions. This study suggests several alternatives with the conviction that, if adopted, they could ensure that the almost two million deaf Americans partake in the benefits of the telecommunications revolution which is upon us all.

C. Structure of the Report

This report first defines the required services that best suit the needs and abilities of the deaf, and then discusses strategies for commercial provision of those services. The report is organized in eight chapters. Chapter II, directly below, summarizes principal arguments and results. Chapter III discusses the issues that are to be addressed in determining the commercial feasibility of providing such communication services to the deaf. Chapter IV assesses the current status of communication needs and capabilities of the deaf showing what is potentially applicable in the present day technology. Then the Deafnet computer-based communication demonstration system is discussed and reactions of some of the users are summarized. Some pertinent information about the recent developments in California about providing communication devices to the deaf as part of the basic telephone service

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is discussed, and, finally, a discussion of several economic factors relating to communication for deaf individuals is presented.

Chapter V develops a structure (architecture) for a commercial-vendor based system and a charging method that is tailored to the unique needs of the deaf. Chapter VI applies some recent economic theory in designing tariffs and assesses them in terms of "critical mass" (minimum number of users necessary to make a communication system go), ultimate network size, and potential revenues, costs and profits for a mature service. Chapter VII gives concrete estimates of these quantities for a specific target population that might be served nationwide. Finally, Chapter VIII discusses the evolution of the network from both political and economic points of view.

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II SUMMARY

The key objectives of this study are to define an affordable, useful, new communication service for the deaf and to assess the viability of developing commercial computer-communication networks to provide these communication services to the deaf community on a nationwide basis. The motivation is to help the deaf overcome the difficulties they experience in using the telephone system, radio, and, to a certain extent, TV in this modern communication-intensive world. In the process of achieving this goal, the deaf and other handicapped individuals could become the vanguard of the computer-based communication movement rather than continuing to lag years behind the technology. The combined service that we describe (denoted DNAS--Deaf Network and Associated Services) would allow access by existing Baudot/Weitbrecht Telecommunications Devices for the Deaf (TDDs) as well as by ASCII terminals with Bell modems and would provide limited intercommunication between deaf and hearing.

Deafness entails a multitude of incompletely understood factors for which there is no single panacea. However, the deaf, as well as the hearing, should benefit from the great advances in communication that the electronics industry has spurred; indeed, it is singularly appropriate that these benefits be provided by the very technology on which the telephone is based.

The more than 40,000 Baudot TDD's used by the deaf today are primitive devices when compared to the half million ASCII computer terminals now in general use. Faster and more reliable, the ASCII terminals offer more features for the money. More important, the ASCII standard is used almost exclusively in the ever-growing number of computer-communication systems.

The Deafnet demonstration has offered the deaf valuable exposure to new technologies, while giving researchers fresh understanding of the deaf user's needs. The research has shown, for instance, that EMS for the deaf should have features which are also suitable for the broader market of home consumers. In particular, the system should be easy to operate and affordable, with charges based more on the services used rather than time spent on the system.

But the full potential of electronic text services for the deaf community will not be realized until several transitions are completed. First, the telecommunications industry itself is not only growing rapidly but is in the midst of a massive restructuring due to the Federal Communications Commission's (FCC) deregulation decision in its Second Computer Inquiry. Although such deregulation may generate new industry competition and superior products at lower prices, Computer Inquiry II probably will bring with it a shift to cost-based pricing of telephone services. Second, as the telecommunications industry grapples with internal restructuring, it will, at the same time, be struggling to penetrate a marketplace that may resist some of its newest products and services. Finally, as part of this general process of innovation diffusion, the deaf will be facing still another change that is even more directly relevant to their immediate concerns: the technological transition from outmoded Baudot teletypewriters used exclusively by the hearing impaired to ASCII-standard terminals used in computer-communications. This transition will not only minimize the cost of serving the deaf, but will also lead to the fullest market penetration and the largest overall net social benefit.

The Deafnet experiment, while it has demonstrated technical feasibility, falls far short of demonstrating ultimate commercial viability on a nationwide basis. To be profitable, a product or service must be low enough in cost to attract customers willing to pay for it. Although the cost of computer hardware has dropped dramatically in recent years, telecommunications costs (as seen by both supplier and user) have stayed relatively constant. For DNAS, we expect some such

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economies, but not substantial ones. Whereas communication costs are estimated to be about 33 percent of total costs for serving the urban population, they might constitute as much as 51 percent of total costs for the rural population, resulting in an overall figure of 42 percent for a system reaching all users.

The communication systems the deaf use must be convenient, affordable, and reliable, with adequate privacy protections. As the present incompatibility between the Baudot and ASCII standards demonstrates, the communication system also must be flexible enough to accept or adapt to technical improvements as engineers and vendors make them available.

A communication system for the deaf must be responsive to its users' multiple limitations. Specifically, the system must be easy to use with a minimum amount of training. Because a written "conversation" between two deaf individuals will take significantly longer than its spoken counterpart, user costs should not be determined solely by time spent on the system. Indeed, cost is an especially critical factor given the comparatively limited incomes of many of the hearing impaired.

Computer-communication services are more prevalent in the commercial sector, where Xerox, IBM, AT&T and Wang are just a few of the companies aggressively promoting various components of the "office of the future." Although effective, such services usually are priced well beyond the means of most deaf or residential users.

In short, the public at large must become more aware of, and confident in, the ability of electronic text systems to function as partial replacements for traditional telephone service, mail delivery, and publishing. To put it differently, the proponents of computer-communication services must acknowledge and solve the problem of innovation diffusion, the means by which society learns of, and begins to use, a new product or service.

The technical problems of developing a communication system for the deaf have, for the most part, been solved. Deafnet demonstrates that computer communication can provide a wealth of options never before available to the hearing impaired. While minor hardware and software adjustments still are necessary, the major problem now facing the community is ignorance--the deaf must be informed of the new service. Without that knowledge and support, even the most superb technical system offered at an affordable price may go unused.

In general, most Deafnet users interviewed were very enthusiastic about the system and hoped that it could continue. As the reported usage data suggest, by far their favorite feature is the electronic message service. The popularity of this service explains many respondents' desire that their friends be on Deafnet and that Deafnet be expanded to more areas of the nation.

A number of users suggested that newsletters and workshops explaining how to use Deafnet would be helpful. These suggestions reflected the feeling of many respondents that they did not understand how to use Deafnet as well as they would have liked, often because they felt the manual was confusing or because they were unaware of, or felt uncomfortable with, the on-line instructions. These comments point up the importance, whatever the service, of simple instructions and ease of operation.

When asked about features that should be added to the system, the most enthusiasm was expressed for a communication or answering service of either a voice-text conversion type or a standard message service.

A majority of the respondents said they would be willing to pay the somewhat higher bills (almost always under $20) that we expect for similar useage patterns on a commercial nationwide system. It seems likely that, if the system actually were nationwide and had a large number of users, its value would be increased considerably beyond what is perceived at this point, since its practical value as a communication device would be so much greater.

The recent California legislation and the CPUC implementation program to have the telephone companies distribute dual-mode TDDs to

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certified deaf individuals at no additional cost above the standard monthly phone charge will generate a large population of ASCII-compatible terminals for use by the deaf. As this type of legislation spreads to other states, even more users will become aware of, and skilled in, new communication capabilities. They will also begin realizing the (proportionally higher) cost of using direct distance dialing over the telephone network for terminal communications. This will spawn a group of users familiar with terminal equipment that demand lower-cost communication systems. The terminals will be (nearly) compatible with digital networks and thus can take advantage of them as well as force the development of better communication services.

Cost is an especially critical factor for the deaf, who often have low incomes due to their comparatively limited employment opportunities. Whether one is considering conventional telephone service or the most sophisticated computer-communication system, cost can be divided into two elements: (1) the cost of terminal equipment and maintenance and (2) the cost of transmission services.

Prices for conventional TDDs range from $450 to $750. TDDs can be leased from the telephone companies at per-monthly rates from $6.68 (Michigan) to $15.30 (Kentucky). Of course, the convenience of leasing may surrender the choice of TDDs to the telephone company, which may, unwittingly, frustrate the distribution of new equipment using the ASCII standard.

Although growing steadily since the late 1970s, the market for personal computers is expected to explode within the next five years. The anticipation of rapid growth has spawned the development of new businesses eager to supply housewives, students, and small commercial users with an array of supportive services ranging from electronic information retrieval to customized software.

Improved software and processing ability could represent an important breakthrough for many deaf users who are intimidated by the new technology or frustrated in its use, given their sometimes poor language skills. Personal computers are not inexpensive, although a few already are competitive with conventional TDDs with prices ranging from $399 to $2,500. The sheer number of models, brands, and prices may intimidate some potential users. This characteristic, combined with the fact that retailers will often offer discounts of up to 30 percent for bulk orders, suggests an important role for leaders in the deaf community: a computer-communication system may be more successful and economical if it is introduced simultaneously to a group of deaf users. A group introduction, however, requires persuasive and organizational skills--which are less likely to be found at a Radio Shack outlet than at a church, school or community center with an active program for the hearing impaired.

In August, 1981, AT&T filed a revised tariff at the FCC seeking to reduce interstate rates for speech and hearing-impaired customers. The normal (maximum) long distance rates of $25-day, $16-evening and $10-night were reduced to $16-day and $10-evening and night.

Thirty-six states now offer reduced intrastate rates to the certified deaf, with similar tariffs pending in two more states and another on file in Texas. Of these, 18 states have plans which are similar to the reduced AT&T interstate tariff. In the other states, the deaf receive a 60 percent discount off the basic day rate at all times.

Less expensive alternatives are available, however. Deaf customers who place a substantial number of long-distance calls, for example, can subscribe to one of several low-cost long-distance services now offered by MCI, Southern Pacific Communications and other companies. Time-sharing systems may also be cost effective, especially for computer-communication systems. For instance, Telemail's night time rate of $4 per hour is significantly lower than AT&T's. Telemail's customers can further minimize transmission costs by using a personal computer to compose and store messages before they are sent. A printer combined with a personal computer would achieve similar economies for receiving messages. GTE requires that customers spend a minimum of $500 per month for Telemail service; in addition, the company imposes a $140 monthly subscriber charge. Although $640 may not be feasible for an individual subscriber, it is economical for groups of 120 or more.

Leaders of the deaf community have an opportunity to play a pivotal role. They could, for instance, fight fiercely to preserve the status quo, i.e. mandatory leasing of TDDs and rate discounts. However, they do so at a risk. Computer Inquiry II did not spawn the changes now taking place in the telecommunications industry; rather, the FCC's recent decision has only accelerated an already well-established trend toward competition and cost-based pricing--a trend which is driven by technological progress.

Should the deaf community devote its efforts to preserving the status quo, it may miss important opportunities to influence the business and policy decisions which will shape an ever-changing technology. New computer communications hold far more promise for the deaf than today's telephones and TDDs. However, without participation from the deaf community, these new technologies may develop in ways that are not as beneficial to deaf users as they might be. In short, the deaf community may discover that while it was fighting one battle, it lost others which were ultimately far more important.

Leaders of the deaf must be educated--and quickly. They, in turn, must reach out in three directions: to deaf telecommunications users; to the computer-communication industry; and to state and federal policymakers. Whether one labels this process "innovation diffusion," "education" or simple "marketing," its purpose is the same: to ensure that members of the deaf community have access to a new technology that is convenient, affordable and responsive to their communication needs.

The major conclusion we draw is that a service for the deaf must provide basic communication services akin to the telephone system--a service that is economical, convenient and fully integrated. A $5-10 per month charge for the additional convenience of a computer-based system is not unreasonable and would likely be paid willingly by deaf users. If, further, less-expensive long-distance communication could be provided by such a system, then a per-user average charge could be on the order of $15-20 per month. We estimate that a person typing on a TTY would take 5-9 times as long as a talking person to convey an equivalent number of words. At long-distance phone rates, this can give a deaf user a considerable phone bill each month.

From the supplier point of view, startup and provision of the basic communication service represent the largest portion of the cost. Thus, we need to consider carefully whether the consumer can afford this service. From a (deaf) user point of view, we need to make a distinction between 1) economically usable services, 2) urgent services that are not available now but would be used if available, and 3) "enhanced" services. The enhanced class of service can be provided without much additional cost and so has the potential of contributing primarily to profit. The key, then, is to define enhanced services that will be attractive to the deaf community. Representative basic services are computer-based mail, terminal-linking, and online news reports. Examples of enhanced services are games, entertainment guides, home delivery of educational courses, and recipe libraries.

Finally, a good evolutionary strategy would be to start by offering services that the deaf can afford, where the payment is just a substitution within the family budget. Once subscribers begin using such services and become familiar with the new skills and concepts, there is an easy and likely transition to begin using the service for entertainment, business, and other activities. This evolution easily leads to a built-in market for the enhanced services.

The architecture or structure that we recommend is based on "tiered charges" or cost-based pricing. That is, the user should be able to select the services he wishes to use and pay only for those services. This tiered-charge model is distributed and uses regional community centers. The regional centers are connected by a Value Added Network. Each of the regional centers can be tailored to match the communication requirements and available capital (investment potential, income) of the local community and to provide specific services.

This model makes no restrictions on the type of hardware or software used to implement the regional centers, but rather requires only standardized communication procedures. They are of three types: terminal mode, block mode, and message mode. With this structure, a wide variety of services and methods of access can be provided.

Recent economic theory should be applied in designing tariffs to assure a "critical mass," the minimum number of users that would be necessary for commercial viability. Tariff design is also critical in assuring a maximum number of subscribers for the mature or "equilibrium" network.

Critical mass would vary considerably, depending on the tariff structure and on supplier costs. For the best case considered, attracting 130,000 subscribers would ensure spontaneous growth. For the worst case, 750,000 subscribers would be necessary. Multipart tariffs reduce this initial barrier by lowering the subscription fee.

Equilibrium network size would range from one million to 1.76 million subscribers, depending on assumptions. For maximum market penetration, a nonlinear tariff should be employed.

Average subscriber outlay (exclusive of any terminal costs or basic connection charges) appears to be relatively insensitive to the modelling assumptions posited and ranges from $28 to $33 per month. Annual call volume for the nationwide system could exceed three billion.

Total system revenues could be considerable, ranging from $360 million to over $500 million. Multipart tariffs stimulate revenues substantially; lower supplier costs also stimulate revenues by increasing, indirectly, the ultimate network size.

As expected, multipart tariffs tend to reduce usage per subscriber. However, this effect is offset by the additional subscribers they stimulat into joining.

Once critical mass is achieved, all cases studied are viable, with revenues exceeding costs by a considerable margin. Net revenues would be substantial, varying from $120 million to $450 million.* The nonlinear tariff is clearly the most profitable choice indicated by the model. Although consumer surplus is reduced by multipart tariffs, this effect is more than offset by increasing producer surplus (net revenue). Hence, usage charges for DNAS appear to increase overall net social benefit.

Still, some form of subsidy appears to be needed at the outset. This will be true overall, and for each regional center. Most subsidies are in the form of government infusion of funds or legislated surcharges. However, another mechanism, based on the free market place itself, is to take advantage of the increasing popularity of these services outside the deaf community. Businesses have already shown a keen interest in the word-processing and rapid communication capabilities of such computer-based systems.

Thus, the deaf and the hearing share a motivation for use of such a system. A commercial regional system could sell excess capability to the deaf or the deaf regional system could sell excess capability to the non-deaf until the number of deaf subscribers reaches critical mass. The business users could even continue to be served beyond that point as long as capacity was available and the service to the deaf was not degraded. This shared use would also offer the ancillary benefit of increased potential communications since the deaf could communicate directly with these business users.

The foregoing analysis indicates that DNAS is likely to be a commercially viable offering, capable of generating revenues that exceed costs by a comfortable margin over the long term. Thus, although outside subsidy will almost certainly be needed to initiate the network, it is highly probable that such payments will no longer be needed once

*These figures indicate profit potential, rather than actual profit. Front-end losses during startup, taxes, and competitive pressures are not accounted for in our model and can be expected to reduce these figures considerably.

the network reaches critical mass. Depending on how the network evolves, the offering may become profitable long before critical mass is reached.

Finally, results show that the nonlinear (block declining) tariff is clearly the best choice, not only because it maximizes supplier net revenues, but because it leads to the fullest market penetration and maximizes overall net social benefit. For DNAS, however, its most valuable property may be that it induces a voluntary functional equivalent of cross subsidy, allowing those persons least able or willing to pay to join the network.

We have discussed the commercial feasibility of DNAS in terms of specific costs and revenues for a target population of users. However,it should be stressed that these costs and revenues, though they appear to be appropriate and reasonable, are based on models and assumptions that bear further investigation before proceeding to build the network.

In summary, many factors are involved in determining how much subsidy will be needed. Costs, revenues, prices and the way in which the network expands are primary economic determinants. But the success of DNAS will depend ultimately on the users themselves and on their own leadership in fostering its growth.

III KEY FACTORS IN DETERMINING COMMERCIAL FEASIBILITY

By means of direct experiment, it has now been demonstrated that Deafnet is popular with those who have had the opportunity to use it. Nevertheless, this initial test falls far short of demonstrating ultimate commercial viability on a nationwide basis. Before launching any enterprise to offer such services--with or without any startup subsidy--a much clearer picture of supply (i.e., the network, equipment, personnel and their cost) and demand (i.e., the users as a market and their sensitivity to price) will have to be ascertained. The following issues are offered to set a context for subsequent, more detailed analyses contained in Chapter VI of this report.

A. Viability

Until the 1960's, telecommunications services in the U.S. were offered by a highly regulated, relatively closed, monopolistic industry. Such an environment fostered development of a telephone network without peer, offering basic services to cities and remote rural communities alike at very low rates. Such was the intent of the Communications Act of 1934, with its mandate for "universal service." Unfortunately, this same environment did not foster as much technical change as many believed was needed. Indeed, had it continued, computer networks in general, and DNAS in particular would likely have remained little more than an academic concept.

Instead, over the past twenty years, the telecommunications industry has moved toward being a free marketplace. The new technologies and services it has spawned, including satellite transmission, packet networks, and interactive, decentralized computer services, have been phenomenal. Coincidently, the markets have become less protected and competition has become fierce. For a business operating in such an environment, the issue of primary concern is that of economic viability.

To be "viable", (that is, profitable), a company offering a product or a service in a free marketplace must be able to produce it at a low enough cost to attract consumers willing to pay for it. For telecommunications services such as DNAS, this truism is complicated by certain market externalities, inherent in the service itself, which tend to impose distinct thresholds on viability, making it less amenable to standard continuous supply/demand curve analysis. Still, the cost as borne by the supplier must ultimately fall below the price as borne by the consumer if the enterprise is to be successful.

B. Supply Considerations

Despite inflation, costs of computer hardware have dropped dramatically in recent years. Telecommunications costs (as seen by both supplier and user) have also dropped, but far less dramatically: inflated dollar prices have kept costs relatively constant (that is, a decrease in real dollar prices of about ten per cent per year has been offset by inflation). Toll prices have dropped substantially, largely because of a recent opening up of this area to competition. However, since toll revenues are the major source of subsidy for local exchange telephone plant, local access charges have, of necessity, increased in relative terms and will continue to do so in the future. (See the appendix for a further discussion of this point). The main vehicle used to increase local charges will be the imposition of measured usage fees, which could have a severe impact on such systems as DNAS*.

1. Economies of Scale

Because of generally high fixed startup costs relative to generally low variable (that is, marginal) costs, most businesses exhibit economies of scale. That is, the average cost per unit produced tends to decrease as the number of units increases--the (supplier) cost

* The use of intelligent terminals with memory buffers could alleviate this potential problem.

per user tends to drop as the market of users increases. For nonzero startup costs, this characteristic holds true even if the marginal cost of serving each additional user is constant; higher startup costs tend to produce stronger scale economies (see Fig. III-1).

For DNAS, we expect some such economies, but not substantial ones. SRI's preliminary cost analysis[6] determined that, despite the computer-intensiveness of the service, the computers themselves would contribute but a small portion to overall costs. Indeed, most of the costs are incurred by the telecommunications links (local access charges, especially) and the user terminals. Since each new user will require a terminal and local access to the network, the variable costs will tend to dominate any fixed startup costs--the situation depicted in curve (A) in Figure III-1. The best approach toward reducing these costs may be to offer DNAS as part of a much larger system, thereby sharing both fixed and variable costs with the larger resource. Owners of such larger systems (notably, The Source), when interviewed personally by SRI on the subject of implementing DNAS commercially, expressed keen interest in pursuing this "piggyback" approach.

2. Rural Subscribers

One of the basic problems faced by any telecommunications offeror whose motivation--or mandate--is to serve the nation's interest as a whole, is the high cost of reaching the more sparsely populated areas of the country. These high costs are one of the prime reasons why the U.S. telecommunications industry was structured the way it was (and, for the most part, still is). As the system stands today, most of the basic services are offered by regulated monopolies who agree among themselves to subsidize service to rural areas with excess revenues obtained from toll service and from other profitable offerings. In contrast, a company operating in a competitive free-market environment would not care. It simply would ignore the rural areas or any other set of potential subscribers unable or unwilling to pay for the actual cost of being served.

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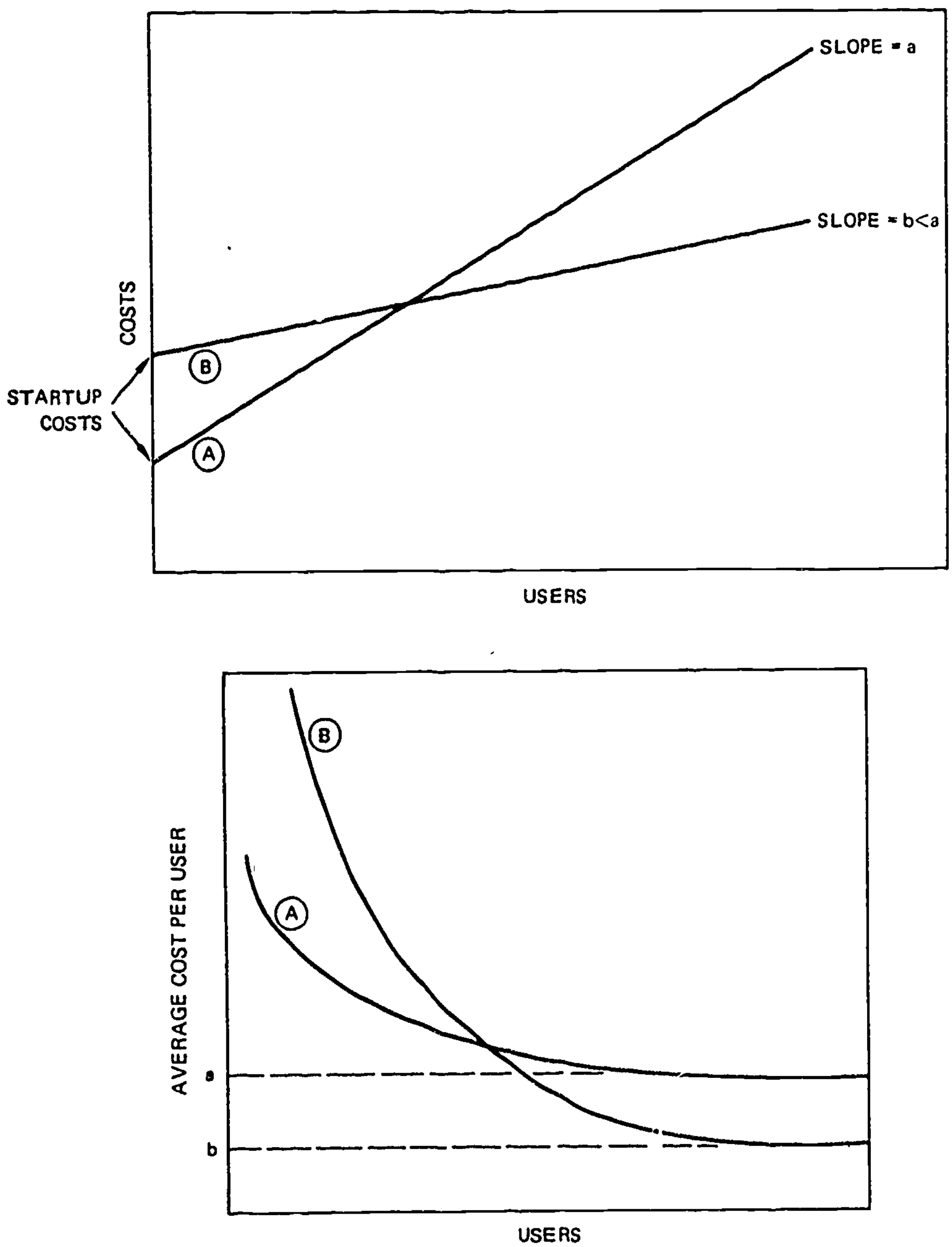

FIGURE III-1 ECONOMIES OF SCALE

For DNAS, which is designed to serve an underprivileged minority, it would be ironic if a subminority (hearing-impaired people in sparsely populated areas) were not allowed equal opportunity, should the system be implemented. Yet the preliminary cost studies conducted by SRI thus far indicate that the rural areas will indeed be expensive to reach. If the deaf population is distributed geographically in the same manner as the hearing population*, about 60 percent of the hearing-impaired live in urban areas (the top 129 cities). For the least expensive case studied by SRI (a system linking regional computers to inexpensive, unintelligent terminals), these urban DNAS users might be served at an average cost of about $10 per month**. However, serving the remaining 40 percent might cost as much as much as $27 per month, raising the average cost of the overall composite to $17 per month--a substantial increase. Further analysis has indicated that most of this increase is due to the communication portion of the computer-communication system. In particular, whereas communication costs would be about 33 percent of total costs for serving the urban population, they might constitute as much as 51 percent of total costs for the rural population, resulting in a overall figure of 42 percent for a system reaching all users.

Such increased costs can be interpreted as diseconomies of scale. As shown in the previous section, we might expect per-user cost to drop slightly as more and more of the urban population is served. If scale is increased further to encompass the rural areas, however, higher marginal costs would tend to pull up overall average cost.

* This assumption requires further study to be verified fully. It must be stressed that these results were derived under assumptions that would allow relative comparisons; they are not intended as absolute dollar amounts.

** Excluding costs of the user's basic telephone connection (assumed to be $6 per month) and the user's terminal ($15 per month). It must be stressed that these results were derived under assumptions that would allow relative comparisons and thus the dollar amounts should not be considered absolute. For instance, taxes and profits were not included.

A more detailed study of tariff design for this market and a discussion of more diversity in implementing the system (using new technologies such as microcomputers, for instance) is discussed in Chapter V and VI. In fact, by proper design of tariffs, the impact of providing rural service may be lessened--see Section VI.D.3. However, it is clear that any business plan proposed for DNAS must address ways to provide comparable service to rural users.

C. Demand Considerations

Estimates vary widely as to the number of hearing-impaired people in the U.S. whose deafness is severe enough to preclude use of the telephone--even with special amplifier attachments (See Table I-1). For purposes of this discussion, we can assume that at least one million persons are so impaired and would welcome a service such as DNAS. It is possible that another 1 million hearing relatives, acquaintances and other interested parties (including local, state, and federal government offices) might subscribe. Thus, the potential market might be as high as 2 million users, or roughly 1 percent of the total U.S. population.

How much of this market can be realized depends on subscriber willingness to pay* (that is, demand as a function of price) and on an externality peculiar to interactive telecommunications, called critical mass (See Section VI-A for a detailed analysis of critical mass in this type of market).

1. Willingness to Pay

In general, the amount of the potential market penetrated will depend on the price charged: more people will subscribe if the price is less. Since the basic purpose of DNAS is to improve the quality of services to an underprivileged minority, capturing the entire potential market (that is, pricing the service low enough to be affordable to all) is certainly an important goal. However, commercial viability dictates that total revenues exceed total costs. Depending on willingness to pay

* Several technical terms that appear in the text are defined in the Glossary at the end of this report.

(in particular, the price elasticity of demand), maximum revenues may or may not accrue at full market penetration. Unfortunately, it is likely that they will not.

Figure III-2 depicts a generalized demand function. Also shown are the standard definitions of price elasticity, willingness to pay, and consumer surplus. Price elasticity of demand, "e", is the percent change in quantity demanded (that is, number of subscribers or market penetration) for a percent change in price; the percent change in revenue for a percent change in price is one plus the elasticity. Assuming the demand always decreases as price increases (as depicted in the figure), price elasticity of demand will always be negative. Demand is said to be elastic if $|e|>1$, inelastic if $|e|<1$ and to have unit elasticity if $|e|=1$. As prices are reduced, revenue will fall if demand is inelastic, will rise if demand is elastic, and will remain unchanged if demand is unit elastic.

Most telecommunications services in the U.S. and elsewhere have been shown to be inelastic (that is, up to a point, as the price rises, people will continue to use the service at the same rate of usage). Thus, telecommunications revenues tend to rise as price increases; conversely, they fall as price decreases. For new services such as DNAS, there is as yet no firm base of data on which to estimate elasticity, although the fact that only a limited number of subscribers dropped out of the WDC Deafnet experiment when fees were first imposed suggests that demand is inelastic (See Section VI-B for more details on the WDC Deafnet experiment).

Still, it must be borne in mind that the deaf minority has fewer job opportunities and, hence, less income than the hearing majority. Because of this, DNAS users may be more sensitive to price than the general population. This is borne out in the preliminary survey of potential TDD users conducted by SRI in 1974 at the NAD Convention in Seattle[7]. The survey indicated that price was indeed a critical consideration to most of the 42 deaf people interviewed. This

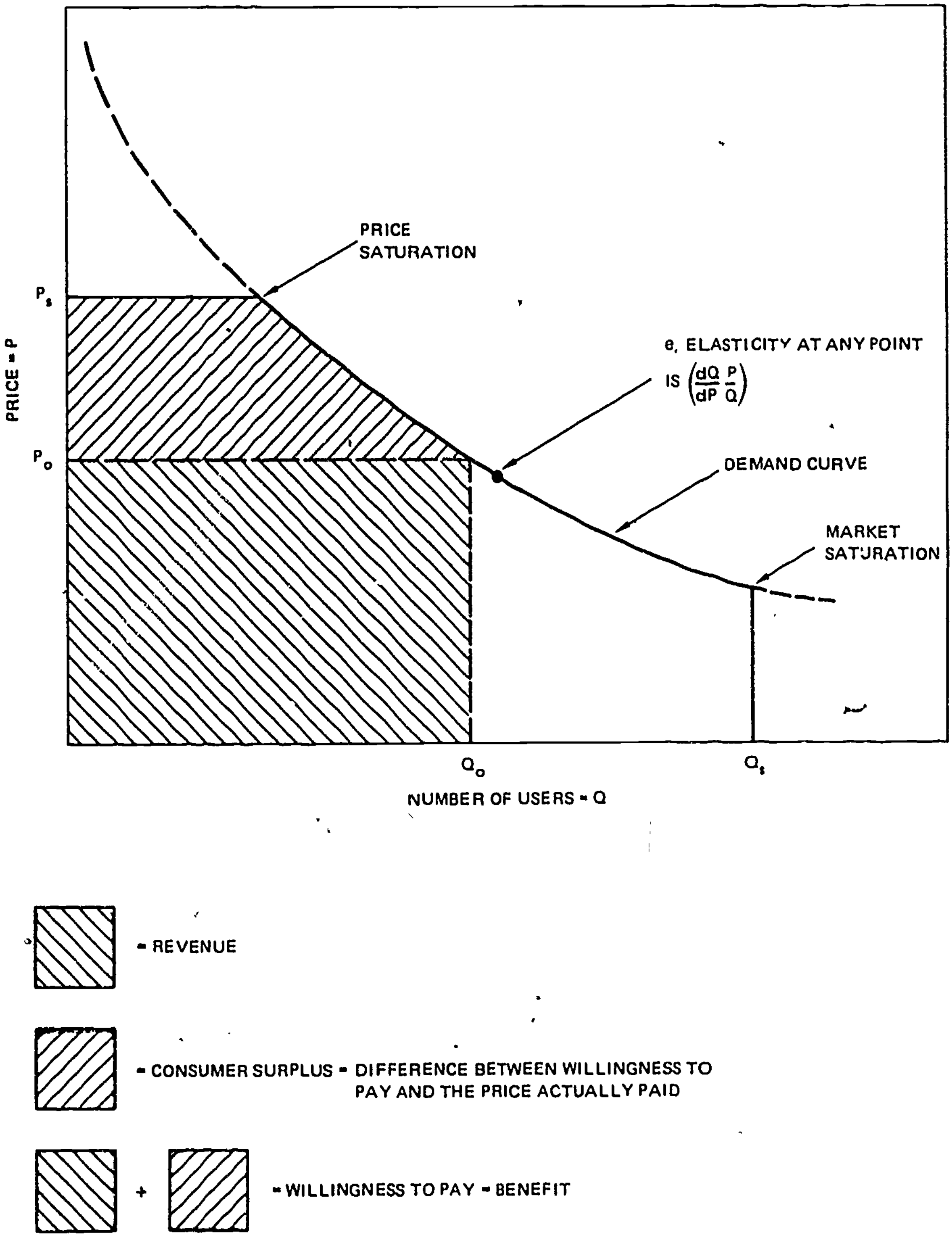

FIGURE III-2 DEMAND CONCEPTS

result carries additional weight since the interviewees were "self-selected", that is, they volunteered to participate. In general, such persons would be more enthusiastic and more willing to pay than those who wouldn't even participate in the survey. Although all appeared willing to pay a lease price of $5 per month for the personal use of a TDD, and 65 percent were willing to pay $10, only 9 percent were willing to pay $15 or more. These dollar figures are out-of-date today. In relative terms, however, they imply a demand curve that is inelastic when prices are low, becoming strongly elastic as prices rise beyond a tolerable level.

Although specifying the demand function for DNAS is primarily useful as a tool to estimate revenues (the shaded rectangle in Figure III-2) and market penetration (Q_0) for a given price (P_0), it also yields additional information regarding the total benefit of the service. Such information will be of special interest to those government agencies responsible for any short-term subsidies needed for DNAS startup. As shown in the figure, the benefit is defined as total willingness to pay (revenues plus the consumer surplus). Thus, benefits will exceed revenues, but probably not substantially for DNAS, since few prospective users have high enough incomes to pay the saturation price sketched in the figure.

2. Critical Mass

Demand for interactive telecommunications differs from demand for most other goods and services in one important respect: each additional subscriber makes all other subscribers better off. Buying a toaster has little if any impact on other toaster buyers; joining a network of telecommunications users, however, not only allows the new user to access those already interconnected, but allows each of those already interconnected to access the new user. This characteristic, or demand "externality" tends to cause demand to snowball at an accelerated rate as the system grows--an effect that has often caught communication planners short, especially in newly developing areas of the world.

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By the same token, telecommunications demand for incipient networks has an extra barrier to overcome. The first toaster buyer has a new toaster; the first network subscriber has nothing until at least one other subscriber joins. In particular, a certain minimum subset of potential subscribers must be induced to join, or join in anticipation of others joining, to make the action worthwhile to each.

This minimum subset is known as the "critical mass" of users[8]*. For electronic message systems targeted for the general populace, we can expect critical mass to be considerably greater than two--or even two hundred. (For DNAS, the threshold may be smaller than for systems targeted for the general population--which as yet has no special need for such a service.) In general, critical mass will depend on the perceived value of the service (that is, the utility function of each potential subscriber), and on price (that is, the tariff structure).

The type of tariff imposed can have a considerable impact on critical mass, ultimate market penetration, and overall social benefit. The subject deserves deeper study than is possible in this initial exploration. Two-part or multipart tariffs may reduce critical mass considerably, though they may also reduce usage and consumer surplus to a slight extent. An example of a two-part tariff might be a fixed minimum subscription charge, a "free" amount of usage bundled with the subscription, and an additional charge, linear with usage, levied whenever the free portion is used up. Care will have to be taken, however, to ensure that subscribers are not penalized too harshly for additional usage. Otherwise, low-income users will take special pains to stay at or below the free usage level. This would inhibit communication and reduce revenues. Chapter VI gives an analysis of various tariff options in light of required critical mass and other market factors.

*Note that, for DNAS, the number of terminals needed to serve this critical mass may be less than the number of users, since the deaf tend to cohabit.

D. Subsidy Mechanisms

From a purely economic point of view, the best form of subsidy is one that disturbs the free marketplace the least. That is, the subsidy should not distort prices to the point where they no longer reflect costs -- especially in a mature market. More generally, the subsidy should promote efficient pricing so as not to erode overall social net benefit (the sum of supplier net benefit and consumer net benefit). According to this ideal, telephone toll rates should not subsidize telephone local rates; high-density airline routes should not subsidize low-density routes. Indeed, as deregulation proceeds in the telecommunications and airline industries, such "inefficient" disparities between price and cost are being reduced. For example, prices for long-distance calls are declining; prices for local calls are rising. Both sets of prices now more clearly reflect the costs of provision.

Nevertheless, it is important to remain aware of the underlying reasons why such industries were regulated in the first place. Other social concerns are involved as well and could be severely affected if economic efficiency alone were to be pursued. Examples of these other -- even conflicting -- social desires include universal telephone service (a telephone in every home at an affordable price) and scheduled airline service to the smaller cities.

In any case, for markets having demand externalities (such as the market for communication network services), such efficiency arguments hold only in aggregate for the overall network. They should not be applied to a particular consumer or group of consumers. For example, it may benefit subscribers and suppliers of an existing network to extend service to an added group of subscribers, even though prevailing prices do not cover or otherwise reflect the costs of doing so.

For computer-based message services in general and for DNAS in particular, the effective cross-subsidy inherent in a multipart tariff structure may suffice to assure commercial feasibility as the market

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approaches and reaches maturity. This salutary possibility and the reasons underlying it are analyzed in considerable detail in Chapter VI. However, as is also shown in Chapter VI, an initial outside subsidy will almost certainly be needed to initiate the network and to allow it to attain critical mass.

In terms of recipients, there are two basic forms of subsidy: supply (provided to the producers) and demand (provided to the consumer). Examples of supplier subsidies include underwriting research and development costs, or offering tax incentives. Examples of use subsidies include providing terminals free of charge or below cost for the deaf (as is being done in California), or issuing vouchers to offset usage charges. For purposes of economic efficiency, user subsidies are often preferred over supplier subsidies. However, since there are usually more consumers than providers, user subsidies are generally more intractable and may require considerable bureaucratic overhead to implement.

In terms of subsidy sources and mechanisms, there are a number of alternatives, including direct Federal payments (grants), mutual sharing of responsibility between the federal, state, and local governments, (matching grants), and surcharges imposed on telephone subscribers in general*. However, these alternatives will require some sort of direct government action--either infusion of funds or legislated surcharges.

Another approach, based on the market place itself, is to take advantage of the increasing popularity of these services outside the deaf community. Businesses have already shown a keen interest in the word-processing and rapid communication capabilities of such computer-based systems. We have discussed how "piggyback" use by the deaf of an existing commercial service can reduce costs. Such sharing can also work in reverse. If a deaf group were to raise the capital for an initial system and sell unused capacity to the non-deaf (for business

* In California, for example, a 15 cent monthly surcharge per main station was initiated in September, 1981, to subsidize most of the cost of providing TDDs to the deaf community there -- see Section IV-C.

uses and at business rates) the venture could be viable at the outset--long before the number of deaf subscribers reaches critical mass. The business users could even continue to be served beyond that point as long as capacity was available and the service to the deaf was not degraded. This shared use would also offer the ancillary benefit of increased potential communications since the deaf could communicate directly with these business users.

Finally, the amount and duration of the subsidy must be determined. The analysis necessary to specify these quantities is extremely complex and is developed further in Chapter VIII.

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IV THE CURRENT SITUATION

A. Communication Needs Of The Deaf

In the broadest sense, the communication needs of the deaf resemble those of other user groups. Like doctors, sports fans, family members, or any other group of individuals who share a common occupation, interest or bond, the deaf need to communicate, with one another and with the larger society. The communication system(s) they use must be convenient, affordable, and reliable, with adequate privacy protections. As the present incompatibility between the Baudot and ASCII standards demonstrates, the communication system also must be evolutionary; that is, flexible enough to accept or adapt to technical improvements as engineers and vendors make them available.

In addition to these general communication needs, the deaf have several others which are a direct or indirect consequence of their handicap. With a reduced ability to hear and, in some cases, to speak, the deaf cannot use conventional telephones or radios; they are, then, dependent on visual communication, whether that be signing, reading, or writing.

But even these types of communication may be troublesome. An individual who has been deaf since birth often has difficulty learning basic language skills. Once acquired, such skills are often limited. The deaf community's physical handicap combined with their reduced language skills can, in turn, severely restrict their employment opportunities and, thus, their incomes.

Although literate, the deaf often discover that even the print media readily available to them do not serve all their needs. For example, a local newspaper may fail to publish announcements of captioned films, signed lectures or special employment opportunities.

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An effective communication system for the deaf would have the capacity to disseminate this type of news and information.

A communication system for the deaf must be responsive to its users' multiple limitations. Specifically, the system must be easy to use with a minimum amount of training. Because a written "conversation" between two deaf individuals will be significantly longer than its spoken counterr ,rt, user costs should not be determined solely by time spent on the ,stem. Indeed, cost is an especially critical factor given the comparatively limited incomes of many of the hearing impaired.

Society at large relies on several different systems to meet its overall communication needs: mail, telephone, broadcasting, and publishing respond to demands for specific types of communication. A telephone call, for example, provides point-to-point communication in real time; a letter serves a similar function within a delayed time dimension, while also offering the advantage of easy storage and retrieval. Point-to-multipoint, or mass, media also demonstrate a sensitivity to time. Radio and television have the ability to operate in real time, covering events as they unfold. Although newspapers, magazines and other print media lack this capacity, they offer the advantage of convenient storage and retrieval, in much the same way letters do.

Like their counterparts in the hearing community, the deaf, too, have had to rely on several communication systems to meet their needs. Although still unable to use most telecommunications services, the deaf have made some progress of late. For example, within the last three years, the Line 21 Closed Captioning Service has started to offer television programs with "subtitles" to deaf users who have purchased special decoders.

The FCC's 1978 inquiry into telecommunications services for the deaf highlighted many of the problems facing deaf users of TDDs[9]. Hundreds of deaf people as well as educators, social service professionals, and volunteers who work with them filed comments with the

Commission. Although individuals identified various needs and possible solutions, several major problems were mentioned repeatedly. Deaf users seemed particularly eager for TDDs that were affordable, easily maintained, and available from local telephone companies. The ability of TDDs to produce a hard copy of a message seemed to be a particularly important feature.

The deaf community's concern with cost extended to reasonable rates for both local and long-distance calls; indeed, most participants argued that the deaf should receive reduced rates or be charged on the basis of the amount of information transmitted rather than transmission time. The deaf also asked telephone companies to provide listings of TDD numbers; TDD access to police, fire, and other emergency services; and TDD operators who could handle person-to-person, collect, conference and other operator-assisted calls.

Although cost still remains an important concern, many local telephone companies and state commissions have responded to the needs of the deaf. As discussed in Section IV-E, several Bell operating companies now lease TDDs to the certified deaf as well as offering reduced intrastate rates. AT&T recently proposed reduced interstate rates as well. The company also has created a TDD/TTY operator service. Available through a toll-free "800" number, the TDD operator will handle credit card, collect, person-to-person and other operator-assisted calls for TDD users[10].

However encouraging these gains may be, the marriage of computer and telecommunications technology promises still more dramatic improvements, which could allow the deaf to converse, correspond, "broadcast," or publish by means of a single system. Thus, with such a system, the deaf could conduct person-to-person conversations in real time, much as they do with TDDs. However, that same system also would allow them to "broadcast" their message to multiple receivers, exchange electronic mail or create an electronic bulletin board. Most important, computer-communication systems offer virtually identical opportunities to society at large. Thus, for the first time, the deaf have a chance to gain communication parity.

Although such systems are technologically feasible, their potential utility remains uncertain. On the one hand, this study has demonstrated that it is possible to develop a system which is convenient and reliable, with adequate privacy protections. For example, the Deafnet system developed by SRI (see Section IV-B) has functioned for two years with a minimum number of "crashes" or breakdowns. Moreover, the hearing impaired whom we sampled were able initially to use Deafnet with minimal training and were satisfied enough with the system after one year's use to begin paying a nominal fee for it. The experience of other deaf users in Framingham, MA with the Hermes and GTE Telemail systems supports our general findings. This is not as surprising as it may first appear: the increasing popularity of word processors at the office and personal computers in the home suggests that almost anyone anywhere can make effective use of a properly designed computer-communication system. The deaf are no exception.

On the other hand, DNAS or any other such system will have to overcome several obstacles if its potential for the hearing impaired is to be realized. Although industry observers regard electronic text as a promising market, it remains just that--promising. Despite increased publicity and sales, personal computers are not yet a standard household appliance. For example, only 12,000 homes subscribe to CompuServe, one of the few packages offering electronic mail, bulletin board, and publishing services for the home hobbyist. IBM's entry into the personal computer field should stimulate overall market growth, as should AT&T's recent announcement of a Presentation Level Protocol which is compatible with most existing videotex systems. But even with terminals installed, home computer users may not necessarily have access to electronic mail and bulletin board services.

Computer-communication services are more prevalent in the commercial sector, where Xerox, IBM, AT&T and Wang are just a few of the

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companies aggressively promoting various components of the "office of the future." Although effective, such services usually are priced well beyond the means of most deaf or residential users.

In short, the public at large must become more aware of, and confident in, the ability of electronic text systems to function as partial replacements for traditional telephone service, mail delivery, and publishing. To put it differently, the proponents of computer-communication services must acknowledge and solve the problem of innovation diffusion, the means by which society learns of, and begins to use, a new product or service.

This problem is especially acute among members of the deaf community. Given their restricted employment opportunities, the hearing impaired may not encounter simple word processing and computer services at their workplace. Moreover, many deaf individuals already have mastered Baudot teletypewriters. The prospect of shifting to other, more expensive, sophisticated and unfamiliar systems can be frightening. As Rogers and Shoemaker[11] note in their excellent study, Communication of Innovations--A Cross Cultural Approach, "A certain degree of risk is usually associated with the reception of innovations, and this leads to somewhat different behaviors on the part of the individual than if he were receiving routine ideas." Thus, ignorance or anxiety may prevent the hearing impaired from fully realizing the potential of electronic text systems.

The technical problems of developing a communication system for the deaf have, for the most part, been solved. Deafnet demonstrates that computer communication can provide a wealth of options never before available to the hearing impaired. While minor hardware and software adjustments still are necessary, the major problem now facing the community is ignorance--the deaf must be informed of the new service. Without that knowledge and support, even the most superb technical system offered at an affordable price may go unused.

B. The Deafnet Demonstration

Providing an efficient, low-cost telephone replacement for the deaf is the immediate focus of a 39-month research project being conducted by SRI International for the Department of Education-Office of Special Education (ED/OSE). A long-term goal of this work is to provide a wide range of telecommunications services for the deaf through a nationwide access network. The project is composed of two major activities: a service delivery demonstration and an engineering design study (see the report on the first 18 months' activities[1].

The service delivery demonstration is being implemented by installing computer message systems at Gallaudet College in Washington, D.C. and at SRI in Menlo Park, California. The WDC demonstration system is capable of supporting 500 users and 25 simultaneous accesses. The second system at SRI serves the San Francisco Bay Area, using a smaller computer and similar software, providing service for about 50 users. The two systems are demonstrating a coast-to-coast network capability by exchanging messages over a commercially available communication medium.

Capabilities for "linking" terminals so that direct conversation can occur are being used to allow three- or four-party conferences. This capability is similar to that in the TTY network but allows more than two terminals of any type (ASCII/Bell or Baudot/Weitbrecht). As in all aspects of this study, the computer programs incorporate considerable sophistication in user support, rather than requiring an involved learning process by the user.

The SRI effort has been coordinated closely with other similar demonstrations of computer-based communication for the handicapped. The Deaf Counseling Center (DCC) has made very similar use of EMS for the deaf in Framingham, MA[12]. For a while the SRI and DCC systems were interconnected, giving an opportunity to study further a national communication interchange. In general, the results of these demonstration projects have been positive--the users are very enthusiatic about and adapt to the new style of interpersonal communication. In both cases, there is an effort by the deaf communities themselves to continue the demonstration activities as a permanent community communication service. Another study substantiates these results. The Institute for the Future has been studying telecommunications and developmentally disabled (DD) people[13]. This study evaluated audio conferencing, personal computers, computer conferencing, and electronic mail by means of demonstrations with DD people and also staffs of institutions concerned with DD people. The evaluation criteria were similar to those stressed in this report: the services had to prove effective, affordable, and accessible. The personal computer and electronic mail demonstrations achieved some success while the more sophisticated application--computer conferencing was not as well accepted. This is a similar result to that found in the WDC Deafnet demonstration; it might be better understood upon closer examination of WDC user reactions.

The SRI engineering design study began with surveys conducted to gather information relevant to the design of a comprehensive communication system to serve the deaf population in particular and the public in general. In the spring and winter of 1980, SRI conducted two random sample surveys of users of the Deafnet demonstration system in Washington, D.C. The purpose of the surveys was to determine users' likes and dislikes regarding the system, frequency of usage of various features of the system, and, in the winter survey, reactions to the recently instituted pricing system. Each interview was conducted using Deafnet or a direct TDD contact. A total of 50 individuals participated in the spring survey, and 44 of these participated in the winter survey.

1. Characteristics of Deafnet Users

The users of Deafnet, as represented by survey respondents, are definitely an elite subset of the deaf population in terms of their demographic characteristics and their experience with computer-based systems and TDDs. About two-thirds have at least a bachelor's degree, and about 60% have household incomes of $20,000 or more. About 80 percent own a TDD, and about half have had some kind of previous experience with computers. These characteristics should be kept in mind if one is interested in extrapolating the results of these surveys to a broader population. For example, we would expect members of this group to be less sensitive to price levels, to be much faster learners, and to be more receptive to new ideas, than the average deaf person. (Highly educated individuals tend to be innovators in any population.)

2. TDD and Deafnet Use

In the spring survey, about half the respondents reported using a TDD an average of more than an hour per day. Only about a third reported this much use during the winter survey, probably reflecting the many requirements on one's time that tend to occur during the holiday season, when the winter survey was conducted.

In both surveys, Deafnet use accounted for only a small proportion of TDD-use time. About three-quarters of the spring survey respondents said they used Deafnet an average of 30 minutes or less per day. In the winter survey about half said they had not used Deafnet at all during the past month; another third said they used it less than 15 minutes a day. This low level of use, relative to the total TDD use, may be attributed mostly to the limited size of the network--about 140 users. Most people with whom Deafnet users would want to communicate are not part of the network and so cannot be contacted through Deafnet. Also, most TDDs used by the Deafnet user group are compatible, so that linking through Deafnet (with its translation between 8-level and 5-level machines) is unnecessary. The drop in use of the system between the two surveys seems to have been caused in part by the users being busy with other matters, in part by a fading of Deafnet's novelty, and in part by the newly established policy of charging for use. The introduction of charges for Deafnet useage was made between the two surveys. The users who were interviewed joined Deafnet under the expectation that it :ould be free.

The Deafnet feature used most often was the ability to receive and send messages. The majority of respondents said they used this feature at least three times a week during the month prior to the spring survey, although the frequency dropped to once a month prior to the winter survey. Least used were the bulletin boards. Half the respondents in the spring survey and 85 percent in the winter survey said they had not read the bulletin boards at all in the month prior to the survey. Respondent comments suggest that many users were not aware of some of the boards, and some users did not understand how to access them. Also, a few users said they stopped reading the bulletin boards when the charging system was established. Furthermore, national and international news (probably one of the more popular boards) evidently was not updated regularly. This discouraged users from accessing it and it finally was dropped altogether in the fall when WGBH-TV in Boston could no longer provide the news*.

3. Attitudes Toward Deafnet

In general, most respondents were very enthusiastic about the system and hopeful that it can continue. As the reported usage data suggest, by far their favorite feature is the electronic message service. Many respondents commented on how convenient it is to be able to send and receive messages at one's leisure--both not being constrained by having to find the other party at home when one is placing a call and not being interrupted by calls when one is busy with other matters. The popularity of this service explains many respondents' desire that their friends be on Deafnet and that Deafnet be expanded to more areas of the nation (since the message service is not very useful if only a few people whom one wishes to send messages are on the system). Similarly, it appears that direct-terminal linking would be much more widely used if the system were expanded. In this context, it might be noted that use of the system probably would be greatly

* The reason was a transfer of the Boston Deafnet users to GTE Telemail. Telemail is not compatible with the WDC-Deafnet system and messages cannot easily be sent between users on the two systems.

encouraged if expansion were done on a "snowballing" basis, that is, by encouraging current users to nominate a certain number of friends for membership.

A number of users suggested that newsletters and workshops explaining how to use Deafnet would be helpful. These suggestions reflected the feeling of some of the respondents that they did not understand how to use Deafnet as well as they would have liked, often because they felt the manual was confusing or because they were unaware of, or felt uncomfortable using, the on-line instructions. For example, a number of users seemed either not to understand how to use the "help" command or to be unaware that it existed.

These comments point up the importance, whatever the service, of training, simple instructions and ease of operation. The respondents, who undoubtedly represent the innovators among the deaf population, often seemed simply to give up when faced with something they did not understand; so it is likely that future users will try even less to work through difficulties. The desire for newletters and workshops suggests, further, that a multimedia approach to Deafnet training and continuing education might well be the most effective approach.

During the winter survey, respondents were asked how much they would like to have certain features and services. The most enthusiasm was expressed for a communication or answering service (almost three-quarters said they would like it "a lot"). Both voice-text conversion and a more or less standard message service based on TDDs were mentioned. Another popular service was a "911" emergency line, which was liked "a lot" by about 60 percent of the respondents. A "411" service was somewhat less popular, partly because a number of respondents recognized that this service is already available to the deaf from the telephone company.

Despite the relatively low usage of the existing bulletin boards, over half the respondents said they would like national/international news and deaf community news to be available on Deafnet. Respondents also overwhelmingly preferred "regular" news to "language adjusted" news, which is written at about a fourth-grade reading level. Its unpopularity among our respondent group probably reflects their high education level.

Only about a quarter of the respondents said they would like "a lot" to have more bulletin boards, and only a fifth said they would like "a lot" to have more games on Deafnet. A few volunteered that they thought games are an inappropriate use of the system. Spelling assistance also seemed relatively unpopular, with only a quarter saying they would like it "a lot". (Confusion about how this feature would work contributed to the low level of interest expressed.)

Respondents were not asked about the desirability of editing capabilities because of the wide range of possibilities in this field for any given system and because of the difficulty of explaining the concept. However, a number of respondents volunteered that editing capabilities would be helpful, and it is likely that such a capability would be well received--especially among users with CRT rather than hard copy terminals--if it were simple to understand and use.

In sum, the reported usage and attitudinal data suggest that the major emphasis of a system like Deafnet should be on facilitating communication among individuals rather than on providing information (for example, in the form of bulletin boards). A key attraction of Deafnet was that many of the respondents seemed to feel that it enabled them to become "more equal" with hearing persons in communicating. They would like to be able to reach anyone at almost any time, as they perceive that hearing persons can do, and they particularly want to be free from relying on others to communicate for them. To a large extent, a system like Deafnet can provide this capability particularly if it becomes a truly nationwide system.

4. Price Sensitivity

During the first year or so after Deafnet was initiated, users were not charged. The spring survey was conducted during this period. Then, in late fall of 1980, Deafnet began to charge all users for its services. The winter survey was conducted shortly after users had received their first bill, so that reaction to the new charging system could be ascertained.

Not surprisingly, there was a wide variety of reactions. They ranged from "It doesn"t affect me at all," to "The deaf deserve to have such services provided free," to "I just can't afford it." Since most respondents have household incomes of over $20,000, and the average bill was between $4 and $5, this last attitude was fairly rare.

Seventy percent of the respondents said they would be willing to pay the somewhat higher bills (almost always under $20 a month) that we expect for similar usage patterns on a commercial nationwide system. It seems likely that, if the system actually were nationwide and had a large number of users, its value would be increased considerably beyond what is perceived at this point, since its practical value as a communication device would be so much greater*. As a general rule, people's predictions about what they would do in hypothetical situations, especially ones that are not well defined, are not very accurate.

On the other hand, the initiation of charging for Deafnet might have contributed to a decline in use between the two surveys. This is not surprising, because the users were not told until after the first survey that charging for Deafnet use would be instituted. Even some of the respondents who said they were not bothered by the costs reported that they had become, or were trying to become, more efficient in their use of Deafnet. Also, the belief that the deaf should not have to pay for a service like Deafnet appears to be quite strongly held, and therefore might lead to a lack of acceptance of a large-scale commercial system.

* This "market externality" is analysed in considerable depth in Chapter VI.

The Deafnet communication service in the WDC area (where the interviews were conducted) is primarily a local or community service. As such, it does not give any savings over other communications services available to the deaf. Thus, the charges a person would be willing to pay would not be a normal part of the household budget (like long distance calls, say). Had there been a significant capability for long-distance communication, then the billing and collecting data from this experiment would have more applicability in the design of a nationwide service.

Finally, one must not forget that Deafnet users who were interviewed are a very elite subgroup of the deaf. As such, they are both more interested in and more able financially to participate in technological innovaions like Deafnet than is the "average" deaf person, who may not be interested even in owning a TTY. In sum, while the results show that users are accepting systems like Deafnet, any extrapolations from these surveys about the potential for a commercial nationwide telecommunications system for the deaf must be made cautiously.

C. The Recent California PUC Rulings On TDDs For The Deaf

In 1979, the California legislature enacted Senate Bill 597 which adds Section 2831 to the Public Utilities Code. This section requires the Public Utilities Commission to design and implement a program to provide a telecommunications device at no extra charge to any certified deaf or severely hearing-impaired individual. The telephone companies are to administer this program so that any qualified subscriber can receive such a device at no additional charge above the standard monthly charge. The program is being phased in over a four-year period ending on January 1, 1984 and will be financed by imposition of a surcharge to be paid by all subscribers[14].

This landmark legislation recognized the communication disparity suffered by a group of the hard of hearing that has no other alternative to the vast telephone network and addressed one aspect of that disparity--the lack of appropriate terminal-user equipment. During the subsequent hearing held by the California Public Ultilities Commission (CPUC), it was estimated that between 43,000 and 220,000 Californians might be supplied with TDDs under this program[15].

The wide spread of these estimates indicates the difficulty in identifying those deaf who are not able to use the telephone because of their handicap, and also the unknown extent of participation by those who are qualified but who choose not to change established communication patterns (see Section IV-A for a further discussion of this point).

The CPUC, in answering their charge to define the program, could have acted in several ways in determining what kinds of terminal equipment would be supplied to the deaf: 1) Not specify the actual technology (which would have likely continued the current situation), 2) Recommend the minimum capability with existing TDDs (which would have dictated that the current situation continue) or 3) Specify a different approach that would take into account the advances of technology. Fortunately, the Commission choose the last alternative. A significant aspect was the very active participation in the public hearings by deaf groups and other interested parties. These groups supported a dual-mode terminal that allowed either Baudot/Weitbrecht or ASCII/Bell operation. They argued that:

> "the use of the Baudot system alone would constitute another form of isolation for the deaf and would not be responsive to their full needs. ... ASCII capability will not only allow for computer communications but would encourage more businesses with ASCII type interface to communicate with the deaf."

The Commission's directives were in accord with this argument and stated that:

> "Telephone companies should purchase TDDs with ASCII or dual mode capability as they become cost-competitive. Such purchases should result in creation of an even larger market and economies of scale. These machines will help link the deaf with

other members of the deaf community as well as the hearing community, which should create greater oppurtunities for social and economic interaction."

The implementation plan offered by Pacific Telephone[16] reinforces the discussion of our experience with Deafnet (see the previous section) of the importance of training. Pacific Telephone intends to establish a TDD center in a central city for each specific geographic territory during the training period. The centers will be staffed with a combination of deaf persons, Certified Interpreters, and Order Negotiators. The training will include hands-on experience and direct contact with selected subjects across the telephone network. Deaf-related agencies and publications will be used to notify potential customers in addition to bill inserts. Special instructional material will be prepared that is tailored to the target users.

Since this distribution program will double or quadruple the number of TDDs used by the deaf, this is a very important decision. In fact, it appears that other states will follow the lead of California in enacting similar legislation. Had the status quo prevailed, a much larger population of terminals incompatible with the computer-communication industry's main thrust would have seriously impeded the type of communication capability we are proposing in this report. As it stands, there will be a significant group of potential users who will have terminal equipment, some exposure to the concepts of communication technology, and a strong motivation to seek better terminal-based communication services.

This desire for a communication system better matched to textual intercourse will partly come from the inadequacy of predominantly voice-based services in the telephone system (for example, disconnected phone messages) but also from the likelihood of higher toll charges for long-distance phone calls by the deaf. This occurs with the use of TDDs because of the longer time necessary to communicate by typing rather then by voice (our earlier study estimates a factor of 5-9 times as long[6]). Technological advances have provided an answer in the form of value added networks (VANs) that essentially aggregate a set of users who are communicating digitally--terminal to computer, computer to computer, or two people communicating directly over the network by a "terminal link". The chief advantage of this aggregation is reduced cost (see the next Section, IV-D, for a discussion of these costs). Instead of paying for a circuit on the basis of time and distance (as in the telephone system), VAN charges are more closely related to amount of information transferred and are independent of distance. This again emphasizes the importance of the decision to specify an ASCII-compatible TDD. Access to these networks is predominantly through Bell modems using ASCII standards. In private discussions, some suppliers of VANs indicated that provision of Baudot support is unlikely or would require an additional surcharge.

The order of the CPUC only requires implementation of part of the features normally found in an ASCII terminal (46 characters rather than 128) and Bell modems (half rather than full duplex operation). It was argued that this was sufficient for terminal linking (as with the current TTY network). There are many communication services that require more terminal features; some even use a full 256 characters. While the ASCII TDDs specified by the CPUC do not meet these needs, it must be emphasized that the specifications are for the minimum standards that all TDDs distributed under this program must meet. Other terminals that have more than the minimum features can be substituted if they are cost-competitive. This should allow the deaf to acquire adequate terminals since the trend of the ASCII terminal market is such that more and more features will be provided at the same or lower prices.

In summary, the California legislation and CPUC implementation program will generate a large population of ASCII-compatible terminals for use by the deaf. As this type of action spreads to other states, even more users will become aware of and skilled in new communication capabilities. They will also begin realizing the proportionally higher cost of using direct distance dialing over the telephone network for terminal communications. This will spawn a group of users familiar with

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terminal equipment that demand lower cost communication systems. The terminals will be nearly compatible with digital networks and thus can take advantage of them as well as force the development of better communication services.

D. Current Costs of Telecommunications for the Deaf

The technological progress of the last 10 years has sparked a revolution in communications, which promises to be as far reaching in its consequences as the invention of the telephone or the development of radio and television broadcasting. Unlike its predecessors, however, the new merging of computer and telecommunications systems can expand significantly the communication opportunities for the deaf--indeed, such systems may allow the deaf to approach telecommunications parity with society at large for the first time in almost a century.

Although technologically feasible, computer-communication systems won't fulfill their promise unless they are also affordable. Cost is an especially critical factor for the deaf, who often have low incomes due to their comparatively limited employment opportunties.

Whether one is considering conventional telephone service or the most sophisticated computer-communication system, cost can be divided into two elements: (1) the cost of terminal equipment and maintenance, and (2) the cost of transmission services. Equipment, of course, determines both the quality and types of services available to the user. For example, a conventional TDD used with traditional telephone transmission provides interactive communication. Although a personal computer terminal linked to GTE's Telemail system, for example, lacks this feature, it offers two others: electronic mail and bulletin boards. Terminal equipment can also affect transmission costs. Thus, a personal computer that allows a user to compose a complete message before it is transmitted can significantly reduce transmission costs.

1. Equipment Costs

Are the new personal computers now on the market affordable for the deaf? How do their prices compare with those of traditional TDD's? More important, which types of equipment deliver maximum service for their price?

a. Purchased Telecommunication Devices for the Deaf (TDDs)

Table IV-1 contains information about several conventional TDD's, including their price, ASCII/Baudot capability, memory, display ,and maintenance. Although not an exhaustive list, it does represent a range of options now available to those deaf users who choose to purchase a TDD. As the table shows, prices range from $450 for a Visual Ear with Baudot capability, an electronic display and no memory, to $750 for a Vuphone, which offers a 700-character memory in addition to Baudot capability and electronic display.

Superphone, a new TDD eagerly awaited by many members of the deaf community, finally became available in the summer of 1981. Retailing for $495.00, it provides both ASCII and Baudot capability and a 1000-character memory.

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Table IV-1

CHARACTERISTICS OF SEVERAL TELECOMMUNICATION DEVICES FOR THE DEAF*

TDD: / Characteristic	Visual Ear	Vuphone	Porta-Printer Plus	Superphone
ASCII/ Baudot:	Baudot only	Baudot only ASCII & Baudot available	Baudot only ASCII & Baudot available	ASCII & Baudot
MEMORY:	none	700 char	none	1000 char
PRINTER/ HARD COPY:	- Display only - Printer compatible	- Display only - Printer compatible	- Hard copy included	- Display only - Printer compatible
MAINTEN-ANCE:	1 yr. warranty	2 yr. warranty	1 yr. warranty	1 yr. warranty
PRICE:	$450.	$750.	$595. $745.(with ASCII/Baudot)	$495.

* This table contains suggested retail prices supplied to the authors by TDD suppliers and/or manufacturers.

At first glance, the Superphone appears to be substantially cheaper than one of its competitors, the Porta-Printer-Plus, which also offers ASCII/Baudot capabilities, but for $745. Trade-offs quickly emerge, however. Although it lacks memory, the Porta-Printer-Plus does provide hard copy, an important feature for the deaf, who often have limited language skills. To achieve comparable capability with Superphone, the deaf user would have to spend an additional $250 to $400 for a printer, bringing the total cost of his Superphone "system" to at least $745--the same price as the Porta-Printer-Plus. With the printer in place, Superphone then becomes the

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TDD with the most features, offering a 1000-character memory for an identical price.

b. Leased TDDs from the Bell System

Eleven Bell operating companies now lease TDD's to customers. In Michigan, for example, state statute requires the phone company to provide a TDD at cost to certified deaf persons. To comply, Bell purchases Porta-Tels for $400.88 per unit and assumes a five-year life span for them, charging customers $6.68 per month*.

In other states, Public Utility Commissions allow Bell to recoup storage, distribution and other costs associated with providing TDDs. As one might expect, the cost to deaf users increases over that for Michigan users. In Kentucky, for instance, Bell charges $15.30 per month for deaf users and $24.50 per month for hearing customers requesting the devices.

Illinois and Maryland are among those states that have imposed a flat ceiling on the charge for leasing TDD's. In Illinois, for instance, Bell can charge no more than $14 per month for the Porta-Printer-Plus.

In many ways, leasing a TDD and leasing an ordinary telephone presents customers with an identical set of economic trade-offs. With leasing, the customer enjoys the advantages of company installation and maintenance. Moreover, monthly leasing charges may be more manageable for some customers than the comparatively high one-time purchase price of a TDD. But in states such as Kentucky, where Bell is allowed to recover the associated costs of providing TDDs, leasing charges over a period of several years may be substantially higher than the single purchase price.

*Information about Bell operating companies that lease TDDs or that offer reduced intrastate rates for certified deaf was provided by Joe Heil, District Manager, Services for Disabled People, AT&T, Parsippany, New Jersey.

Leasing also may be more convenient for the customer than comparison shopping for TDDs. In effect, the customer, through the state PUC, allows Bell to choose a TDD for him. However, in surrendering their decision-making to the telephone company, customers and commissions may, unwittingly, frustrate the distribution of new equipment using the ASCII standard. In Maryland, for instance, Bell offers the Baudot-only Porta-Printer-Plus under a PUC order which imposes a $13 per month ceiling. A customer who leased such a TDD at $13 per month for slightly less than five years would have spent the same amount of money as another customer who purchased the Baudot-ASCII Porta-Printer-Plus today.

c. Personal Computers.

Although growing steadily since the late 1970s, the market for personal computers is expected to explode within the next five years. When IBM unveiled its first personal computer in August, 1981, it entered a field that already included firms such as Radio Shack, Apple, Xerox, Hewlett-Packard and Zenith. As the New York Times recently reported,

> "Worldwide, some 500,000 computers costing less than $5,000 were sold last year at a total value of $730 million, according to Dataquest Inc., a Cupertino, Calif., market research firm. That total will grow at least 40 percent annually, to 3.7 million units, valued at $3.9 billion, in 1985, the firm estimates."

The anticipation of rapid growth has spawned the development of new businesses eager to supply housewives, students and small commercial users with an array of supportive services ranging from electronic information retrieval to customized software. In the years ahead, the computers themselves may be able to do more work more quickly. The new IBM computer, for instance, uses a 16-bit microprocessor that improves memory and speed over that of the majority of 8-bit microprocessors.

All of these developments bode well for deaf users. The appearance of personal computers in more homes and offices should lead, in turn, to the growth of computer-communication systems generally, thus expanding the number of people who can communicate with the deaf. Improved software and processing ability could represent an important breakthrough for many deaf users who are intimidated by the new technology or frustrated in its use, given their sometimes poor language skills.

Personal computers are not inexpensive, although a few already are competitive with conventional TDDs (see the Deafnet Report[17]). The Radio Shack Videotex terminal, for example, now costs $399, complete with modem and four thousand characters of memory. What does the user get for this price? The Videotex terminal is not portable and does not have a printer, nor is it compatible with traditional Baudot TDDs. It is, however, accessible to other ASCII-compatible equipment, whether that be a TDD, IBM personal computer connected to a modem, or one of the many commercial databases, such as CompuServe, that offer news and other information.

Computer-communication systems consist of several different components, ranging from the terminal itself to various software packages, modems, modem connector cables, displays and printers. Although these pieces usually can be assembled with help from a competent salesman, the sheer number of models, brands and prices may intimidate some potential users.

This characteristic, combined with the fact that retailers will often offer discounts of up to 30 percent for bulk orders, suggests an important role for leaders in the deaf community: a computer communication system may be more successful--and economical--if it is introduced simultaneously to a group of deaf users. A group introduction, however, requires persuasive and organizational skills--skills which are less likely to be found at a Radio Shack outlet than at a church, school, or community center with an active program for the hearing impaired.

Equipment costs of computer-communication systems will be determined by a variety of factors, including technological progress and overall market growth. The cost to deaf users, however, may be directly linked to the degree of interest in and familiarity with computer communications found among the professionals and volunteers now working with the hearing impaired.

2. Transmission Costs

Although the cost of a TDD or personal computer may be high, especially when compared to retail prices of a conventional telephone, it can be, nevertheless, a one-time expenditure. Moreover, the cost of both TDDs and personal computers can be expected to decline due to technological advances and mass production. By contrast, transmission costs are variable, are on-going and are expected to rise, at least for local service, as this study discusses below. Indeed, transmission may represent as much as 70 percent of the total cost of DNAS (excluding TDD costs), and as much as 90 percent of this transmission cost may be for local access[6].

a. Interstate Rates.

Table IV-2 below lists current interstate rates for Bell customers. In August, 1981, AT&T filed a revised tariff at the FCC seeking to reduce interstate rates for speech- and hearing-impaired customers. Offered in recognition of the United Nation's International Year of Disabled Persons, the revised tariff "proposes that evening rates be charged for calls placed during the day rate period and that night rates be charged for calls placed during the evening rate period for [such] special customers[18]." This will significantly expand the hours during which deaf users can place long-distance calls at the lowest interstate toll rate--$9.66 per hour.

Table IV-2

AT&T INTERSTATE RATES

SAMPLE CALL: WASHINGTON, D.C. TO SEATTLE, WASHINGTON

$24.17/hour	Weekday Full Rate	8 a.m.- 5 p.m. M - F
$15.71/hour	Evening 35% Discount	5 p.m.- 11 p.m. M - F, Sun. 8 a.m.- 11 p.m. Holidays
$ 9.66/hour	Night 60% Discount	11 p.m.- 8 a.m. M - F, Sun. all day Sat.

The proposed tariff is an improvement over the status quo; however, $9.66 per hour still may prove burdensome to the deaf, who can incur significantly higher transmission costs given the length of time it takes to type a message rather than to speak it. Although the reduced rate may encourage the deaf to call others, it does not extend to hearing customers who wish to call the deaf.

Given these circumstances, alternatives to conventional local and long-distance service may prove to be more economical for the deaf. For instance, GTE's Telemail offers rates significantly below those charged by AT&T for long-distance service, as Table IV-2 and IV-3 illustrate. However, GTE, like most other time-sharing services, is targeted for the large commercial user, who is expected to spend a minimum of $500 per month. Although affordable when divided among a group of 100 deaf users, this sum is not feasible for the average individual subscriber. Deaf customers who place a substantial number of long-distance calls, for example, can subscribe to one of several low-cost, long-distance services now offered by MCI, Southern Pacific Communications and other companies.

Time-sharing systems may also be cost effective, especially for computer-communication systems. As Table IV-3 shows, Telemail's night time rate of $4 per hour is significantly lower than AT&T's. Telemail's customers can further minimize transmission costs by using a personal computer to compose and store messages before they are sent. A printer combined with a personal computer would achieve similar economies for receiving messages. GTE requires that customers spend a minimum of $500 per month for Telemail service; in addition, the company imposes a $140 monthly subscriber charge. Although $640 may not be feasible for an individual subscriber, it is economical for groups of 120 or more.

Table IV-3

TELEMAIL RATE SCHEDULE*

<u>BASIC CHARGE</u> **

$14/hour	Business	7 a.m. – 6 p.m. M – F
$ 7/hour	Off-Peak	6 p.m. – 9 p.m. M – F 7 a.m. – 9 p.m. Sat., Sun., and holidays
$ 4/hour	Night-time	9 p.m. – 7 a.m. Daily

<u>BROADCAST DELIVERY</u> -- $ .05/addressee after the first addressee

<u>STORAGE CHARGE</u> -- $ .005/day/2000-characters, with no charge for the first five days of storage

<u>SUBSCRIBER ACCOUNT CHARGE</u> -- $140/month

* Information in this table was supplied by GTE Telenet/Telemail marketing representatives.

** Minimum $500/month per subscriber-organization after first three months of service.

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b. Intrastate Rates

On August 27, 1981, Chesapeake and Potomac (C & P) of Maryland asked the Maryland Public Service Commission to approve a new tariff that would increase annual revenues by 26 percent, claiming that, "In spite of our and Bell System efforts to increase productivity, which now runs about 4 times the national average, we still find ourselves faced with increasing costs[19]." C & P's request is hardly unique. Telephone companies, like other businesses, are experiencing the pressure of rising energy costs and inflation. In addition, a series of regulatory decisions and industry trends are forcing the individual Bell operating companies across the country to demand that customers who use a particular service bear a greater percentage of its costs.

In the long term, these developments may have a negative effect on the hearing impaired, especially those who are dependent upon conventional TDDs and telephone transmission. In the example described above, the deaf were one of several user groups exempt from many of the new service charges. Moreover, in January, 1981, when C & P had received its last rate increase, the Maryland PSC had also approved reduced intrastate toll charges for the deaf, allowing a 35 percent reduction of the basic rate during the day and 65 percent discount at other times[20]. However, despite these percentage discounts, intrastate toll rates for the deaf will continue to rise with basic intrastate rates.

Thirty-six states now offer reduced intrastate rates to the certified deaf, with similar tariffs pending in two more states and another on file in Texas. Of these, 18 states have plans which are similar to Maryland's. Others resemble the plan in Rhode Island, where the deaf receive a 60 percent discount off the basic day rate at all times.

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E. The Impact of Rate Restructuring on the Deaf

Telephone companies have only recently begun to offer TDDs or reduced rates to the certified deaf. More important, such services are, in many cases, included as part of the costs of basic regulated service; thus, all customers subsidize to some degree the cost of providing them. From the deaf's perspective, then, it is especially regrettable that just as they seem to be gaining ground, the telephone industry has begun a massive shift to cost-based pricing. On the one hand, this shift appears to threaten affordable service to the deaf. On the other, it may provide the impetus for the deaf to switch from traditional Baudot TDDs to superior computer-communication systems.

The shift to cost-based pricing is a result of the FCC's deregulation activities and the Commission's attempt to develop a consistent policy for the new computer-communication services which were entering the market (see Appendix). It has caused higher local rates, a move to measured service for local access, and increased installation charges. More important, they are only the first of many changes that will be sparked by the growing competition in the telecommunications marketplace. Leaders of the deaf community and of the telephone industry, as well as state and federal policymakers, will be confronted with a host of questions and possible answers. Should telephone companies, for example, be required to continue leasing TDDs in the new deregulated environment? If so, shall the cost of providing that service be subsidized by all telephone customers? Should the deaf continue to receive rate reductions on intra- and interstate toll calls? Again, should the cost of providing these reductions be borne by all users--despite the fact that the industry as a whole is shifting to cost-based pricing?

Regardless of how these policy dilemmas are resolved, one point seems certain: leaders of the deaf community have an opportunity to play a pivotal role. They could, for instance, fight fiercely to preserve the status quo, that is, mandatory leasing of TDDs and rate discounts.

However, they do so at a risk. The FCC did not spawn the changes now taking place in the telecommunications industry; rather, the Commission's recent decisions have only accelerated an already well-established trend toward competition and cost-based pricing--a trend which is driven by technological progress.

V SYSTEM AND SERVICE DEFINITIONS

A. Definition Of Services--User Point-Of-View

One of the key objectives of this study is to define an affordable, useful, new communication service for the deaf. The motivation (as discussed earlier) is to help the deaf overcome the communication difficulties they experience in using the telephone system, radio, and, to a certain extent, TV in this modern communication-intensive world. In the process of achieving this goal, the deaf and other handicapped individuals could become the vanguard of the computer-based communications movement rather than continue to lag years behind the technology. The serious implications of the whole ASCII/Baudot issue (and, potentially, the debates about data rate and bandwidth for closed captioning on television) causes us to make a conscious effort to promote a different approach that is very responsive to the needs of the deaf community.

It is clear that the computer-communications industry will evolve on its own, independent of the needs of the deaf community. Electronic (computer-based) mail service is already being actively marketed. The majority of applications are in the business world, but there is a clear trend toward more pervasive and varied communication services. Indeed, without some positive intervention, this trend may leave the deaf hind because the current pricing structure for electronic mail and related services is quite high. These high prices can only be justified in the business world. Thus, we need to consider whether the consumer can afford this service. From a deaf user point of view, we need to make a distinction between 1) economically usable services, 2) urgent services that are not available now but would be used if available, and 3) "enhanced" services. We will adopt the following definitions:

(1) Economically usable services -- replaces some item in the family budget (long distance charges, newspapers, special-interest newsletters);

(2) Urgent services -- calls to employers, disaster warnings;

(3) Enhanced services--electronic games, resturant guides, library of congress card catalog access.

Electronic mail services (EMS) crosses the boundary between economically usable and enhanced services. It is a relatively new communication service that involves different skills (typing, concepts of "store and forward" networks, word-processing) and social patterns as compared to traditional conversational media such as telephony. There are certain advantages, though, that make it attractive: e potential for rapid long-distance communication and convenience (sender and receiver need not be online at the same time). In fact, in the Deafnet experiment funded by the Department of Education, it was found that the deaf were able to adapt to the new concept and use it as an adjunct to, and sometimes substitute for, their traditional communication method of using terminals and modems to converse over the telephone system--a process we will refer to as terminal linking. To the extent that EMS is accepted as a replacement for terminal links by the deaf, it is not a enhanced service.

There are certain capabilities of EMS that satisfy the basic needs of interpersonal communication and others that are more advanced. Table V-1 shows these distinctions. The initial commands are for beginning training. The basic commands are the next step but still can be considered necessary for basic communications. The enhanced and advanced commands are for more sophisticated uses of EMS such as filing and word-processing.

Table V-1

SEPARATION OF EMS FUNCTIONS

Initial EMS Commands:

WHO	-- who is on the system
TALK	-- talk to someone on the system
PICKUP	-- pick up new messages
READ	-- read messages
WRITE	-- write a message
LOGOUT	-- leave the system
SKSK	-- same as LOGOUT

Basic EMS Commands:

WHOIS	-- gives directory information
SCAN	-- shows one-line summary of messages
REPLY	-- answer a message
FORWARD	-- forward a message
DELETE	-- deletes a message
UNDELETE	-- permits you to change your mind about deleting a message
PURGE	-- actually throw away "deleted" messages
PASSWORD	-- change your password
DATE	-- show the date and time
TIME	-- show just the time

Table V-1 (continued)
Separation of EMS Functions

Enhanced EMS Commands:

EDIT -- use a text editor to compose messages
FILE -- allows keeping messages in different folders or files (default folder is INBOX)
OPEN -- accesses another folder or BBoard, then uses the same commands
DITALK -- Dialout talk to a terminal

Other Enhanced capabilities:

- Allow use of a distribution list for message addressing
- Specify a message sequence to any of the commands by content rather than by number
- Automatic recording of last message read in all folders and Bulletin Boards
- Address validation at time of entry
- Mailbox size limits

Advanced EMS Commands:

- Automatic delivery of message hardcopy (like Mailgram)
- Automatic immediate delivery (dialout to auto-answer terminal)
- Confirmed delivery (like registered mail)
- Message withdrawal (after delivery attempted)
- Interactive messages (computer conferencing)
- Automatic message archiving
- Message sorting and special indexing
- Spelling correction
- Formatting of messages (underlining, titles, etc.)

The Deafnet experiment has shown that EMS will be used by the deaf as a alternate communication service to terminal links. The main advantage is user convenience, but it can also be a more economical method of communicating since both parties need not be "on-line" at the same time. For EMS to be a widely acceptable substitute for terminal linking, there are a number of "conversational" features that should be included:

- Dialout (message delivery without recipient initiation, home delivery)
- Capability for interactive (quick) exchanges
- Integrated support services (directory, error messages, etc.)

An example of the need for the latter underscores the provision of a "total communication" service, not just an ability for two people to make a connection. In the current TTY network (terminal linking over the telephone network), for instance, people can dial each other direct. This satisfies the first two criteria, but a number of support services are inadequate. While, on the one hand, Bell has recently announced a nation-wide directory service accessible by TTY, on the other hand, automatic call intercept on changed phone numbers that give voice messages are just not adequate for the deaf. This problem comes into perspective when considering the current tendency by Bell companies not to update directory information as often as before but to rely on the automatic intercept mechanism. A deaf person has little chance to learn of a new listing with the current system. We give this example to illustrate the difficulty of making a system designed and optimized for voice work for data terminal communication. Designing an auto-intercept mechanism that would work with TDDs would undoubtably be difficult. The deaf need a completely integrated system suited to useful and affordable terminals. The support services are a necessary part of this integrated system.

Note that with actions like the California law requiring distribution of TDDs to the deaf (see Section IV-C), there is likely to be a large population of users with terminals. However, the basic, economically usable services will still be used primarily for communication within the deaf community. No significant bridge to the hearing world can occur without relay services--like that offered by the Deaf Informed Communication Resources Center (DICO) in Fremont, California, where human operators take TTY calls and then relay to a voice call, or vice-versa -- or major advances in voice-to-text conversion technology. There are efforts in this area now, but the pay-off may be a decade away. The extreme difficulty a deaf person has in contacting a hearing person to report an emergency, for instance, is the largest communication lack at present. In fact, a National Crisis Center for the Deaf, located at the University of Virginia, has been set up in the past year to take care of this need. However, such actions must be considered stop-gap at best because they are labor-intensive.

An example of an enhanced service that warrants some discussion is delivery of education services. We have already indicated that the deaf are in need of additional education because of their handicap. There are many others that cannot take advantage of conventional educational processes because of handicaps or other responsibilities (such as raising childern). Telecommunications has already made inroads into education in the form of video courses available at off-campus locations. The type of interactive communication services described here has a vastly greater untapped potential. Instruction of the homebound, retraining of adults (to compete in a changing society and job market), extension courses, in-school tutorials, computer-aided instruction, in-service training of teachers, and interactive correspondence courses are just a few of the possibilities. The need for such dynamic and pervasive access to education resources will grow in this modern society as technologies and work-skills become obsolete at a faster and faster pace. Education is becoming an ongoing necessity and requires infant-to-aged programs, many of which can be taught or must be taught in homes and in offices both formally and informally. The broad-based telecommunications services we describe are a new method of education delivery that needs to be explored.

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The major conclusion we draw is that a service for the deaf must provide basic communication services akin to those available to the general public that are economical, convenient and fully integrated. We have noted in reporting on the Deafnet experiment that a $5-10 per month charge for the additional convenience of a computer-based system is not unreasonable and would likely be paid willingly by deaf users. If more pervasive long-distance communication could be provided by such a system, then a per-user average charge could be about $15-20 per month. We estimate that a person typing on a TTY would take about 5-9 times as long as a talking person to convey an equivalent number of words. At long-distance phone rates, this can give a deaf user a considerable phone bill each month.

From the supplier point of view, startup and provision of the basic communication service represent the largest portion of the cost. The enhanced class of service can be provided without much additional cost and so has the potential of contributing primarily to profit. The key, then, is to define enhanced services that will be attractive to the deaf community. Representative basic services are EMS, terminal-linking, and online news reports. Enhanced services are games, entertainment guides, and recipe libraries.

Finally, a good evolutionary strategy would be to start by offering services in the economically usable class, where the payment is just a substitution within the family budget. Once subscribers begin using such services and become familiar with the new skills and concepts, there is an easy and likely transition to begin using the service for entertainment, business, and other activities. This evolution easily leads to a built-in market for the enhanced services.

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B. Tiered Charge Concept for Commercial DNAS

We now have some experience with providing computer-based communication services to the deaf community. This experience includes both a Government-supported demonstration system that has been tailored to the needs of the deaf in California and Washington, DC, and provision of commercially available computer-mail systems and modern terminals to a group of deaf users in the Boston area. We have collected some data on user reactions and system usage, by means of user surveys (see Section IV-B) and statistics on system usage. From these data and experience, we are proposing a model for how such services can be provided to the deaf by a combination of commercial vendors and interested deaf groups.

The view we are taking is that such services must fulfill some definite need in the users' personal lives and must also be very economically priced. Most of the available commercial offerings are designed for business applications and are priced too high for the deaf community, which is really a segment of the home consumer market. Since there are minimal services currently offered to this market, we can think of the deaf as the "vanguard" group that can generate sufficient demand to motivate more development of such consumer services.

We base the model on "tiered charges" or cost-based pricing. That is, the user should be able to select the services he wishes to use and pay only for those services. Compare that concept to the current pricing structure for commercial offerings of electronic mail. The charges are a fixed price per time unit (actually two, a day rate and a night rate) for all uses of the system--personal communication (local and long distance), games, or database access. While a simple accounting system results, it does not appear attractive to a home user who is selective--usually for economic reasons. As discussed in the previous section, services that a deaf person would require in this home environment must fulfill a personal need (for instance, phone call replacement or alternatives to TV/radio news bulletins for the deaf) or be economically attractive alternatives for some item in the personal budget (for example, long distance telephone charges for TDD calls).

We can define several categories of services (shown in Table V-2) that will match these criteria and can be priced to reflect the complexity of provision and desirability of the service.

Table V-2

CATEGORIES OF COMMUNICATION SERVICES

1) Local communication
   - Baudot-ASCII conversion
   - Community bulletin boards
   - Community news
   - Emergency services (911)
   - Repair services (611)
   - Directory services (411)
   - Computer-based mail

2) Long-Distance communications
   - Nationwide access
   - Interactive communication mode
   - Computer-based mail

3) Applications (programs)
   - Games
   - Financial assistance (check-book, interest calculation)
   - Computer aided instruction
   - Home correspondance education courses

4) Database access
   - Newspapers (UPI, NY Times)
   - Library of Congress
   - Resturant guides

We postulate the provision of these services with a distributed system based on a Value Added Network (VAN). An analysis of a commercial supplier's cost items, which might be thought of as a first approximation of the implementation we are proposing, shows a portion for VAN usage, a portion for CPU costs, (connect time or some other method of billing for use of CPU resources), and a portion for database licenses. If the services categorized above were priced based on costs, category (1) would only have CPU costs (given a wide distribution of community centers not requiring VAN access); categories (2) and (3) many have VAN and CPU charges (unless the programs ran on a local computer); and category (4) would have the full charge.

The architecture of the system to realize this tiered-charge model is distributed and uses regional community centers[6]. The regional centers are connected by a VAN (see Figure V-1). Each of the regional centers can be tailored to match the communication requirements and available capital (investment potential, income) of the local community. For instance, a more exact mix of Baudot/Weitbrecht and ASCII/Bell terminal support can be provided. Further, it will be easier to phase out Baudot/Weitbrecht service if it is localized rather than national. An example of national Baudot/Weitbrecht support would be if the VAN(s) were to support Baudot/Weitbrecht access in all the access ports. The impact of local (state or community) laws and customs can be best matched by this approach.

The community center design actually allows a rational evolutionary growth plan for the full nationwide service. Initially, individual users can access commercial offerings (such as TELEMAIL, or the SOURCE) or specialized systems such as those developed under the Deafnet contract, by calling the local VAN access number. If Baudot/Weitbrecht access is desired, arrangements can be made to put special modems at the VAN access ports. When there is sufficient demand, a community center can be established that meets the local community needs. The community center can be very small (an inexpensive personal computer, for instance) or very large, taking advantage of economies of scale to reduce the per-user cost. This plan allows a user anywhere in the U.S. to begin using the service. Then, as his use and the number of individuals that are interested in the service grows, more cost-effective pricing can be achieved by aggregating the demand and establishing a community service.

The regional centers can also be tailored for certain services. If an important service is currently available locally, such as dial-a-news, it can be easily integrated into this structure. The alternative in a centralized structure, like TELEMAIL, is to replace the local community service with a single service accessible nationwide. The national market may not be proportionally as large, nor can the national service be as easily tailored to local needs--for instance, providing the local gardening club meeting schedule.

The goal of this design is that each community procure a regional center based on the local finances and market for these communication services. The access is either local calls or some combination of WATS/dedicated lines that is matched to the local user community's geographic distribution (See DN report, Vol. IV[6]). Since approximately 80% of telephone traffic is local, a great deal can be accomplished with this approach without the necessity of using a national network.

This model makes no restrictions on the type of hardware/software used to implement the regional centers, but rather requires standardized communication procedures. They are shown schematically in Figure V-1 and are of three types:

(1) Terminal mode--This is the most common, widely available method of accessing computers. A terminal and modem are used to allow a regular phone call to be placed to either a computer directly, or remotely via a VAN. For the VAN, the call is placed to a network access port which we will call a TIP (Terminal Input Processor). The usual (and most pervasive) access is ASCII/Bell. TDDs (Baudot/Weitbrecht) need to go through a regional center convertor or use an intelligent modem that can be placed in a VAN TIP and perform the conversion. The significant cost characteristic of this mode is that, since most charges are based on connect time (telco time-measured service, VAN, and computer CPU charges) the user is paying for network connect time typing and composing. The goal of the tiered model is to minimize the charges for this mode (by providing local centers, to gather and transmit the typed input).

(2) Block mode-- This mode takes advantage of local buffering to reduce the communication transmission time (and thus communication costs). The buffering can be in an intelligent terminal (like a personal computer), or a community center. This strategy is now attractive because of the rapidly declining cost of terminal and computer equipment, and the appearance of special features like terminals with buffering memory. The cost characteristic is that more complicated local processing is done to reduce the transmission costs. Data are sent at modem speeds, not typing speeds. This mode is currently being investigated by some VANs for future implementation. No special procedures are needed at either user or CPU end as this mode just mimics a very fast typist. Some provisions facilitate operation in this mode if certain typing sequences are "preprogrammed", that is, the computer is told that this is a special communication mode and that the data should be expected in a compact noninteractive form.

(3) Message mode--This mode is an extension of the block mode and typically would be used for exchange of information between two computer systems. The data are organized into a standardized format that is compact and regular. The messages could be computer files, messages in an electronic mail context with addresses, subject, etc. or specially coded requests (queries) from a database (like the UPI news on the SOURCE). The cost characteristic is again, minimizing the transmission charges by formating the data and sending at modem speeds. The complexity of the processing is again higher at both ends.

Thus, with this model and the three communication modes, several possible methods of service can be provided.

- Direct access from a TTY throughout most of the U.S. to either commercial (SOURCE, TELEMAIL) or community computers over a VAN.
- Direct access from a TDD in cities where intelligent modems (IM) are placed.
- Access to a VAN from an intelligent TTY (or TDD in the cities with intelligent modems) that allows local composing and editing, then sends the data in a block mode.
- Access to a VAN with dial-out that will allow a person to make a long-distance direct terminal-to-terminal call. The rates for TELENET ($3.75 per hour plus some charge for dial-out) is much less than for Direct Distance Dial ($25 per hour, prime time). With a buffered terminal and auto-dial the charges might be further reduced by composing a paragraph at a time, then dialing and delivering in block mode.

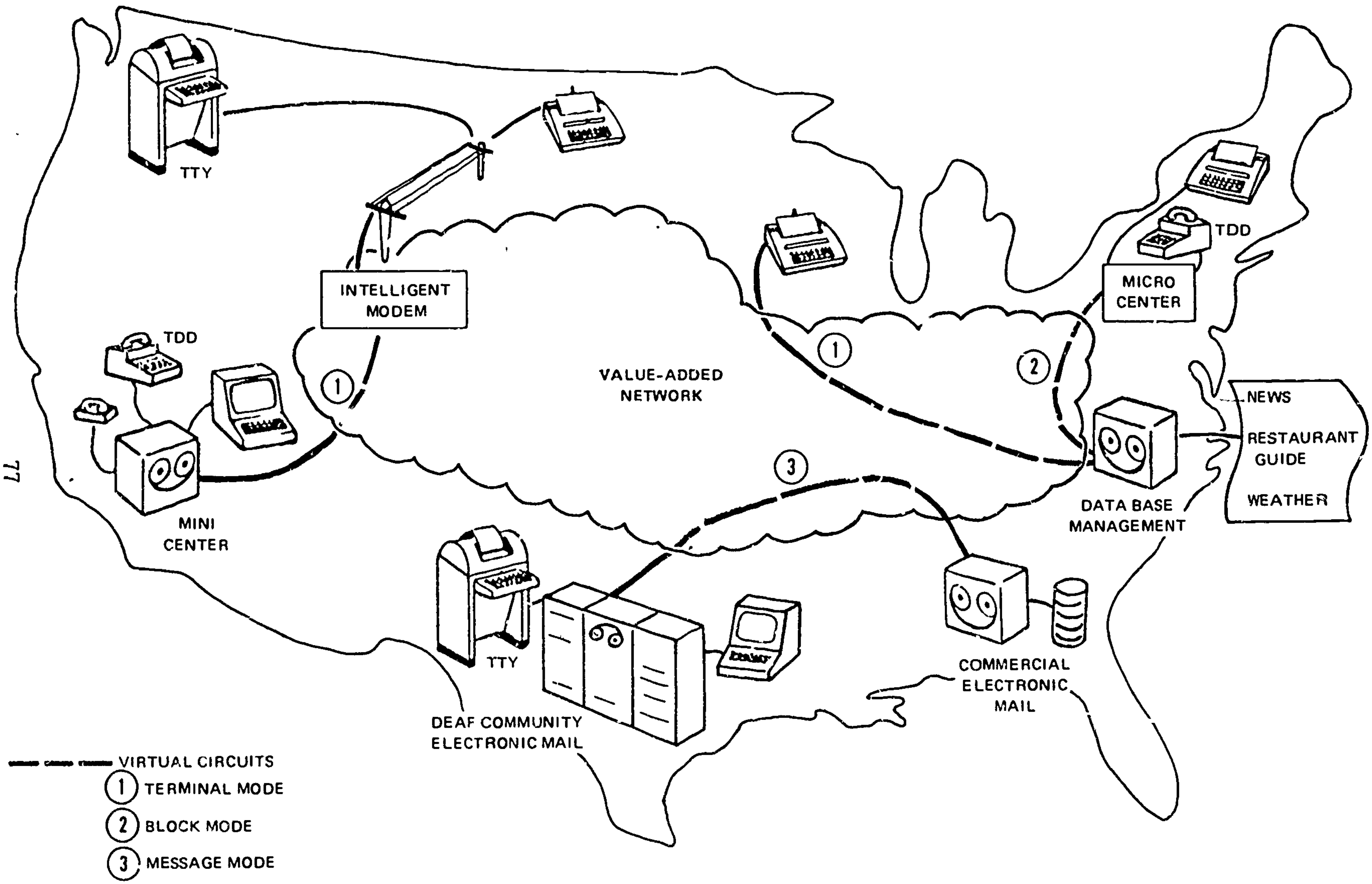

FIGURE V-1 NATIONAL DEAF NETWORK AND ASSOCIATED SERVICES BASED ON COMMERCIAL OFFERINGS AND COMMUNITY CENTERS

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- Access to a local community center by a TDD or TTY where messages are composed and edited then sent by the local computer over the VAN to a centralized mail system.
- Access to a community center mail system where messages are read, filed, and composed. The community center can then store the long distance messages, sending them in the most cost-effective way that meets the user's requirements (immediate or over-night delivery, say).
- Access to a community center "front-end" program to request information from a database. The local "front-end" program determines by question and answer with the user the exact nature of the data to be extracted from the data base. A very compact query is then formed and transmitted to the database computer (again it could either be immediate or overnight). The database computer then sends the requested data back as a file and stores it in the community center to be accessed locally by the user.

In summary, the architecture of the system is based on "tiered charges" or cost-based pricing. That is, the user should be able to select the services he wishes to use and pay only for those services. This tiered-charge model is distributed and uses regional community centers[6]. The regional centers are connected by a Value Added Network. Each of the regional centers can be tailored to match the communication requirements and available capital (investment potential, income) of the local community and to provide specific services.

This model makes no restrictions on the type of hardware/software used to implement the regional centers, but rather requires standardized communication procedures. They are of three types: terminal mode, block mode, and message mode. With this structure, a wide variety of services and methods of access can be provided.

VI TARIFF DESIGN

A. Demand for Subscription and Network Externalities

The phenomenon of critical mass strongly influences the viability and evolution of new telecommunications networks such as DNAS. It is a direct consequence of the demand characteristic referred to in economics as "network externality:" a market condition in which the benefit to a subscriber who joins a communication network depends on how many other subscribers he can access via the network. The increase in benefits accrues in two ways. First, at any fixed usage level, the value of an additional hour (or any other unit of usage) to a subscriber increases as the number of possible destinations increases, since there are more opportunities to use this hour for important communications, such as emergency calls. Second, as the network expands, it can handle more of a subscriber's overall communication needs, thus increasing his benefits.

The first type of benefit is marginal (incremental) and relates to how much of the service is used by those who already subscribe. The second type of benefit is a total one and relates to whether it is worthwhile to subscribe at all. Consequently, as a network grows, the network externality manifests itself in a higher consumer willingness to pay for each incremental unit of usage and for the service as a whole.

The actual decision of a consumer to subscribe, and then how much of the service he uses, depends on his net benefit after paying the required charges. If he subscribes, he will choose a level of usage which maximizes his net benefit (benefit minus cost), and he will subscribe only if this maximum net benefit is positive. Both of these decisions (subscription and usage level) are influenced by the tariff structure and by who else is on the network. In addition, even with these parameters fixed, we will still find individual differences in consumers' willingness to pay which depends on such factors as communication need and income level. This is why demand depends on price: fewer people will subscribe as price increases, a phenomenon manifested by a downward slope in the demand curve.

A typical downward sloping demand curve for subscription, as shown in Figure III-2, determines the number of subscribers, Q, at every price level, P. Alternatively, this curve can be interpreted as showing the price at which the Qth subscriber will join the network, with subscribers ranked by their willingness to pay. The latter interpretation is more appropriate in the presence of network externalities since the price that the Qth subscriber is willing to pay is conditional on the presence of the other Q-1 subscribers and will increase as more subscribers join. In such a situation, the demand curve describing the maximum "joining" price of the Qth subscriber will have a dome shape as shown in Figure VI-1.

The left increasing part shows that willingness to pay increases with the number of subscribers. Note that the benefit for the first subscriber is zero, since he has nobody else to talk to. As soon as another person joins, then both have some willingness to pay in order to communicate. Since subscribers are ranked according to the benefit they can derive from the service, each additional subscriber will be slightly less willing to pay for the service than the last one*. Hence, the upward slope diminishes as shown in the figure, and the curve eventually reaches a maximum, then bends downward as a standard demand curve would do. In this region, the declining effect of increased price sensitivity dominates the positive effect of the externality. Finally, at market saturation, willingness to pay returns to zero.

* This ranking is along the horizontal axis of the figure; those with the most willingness to pay are lowest on the scale (nearest the origin).

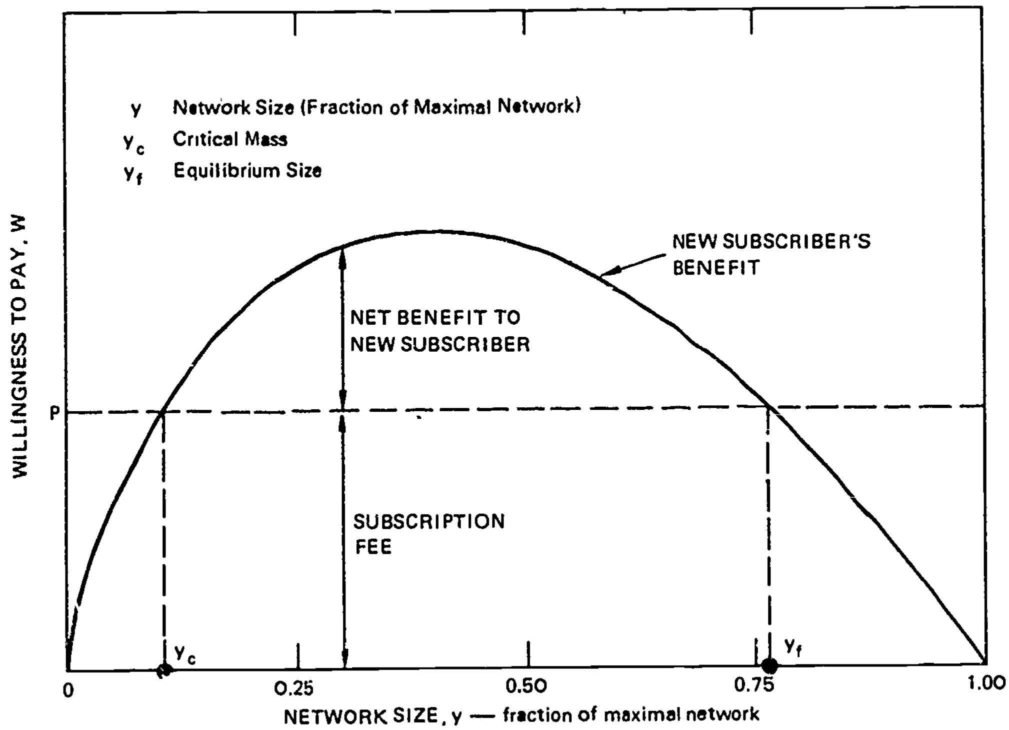

FIGURE VI-1 NEW SUBSCRIBER'S BENEFIT AS A FUNCTION OF NETWORK SIZE WITH A FLAT-RATE TARIFF

B. Tariff Structure

In general, tariffs can be composed of fixed monthly subscription fees and usage charges. The latter may depend on the type of services used and on metered usage (measured in connect time, packets, etc.). The usage charge per unit is not necessarily fixed and may vary with the amount used. For example, there may be a "lifeline" usage quantity (offered by many utilities) for which the price per unit is relatively low while any usage above that level is priced higher. In contrast, the tariff may include a volume discount (for example, block-declining rates) so that the price per unit used declines as usage increases. A tariff also may include a fixed amount of "free" usage which is bundled with the subscription.

Figure VI-2 illustrates some typical tariff structures. The flat-rate tariff imposes a fixed subscription fee and allows unlimited usage at no extra charge. The two-part tariff imposes a fixed subscription fee and a fixed usage charge per unit. A three-part tariff is essentially a two-part tariff with a minimum usage requirement. If the charge for the minimum usage is included in the subscription fee, then the minimum usage becomes "free" since the user sees no usage charge imposed on that part of his consumption. Finally, a block-declining tariff includes a fixed subscription fee and a usage charge per unit which declines as usage increases. This decline may be viewed as a volume discount.

Figure VI-3 illustrates how a block-declining tariff can be implemented by offering the users a selection of multiple two- or three-part tariffs. The subscriber is allowed to choose among a variety of contracts in which he obtains a lower usage charge per unit by paying a higher subscription fee. When each user chooses the tariff yielding the lowest charge for his usage level, the charges are given by the envelope bounding all the contracts from below. This, however, is exactly the shape of a block-declining tariff. As the number of contracts increases, their envelope approaches a smooth concave curve referred to

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as a "nonlinear tariff". Hence, the nonlinear tariff can be used as a bound to find out how good a block-declining tariff can be.

The subscription fee is an important parameter of a tariff since it determines, to a large extent, the critical mass level and the equilibrium size of the network. If the subscription fee is low, a potential subscriber will need fewer communication partners on the network to justify the expense of subscription. Likewise, since more people are able to afford paying the subscription fee, the ultimate equilibrium size of the network will be larger.

These considerations are indeed strong incentives to a supplier, to keep subscription fees low. However, to maximize revenues, he will also want to charge customers as much as they are willing to pay. Balancing these two conflicting objectives depends on the extent to which the tariff structure allows the supplier to discriminate among customers according to their willingness to pay and their usage pattern for the service. A flat rate, for instance, treats subscribers uniformly and does not provide the supplier with any choice in charge mechanism other than the subscription fee. Tariffs involving usage charges, on the other hand, allow a supplier to charge subscribers differently based on their usage level, which usually results in higher revenues.

C. The Virtues of Usage Charges

The flat-rate charge structure is the simplest form of tariff and is currently the predominant tariff for local phone calls. However, the flat-rate structure has some severe disadvantages; we will discuss it primarily for the purpose of illustrating critical mass concepts and the importance of usage charges.

In a flat-rate system, a subscriber's benefit in joining the network equals his willingness to pay for all the usage he can get out of the service, given the current group of subscribers he can communicate with. The demand curve illustrated previously in Figure VI-1 describes this case for each yth subscriber joining the network. When

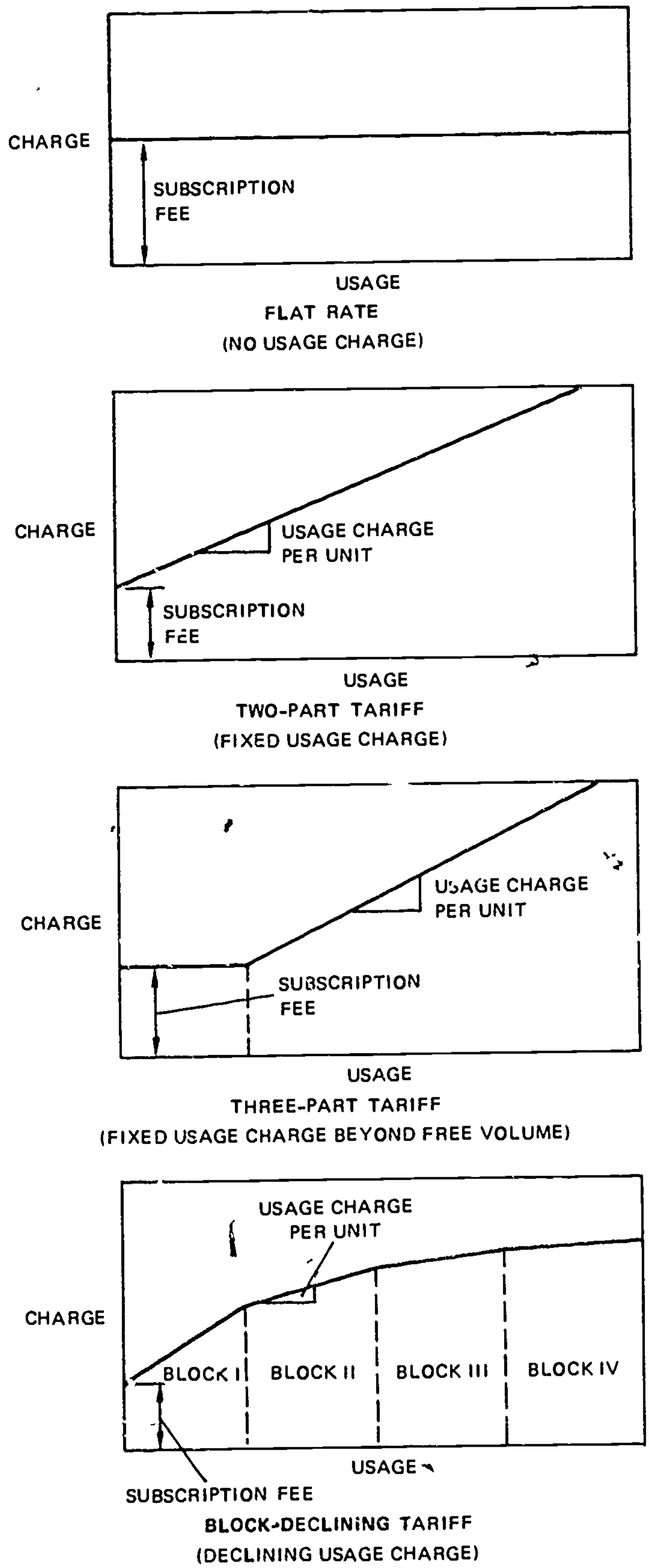

FIGURE VI-2 ALTERNATIVE TARIFF STRUCTURES

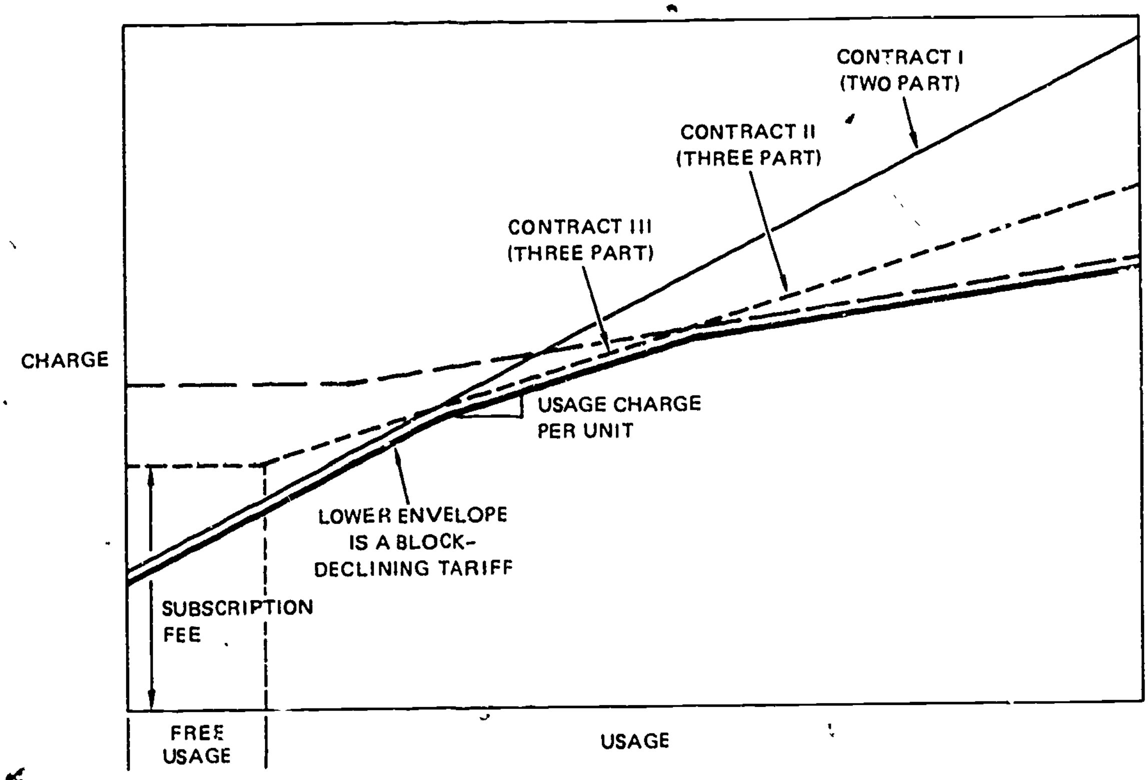

FIGURE VI-3 IMPLEMENTING A BLOCK-DECLINING TARIFF BY COMBINING SEVERAL TARIFF STRUCTURES

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there are fewer than y_c subscribers and a flat-rate charge P is imposed, the last subscriber's net benefit is negative, causing him to relinquish the service, which in turn will cause a chain reaction of cancellations. If, on the other hand, the number of subscribers exceeds y_c then each additional subscriber will have a positive net benefit at price P and will want to join. This will lead to a spontaneous expansion of the network until it reaches its equilibrium level y_f. The threshold number of subscribers y_c is the critical mass. Lowering the price, P, will lower the critical mass and enlarge the equilibrium size of the network.

The weakness of a flat rate is that it fails to exploit the willingness of earlier subscribers to pay more than P by the time equilibrium is reached. In equilibrium, those subscribers who joined earlier get much more use out of the network than when they joined. This results in a "windfall" of consumer surplus to the initial subscribers. To capture some of that surplus, suppliers will be induced to set higher flat rates, which would increase the critical mass and diminish the equilibrium size of the network. While an initial subsidy or gradual price increases may help to overcome the critical-mass problem, they will not increase the equilibrium size of the network, which depends on the ultimate subscription fee.

By imposing a usage charge in addition to the fixed subscription fee, a supplier can capture some of the consumer surplus of the heavy users while maintaining a relatively low subscription fee. This reduces critical mass and makes the service affordable to more consumers. Of course the usage fee will, to some extent, inhibit usage. However, a substantial part of the lost traffic is offset by the new usage of the added subscribers who join and that of all previous subscribers who communicate with them. In total, the imposed usage charge may lower total communication traffic over the network. However, the lost traffic is typically of low priority, so that the net effect will be an increase in the number of subscribers and in the total surplus (consumers' and

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producers'). The reduction in such low priority traffic may even have an added benefit of reducing congestion when traffic overload becomes a problem.

D. Varying Usage Charges

Simple two- or three-part tariffs have a fixed linear charge per unit of usage. In more complex tariffs, however, the charge per unit will vary (nonlinear charge). Such variation may depend on service type (tiered charge)*, on total usage (block-declining or nonlinear tariff), or on both. In general, such variation enables the supplier to implement price discrimination by charging subscribers close to what they are willing to pay. This induces more efficient usage of the service and increases the supplier's incentive to expand network size by reducing the fixed subscription fees.

1. Tiered Service Charges

A tiered-charge system enables subscribers to select the services they want and to pay only when they use them. The alternative to this approach would be a uniform usage charge, based on connect time or amount of information sent, regardless of which service is used. The advantage of the latter approach is that it is simple and does not require elaborate monitoring of transaction type. Unfortunately, it leads to inefficient usage of the various services and may lower overall usage levels as well. A supplier providing such an untiered service will normally set the usage charge somewhere between the lowest and highest charges in a tiered tariff. Consumer surplus thus increases for the high quality services, and decreases for the less valued services. This will induce inefficient use of the high quality services while inhibiting the use of the less valued ones. For instance, suppose a uniform rate were imposed by the U.S. Postal Service for all classes of mail. This rate would probably be lower than the current first class rate but higher than the current third class rate. Consequently, one would expect some third class mail to be mailed first class; some not to be mailed at all.

* Tiered charges in the cable industry provide a good example.

In a paper relevant to this issue, Oren et al.[21] have analyzed, in a theoretical framework, the effects of tiered service quality in two-part tariffs. In an illustrative example, they have shown that when prices are selected so as to maximize net revenue, a tiered, two-part tariff will result in a 50 percent increase in usage, consumer surplus, and total surplus over the corresponding quantities resulting from a comparable untiered two-part tariff. This strongly suggests tiering the usage charges by type of service.

2. Declining Usage Charges

The declining block tariff is another way by which usage charges may be varied. The idea here is to reduce the usage charge per unit as usage increases, in effect offering a quantity discount. Such a charge scheme provides the supplier with the means to discriminate among the light and heavy users of the network. By doing that, a supplier's revenues can be made to track more closely the willingness to pay of each subscriber. The supplier thus captures a higher percentage of the total surplus. Consequently, because of the network externality, it is in the supplier's self-interest to reduce the subscription fee to increase the network size. This, in turn, also reduces critical mass and, consequently, reduces the extent of subsidy that might be needed to start the network.

3. A Comparative Analysis

Table VI-1, based on results of Oren et al.[22-8], gives an illustrative comparison of the welfare implications corresponding to flat-rate, two-part, and nonlinear tariffs*. Since the nonlinear tariff is a limiting case of the block-declining tariff when the number of blocks is very large, it can be used as an approximation of the latter structure. The demand function assumed in this example has a relatively simple form, but it captures all the important elements affecting usage, namely marginal price, network size, and individual differences.

*Key definitions of the terms used throughout this section are contained in the glossary at the end of the report.

Table VI-1

COMPARISON OF THREE TARIFF STRUCTURES
WITH NET REVENUE MAXIMIZING PARAMETERS*

	FLAT RATE	TWO PART	NONLINEAR
EQUILIBRIUM NETWORK SIZE (% of maximum)	57%	73%	88%
CRITICAL MASS NETWORK SIZE (% of maximal network size)	29%	16%	6.5%
SUBSCRIPTION FEE	3.52 k	1.00 k	0.01 k
POTENTIAL USAGE	0.66Nv	0.86Nv	0.97Nv
ACTUAL USAGE	0.66Nv	0.54Nv	0.66Nv
CONSUMER SURPLUS	1.32Nk	1.00Nk	0.82Nk
NET REVENUE	1.44Nk	2.00Nk	2.34Nk
TOTAL SURPLUS	2.70Nk	3.00Nk	3.16Nk

* Result based on demand function for usage

$D(m,t,y) = v [2 - 0.2 mv/k] [2-y] y [1-t]$ and fixed service cost per subscriber (no usage cost to supplier).

m - usage charge per unit
t - consumers subscription propensity rank order index (highest t = 0, lowest t = 1)
y - network size (fraction of maximal network)
v - average potential usage in maximal network
k - supplier's service cost per subscriber
N - potential number of subscribers (maximal network)

The figures are based on the assumptions that suppliers incur a fixed monthly cost per subscriber and prices are set to maximize net revenue. We note that the nonlinear tariff leads to the largest network coverage (88% of the potential market) and to the lowest critical mass (6.5%). It also leads to the highest total surplus (a measure often used by economists to characterize efficiency) and results in the highest revenues to the supplier.

A somewhat controversial aspect of two-part and nonlinear tariffs is that the usage charges they impose decrease usage and decrease consumer surplus, although they increase supplier net revenue and overall net benefit (social surplus). At first glance, then, it might appear that these tariffs benefit the supplier, not the consumer. To put this issue in perspective, it is useful to look at the distributions illustrated in Figures VI-4 and VI-5, which were obtained by Oren et al.[22-8], for the above example.

In Figure VI-4 we see that, while usage charges inhibit usage volume among some of the subscribers, they result in more users obtaining access to the service since the subscription fee is less. An even more revealing picture is shown in Figure VI-5. Here we see that the loss in consumer surplus resulting from the usage charge is borne primarily by the first subscribers, or those who gain in consumer surplus--that is, get a better and better bargain-- as the network expands. The usage charge induces a more equitable distribution of surplus and permits the supplier to extend service to a wider population. Note that, for the nonlinear tariff shown in Figure VI-5, the total surplus curve eventually falls below the consumer surplus curve. This indicates that the low-end subscribers (rural users, say) get their service below the supplier's cost. The supplier will be motivated to incur this incremental loss since extending service to the low-end subscribers increases the value of the service, the usage level and suppliers' revenues for all other subscribers who can communicate with them. Thus, the nonlinear tariff induces a voluntary functional equivalent of cross subsidy.

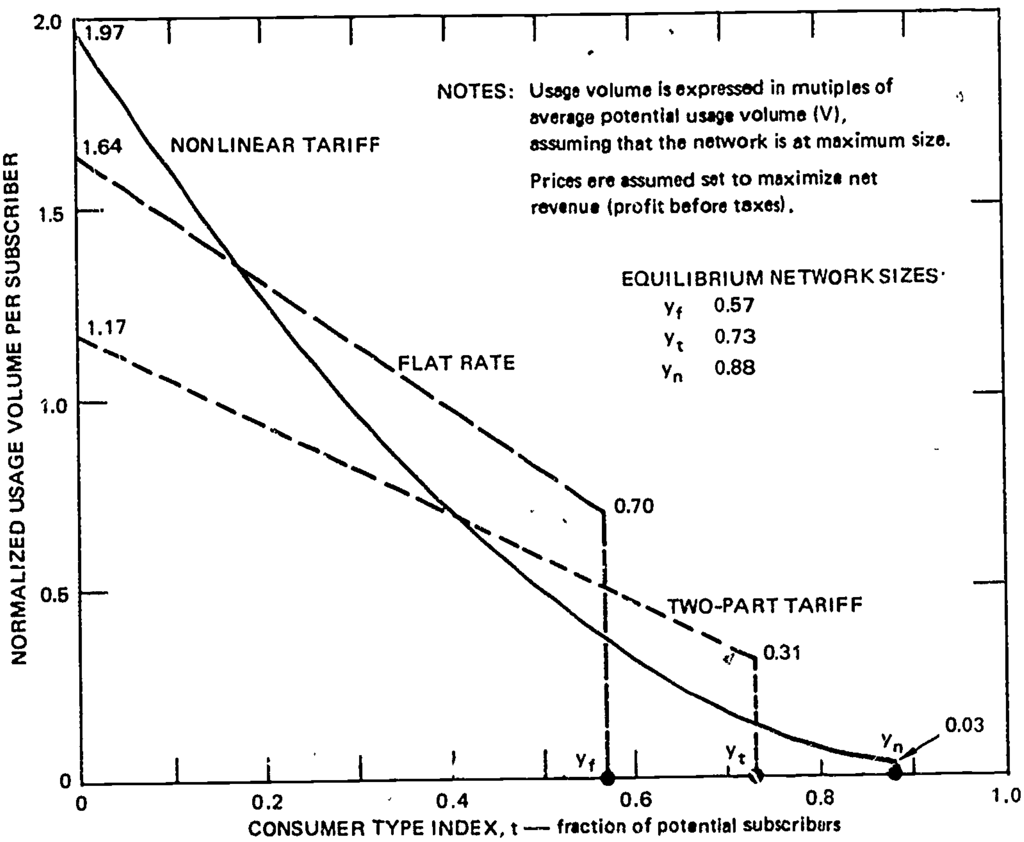

FIGURE VI-4 USAGE BY TYPE OF SUBSCRIBER FOR THREE TARIFF STRUCTURES

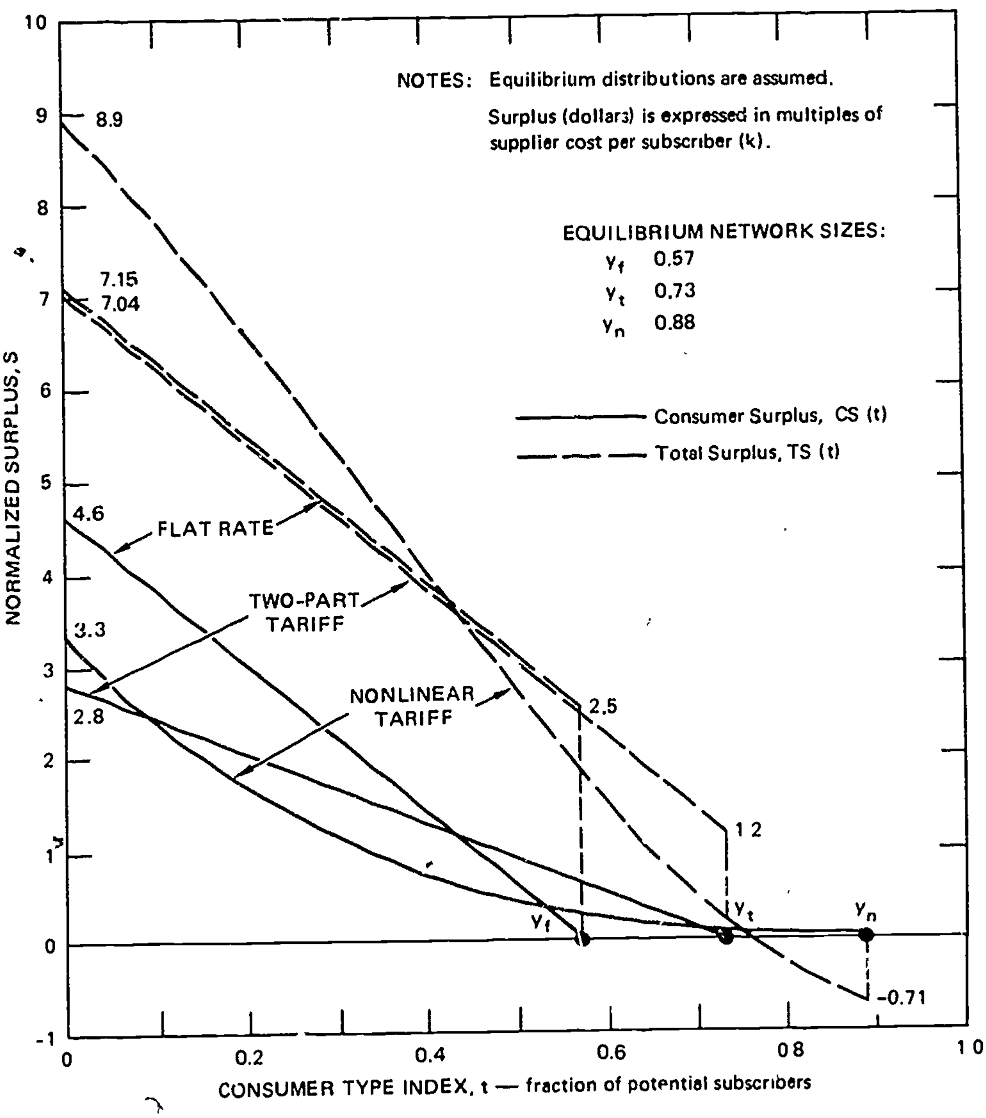

FIGURE VI-5 TOTAL SURPLUS AND CONSUMER SURPLUS BY TYPE OF SUBSCRIBER FOR THREE TARIFF STRUCTURES

Finally, nonlinear (block-declining) tariffs provide a natural mechanism to track the added value of the service without having to vary the tariff structure. As the network expands, subscribers vary their usage levels accordingly, and move automatically along the tariff segments.

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VII ANALYSIS OF COMMERCIAL FEASIBILITY

A. Approach

Having defined the basic communication needs of the deaf and the potential market for DNAS in Chapters I and IV, having developed key concepts concerning commercial viability in Chapter III, having described the services to be offered in Chapter V, and having established a basic analytic framework in Chapter VI, we are now in a position to assess the commercial performance of DNAS as it might be offered to a specific target population. Quantities developed below (including revenues, costs, profits (before taxes), traffic (calls), market penetration, and critical mass) should be of particular interest to the hearing-impaired as well as to prospective suppliers.

However, it should be stressed that these results, though they appear to be appropriate and reasonable, are based on models and assumptions that bear further investigation before proceeding to build the network. The purpose of this chapter is to provide quantitative indications as to whether DNAS will be commercially feasible over the long run. Preliminary estimates are provided for three alternative tariff structures and for two supplier cost models. Further indications of viability over time are presented in Chapter VIII. Nevertheless, more detailed analysis will be necessary to support any particular implementation scheme chosen.

B. <u>Assumptions</u>

Several theoretical assumptions are implied by the model developed in Chapter VI. These assumptions include the following:

- The supplier is a monopoly and wishes, characteristically, to maximize profits.
- The supplier has "perfect information" about preferences of different consumer types and their distribution in the general population. Thus, the supplier can price intelligently.
- Any resale market for DNAS services is precluded, and the supplier can monitor the usage level of each subscriber. Thus, a nonlinear tariff offering block discounts is realistic.

As inputs to the model, the following are posited:

- The potential market (maximal network size) is two million subscribers, or approximately 1 percent of the U.S. population. The deaf will comprise most of this market, although many hearing persons (relatives, friends) and concerned institutions are expected to subscribe as well*
- Willingness to pay for DNAS services, averaged over all potential subscribers (assuming maximum usage and maximal network coverage), is 20 cents per call, in addition to any charges for the terminal and for the basic telephone connection. This is an optimistic assumption, chosen to estimate an upper bound on revenues.
- Potential usage in a maximal network, averaged over all potential subscribers, is 200 calls per month, assuming free usage (flat rate tariff). This is close to the current calling rate (local and long distance) of the average telephone subscriber in the U.S. today [23].

Since provision costs (to the supplier) are especially difficult to estimate for a new service involving rapidly evolving technologies, and since certain potential suppliers may be able to "piggyback" DNAS on existing services at a lower incremental cost than others unable to do so, two cost models are posited for this preliminary analysis. The first model (Case A) assumes a relatively low average provision cost of $8.00 per subscriber and should be considered an optimistic lower bound,

*As noted earlier in Chapter III, because the deaf tend to cohabit, the number of terminals needed to serve this market may be less than the number of potential subscribers.

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more appropriate to mature service in equilibrium that exhibits full scale economies and that exploits the declining costs of computer technologies over time. The second model (Case B) assumes a higher average provision cost of $20.00 per subscriber more appropriate to today's technology[6] and to the network in its earlier stages of development.

Since the analysis is already quite complex, both models assume, for purposes of simplicity, that provision cost is independent of usage. This assumption is not a serious shortcoming, but it is clearly unrealistic. To account for the cost of usage, we have therefore adjusted the average cost in Case B from the $16.00 per subscriber calculated in detail in the SRI study just referenced (which assumed sixty 9-minute calls per month) to the $20 figure given above*.

C. Results

Tables VII-1 and VII-2 show the results obtained for optimistic (Case A) and pessimistic (Case B) cost assumptions**. Key findings can be summarized as follows:

* In effect, then, we have assumed a marginal cost per call of $4/140 or 2.9 cents.

** Table VII-1 is calculated directly from the quantities listed in Table VI-1 (Chapter VI), which is appropriate for Case A. Table VII-2 required additional analysis based on a modified demand function for Case B (see table footnote).

Table VII-1

FEASIBILITY RESULTS: CASE A

(Average monthly supplier cost of $8.00 per subscriber)

	ALTERNATIVE TARIFF STRUCTURES		
	FLAT RATE	TWO PART	NONLINEAR
NUMBER OF SUBSCRIBERS			
Potential Market	2.00M	2.00M	2.00M
Equilibrium Network Size	1.14M	1.46M	1.76M
Critical Mass	0.58M	0.32M	0.13M
SUBSCRIBER PAYMENTS AND REVENUES			
Monthly Subscription Fee	$28.16	$ 8.00	$ 0.08
Average Monthly Usage Payment	-0-	$21.92	$29.19
Average Monthly Subscriber Payment	$28.16	$29.92	$29.27
Total Annual Subscriber Revenues	$385M	$524M	$618M
USAGE			
Average Monthly Calls per Subscriber	232	148	150
Total Annual Call Volume	3.17B	2.59B	3.17B
Average Usage Payment per Call	-0-	14.82 cents	19.46 cents
SUPPLIER COSTS AND PROFITS			
Average Monthly Service Cost	$8.00	$8.00	$8.00
Total Annual System Costs	$109M	$140M	$169M
Total Annual Profit	276M	384M	449M
ANNUAL SURPLUS			
Consumer Surplus	$253M	$192M	$157M
Producer Surplus	276M	384M	449M
Total (Social) Surplus	$529M	$576M	$606M

Notes: M=Million; B=Billion
Demand is characterized by the equation shown in Table VI-1
Profit is before taxes (net revenue or producer surplus)

Table VII-2

FEASIBILITY RESULTS: CASE B

(Average monthly supplier cost of $20.00 per subscriber)

	ALTERNATIVE TARIFF STRUCTURES		
	FLAT RATE	TWO PART	NONLINEAR
NUMBER OF SUBSCRIBERS			
Potential Market	2.00M	2.00M	2.00M
Equilibrium Network Size	1.00M	1.26M	1.45M
Critical Mass	0.75M	0.47M	0.33M
SUBSCRIBER PAYMENTS AND REVENUES			
Monthly Subscription Fee	$30.00	$12.00	$ 0.52
Average Monthly Usage Payment	-0-	20.28	32.76
Average Monthly Subscriber Payment	30.00	32.28	33.28
Total Annual Subscriber Revenues	$360M	$488M	$579M
USAGE			
Average Monthly Calls per Subscriber	225	162	166
Total Annual Call Volume	2.70B	2.45B	2.89B
Average Usage Payment per Call	-0-	12.53 cents	19.69 cents
SUPPLIER COSTS AND PROFITS			
Average Monthly Service Cost	$20.00	$20.00	$20.00
Total Annual System Cost	$240M	$302M	$348M
Total Annual Profit	$120M	$186M	$231M
ANNUAL SURPLUS			
Consumer Surplus	$180M	$154M	$138M
Producer Surplus	120M	186M	231M
Total (Social) Surplus	$300M	$340M	$369M

Notes: M=Million; B=Billion
Demand is characterized by the equation shown in Table VI-1, but with the factor 0.2 m/c changed to 0.5 m/c to account for the higher supplier cost.
Profit before taxes (net revenue or producer surplus)

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- Critical mass would vary considerably, depending on the tariff structure employed and on the supplier costs assumed. For the best case considered (Case A, nonlinear tariff), attracting 130,000 subscribers would ensure spontaneous growth. For the worst case (Case B, flat-rate tariff), 750,000 subscribers would be necessary. Multipart tariffs clearly reduce this initial barrier by lowering the subscription fee.
- Equilibrium network size would range from 1 million to 1.76 million subscribers, depending on assumptions. For maximum market penetration, a nonlinear tariff should be employed.
- Average subscriber outlay (exclusive of any terminal costs or basic connection charges) appears to be relatively insensitive to the modelling assumptions posited and ranges from $28 to $33 per month. Annual call volume for the nationwide system could exceed 3 billion.
- Total system revenues could be conderable, ranging from $360 million to over $0.5 billion. Multipart tariffs stimulate revenues substantially; lower supplier costs also stimulate revenues by increasing, indirectly, the ultimate network size.
- As expected, multipart tariffs tend to reduce usage per subscriber. However, this effect is offset by the additional subscribers they stimulate. Higher supplier costs (Case B) can actually appear to stimulate usage per subscriber by reducing the average price paid per call. This apparent anomaly is a result of a higher proportionate subscription fee for Case B.
- The actual price paid per call for the two-part tariff (and the composite average price per call for the nonlinear tariff) would vary from 12 cents to 20 cents, depending on the cases studied. These are not unreasonable fees, since 9 minute calls are implicitly assumed.
- Once critical mass is achieved, all alternatives studied are viable, with revenues exceeding costs by a considerable margin. Net revenues would be substantial, varying from $120 million to $450 million*. The nonlinear tariff is clearly the most profitable choice indicated by the model.
- Although consumer surplus is reduced by multipart tariffs, this effect is more than offset by increased producer surplus (net revenue). Hence, usage charges for DNAS increase overall social net benefit.

*These figures indicate profit potential, rather than actual profit. Front-end losses during startup, competition, and taxes are not accounted for in this chapter and can be expected to reduce these figures considerably.

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D. Conclusions

The foregoing analysis indicates that DNAS is likely to be a commercially viable offering, capable of generating revenues that exceed costs by a comfortable margin over the long term. Thus, although outside subsidy will almost certainly be needed to initiate the network, it is highly probable that such payments will no longer be needed once the network reaches critical mass. Indeed, as will be shown in Chapter VIII, depending on how the network evolves, the offering may become profitable long before critical mass is reached. Finally, results show that the nonlinear (block declining) tariff is clearly the best choice, not only because it maximizes supplier net revenues, but because it leads to the fullest market penetration and maximizes overall social net benefit.

We stress again that these salutary results, which show a strong commercial potential for DNAS, are offered as first estimates only. They deserve further scrutiny and refinement before the network is actually implemented.

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VIII EVOLUTION

A. Network Evolution: User Considerations

The need to introduce the deaf to the new technologies discussed here is as important to the ultimate success of DNAS as system convenience, reliability, and cost. Indeed, cost and utility to individual users will be affected directly by the deaf community's general acceptance of new computer communications. As Section III-C of this report points out, a telecommunications system for the deaf must achieve a critical mass, that is, reach a sufficient number of subscribers, for it to become both affordable and useful.

How, then, are the hearing impaired to be introduced to some of the new electronic text services now on the market? As Rogers and Shoemaker observe, "Mass media channels are more effective in creating knowledge of innovations, whereas interpersonal channels are more effective in forming and changing attitudes toward the new idea[11]." Consumers, for example, usually learn about a new product from one or two principal sources--a product manufacturer or retailer, or a personal acquaintance who has tried the product. Although manufacturers and merchants alike have aggressively marketed home computers for at least the last two years, they have not promoted its communication capability until recently. As a result, the hearing impaired may be unaware of it, just as the computer industry may be unaware of the potential market of deaf users.

Specialized carriers who provide the communication link for computers also have overlooked or rejected the hearing-impaired market, targeting their efforts instead almost exclusively at the business user. Thus, the deaf cannot expect manufacturers or vendors to seek them out as potential customers. Rather, the hearing impaired will have to discover computer-communication systems independently and alert vendors to their needs.

Individual members of the deaf community often are isolated from one another. When they exchange news and information at all, they usually do so through simple correspondence, by means of Baudot teletypewriters or by meeting at schools, community centers, churches or other institutions offering a full or part-time program of services for the deaf.

Such institutions usually are staffed by a mix of both deaf and hearing individuals working as paid professionals or committed volunteers. By virtue of training, interest, and time spent working with and for the deaf, these individuals often emerge as the "activists" of the deaf community. As such, they usually have maximum contact with both the hearing impaired and the social institutions which can be most useful to the deaf. This, in turn, provides them with access to more information than the average hearing-impaired person.

The leaders in the deaf community have the potential to become what Rogers and Shoemaker term opinion leaders or change agents; that is, individuals who act professionally or informally to influence others, often in the direction of change[11]. As Rogers and Shoemaker note, an innovation's success is often determined by the kind of communication that takes place between the agent and the group that he or she is trying to inform: "More effective communication occurs when source and receiver are homophilus;" that is, when both parties share common backgrounds, values, beliefs, and life experiences. As the two scholars also report, however, "one of the most distinctive problems in the communication of innovations" is that source and receiver usually are not homophilus.

Fortunately, the deaf community seems to be an exception to Rogers and Shoemaker's general observation. Although not designed by the hearing impaired, Deafnet has been implemented and supported by leaders of the deaf community--leaders who themselves may be deaf or who, at the very least, have demonstrated a professional commitment to the hearing impaired. One could expect a strong degree of homophily between the deaf and their leaders.

The ultimate success of computer-communication systems for the deaf may depend on the leaders of the deaf community. Working from schools, churches, and community centers, they are strategically positioned to play a dual role, introducing the new technology to the hearing impaired, while serving as a liaison to computer and communication companies. Most important, their endorsement would carry credibility with the deaf, overcoming prospective users' ignorance or anxiety about the system. At the same time, they could provide manufacturers with the critical information to develop a system that serves the deaf's needs.

The leaders' experience with Deafnet is but a small first step. Leaders of the deaf community from across the country must be informed of Deafnet's success and have an opportunity to use a similar system, if only on a temporary basis. Once acquainted with, and convinced of, Deafnet's utility, such leaders can "market" the system to the hearing impaired far more effectively than commercial vendors.

B. Network Evolution: Economic Considerations

In considering the economic aspects in the evolution of a commercial, nationwide deaf network, we will, of necessity, examine supply and demand aspects separately. The demand considerations deal with the value of the service to its potential users and how the service should be priced to sustain network evolution in the most profitable fashion. The supply considerations deal with least-cost ways of providing the service.

A working assumption that enables this decoupling of supply and demand is that the supply mode is "invisible" to the user*. Thus, during evolution, neither the service quality nor the pricing will

* We may decouple demand and supply considerations during evolution as long as different technological configurations produce indistinguishable services.

reflect the supply technology or the cost to the supplier. Instead, these aspects of the service will be determined by the value they provide to users and by their willingness to pay for them.

Cost-based pricing is often advocated on the basis of economic efficiency. While such arguments are valid in a mature market, in the context of an evolving network such restraints are undesirable. At the outset, supplier's cost per subscriber will be the highest, and the subscribers' willingness to pay will be the lowest. Starting up such a network may require some form of public subsidy to cover supplier front-end losses. To keep such a subsidy at the minimum, suppliers must be allowed to price according to the demand in a manner which allows them intertemporal cross-subsidy--to recapture some of the initial losses later on. Such an arrangement, of course, will lead to lower prices at the outset and higher prices later on; this is contrary to the trends in the provision cost which will exhibit economies of scale.

1. Demand: Critical Mass, Startup Subsidy and Growth

In Chapter VI we discussed the critical mass phenomenon in telecommunications networks such as DNAS. As was shown, this phenomenon results from each subscriber's increasing willingness to pay for joining the network as it grows. Consequently, for every posited subscription charge, there is a critical subscription level (critical mass) such that, if the network size is below that level, then a chain reaction of cancellations will result in the network's demise. On the other hand, if the subscription level exceeds the critical mass, the network will expand spontaneously to an equilibrium size that depends on the cost of subscription.

In Chapter VI we also discussed the effect of alternative tariff structures on the size and profitability of the network in equilibrium and on ways of lowering the critical mass level. In this section, we examine the evolutionary process by which a network will reach its desired equilibrium level.

The nature of critical mass implies that some transitory startup strategy must be adopted to bring the network over that hurdle. One alternative is to create a sufficiently large coalition of subscribers, exceeding the critical mass level, that will join simultaneously (for example, all TDD users). Some may argue that such a coalition is implicit. For example, consumers may subscribe on the basis of expected benefits, believing that the network will reach a certain size in a reasonable length of time. The viability of such an implicit coalition is questionable, however, since it is based on the initial willingness of subscribers to bear a negative consumer surplus,(i.e., to pay more than they are willing to pay during network startup), thereby subsidizing the network themselves until it reaches its promised size. It is likely that consumers will be reluctant to join first and the network will not take off. Thus, unless a sufficiently large coalition can be established, some form of subsidy will be needed to get the network started.

Such a subsidy can be implemented in various forms as discussed in Chapter III. However, its effect, whether direct of indirect, must be a lower subscription fee. The subsidy may, for example, take the form of free usage of terminals for a designated period of time, or an initial rebate on usage. The cost of such a subsidy may be borne by the supplier who may view it as part of his investment. The initial shortfall may be underwritten by the government or some private foundation, or initial unused capacity may be sold to other classes of users (such as businesses).

In order to sustain network growth, the subscription fee should not exceed the willingness to pay. In addition, we can expect that the growth rate will be higher when the subscription fee is lower. Thus, the extent of any initial subsidy beyond the required minimum will influence the length of time before critical mass and equilibrium are reached, the length of time over which the subsidy will be needed, and, hence, the overall amount of the ultimate subsidy. One may view this as a control problem analogous to driving a car. Driving slowly may lower gas consumption per unit time but will increase the length of time to reach a destination and may ultimately increase the total cost of getting there (especially if the cost of overnight stays is included).

This suggests that some optimal* subsidy plan can be developed. We expect that such a plan will call for a higher subsidy at the start and for decreasing support as the network expands to its desired equilibrium. This optimal subsidy trajectory will depend on the discount or interest rate and on the dynamics of the network's evolution.

Figure VIII-1 provides some qualitative insight as to how the effective subscription fee may be varied optimally as a function of the network size. This type of price is optimal if we assume that the network growth rate is directly proportional to the magnitude of the unsatisfied potential market at the current price. The optimal subscription fee increases initially to coincide with the maximum willingness to pay of each new (marginal) subscriber. At the "switch point" it then increases at a slower rate until the equilibrium size is reached. Such a strategy may be approximated by a step function which is more practical to implement since prices need not be adjusted as often. Note that the service is optimally priced below its equilibrium price even after critical mass is reached, in order to accelerate network growth. (This difference between equilibrium price and actual price could be offered as a rebate.)

2. Supply: Modes of Provision

We have discussed how the ultimate architecture of the National Deaf Network (DNAS) can be based on community centers connected through a value-added type of network (VAN). Here, we discuss briefly the evolutionary aspects of providing these services in the most economical way while varying the quality of service as little as possible from the user's viewpoint.

* Optimal in the sense of maximizing the supplier's discounted benefit (net revenue), or, alternatively, of minimizing the overall discounted subsidy stream.

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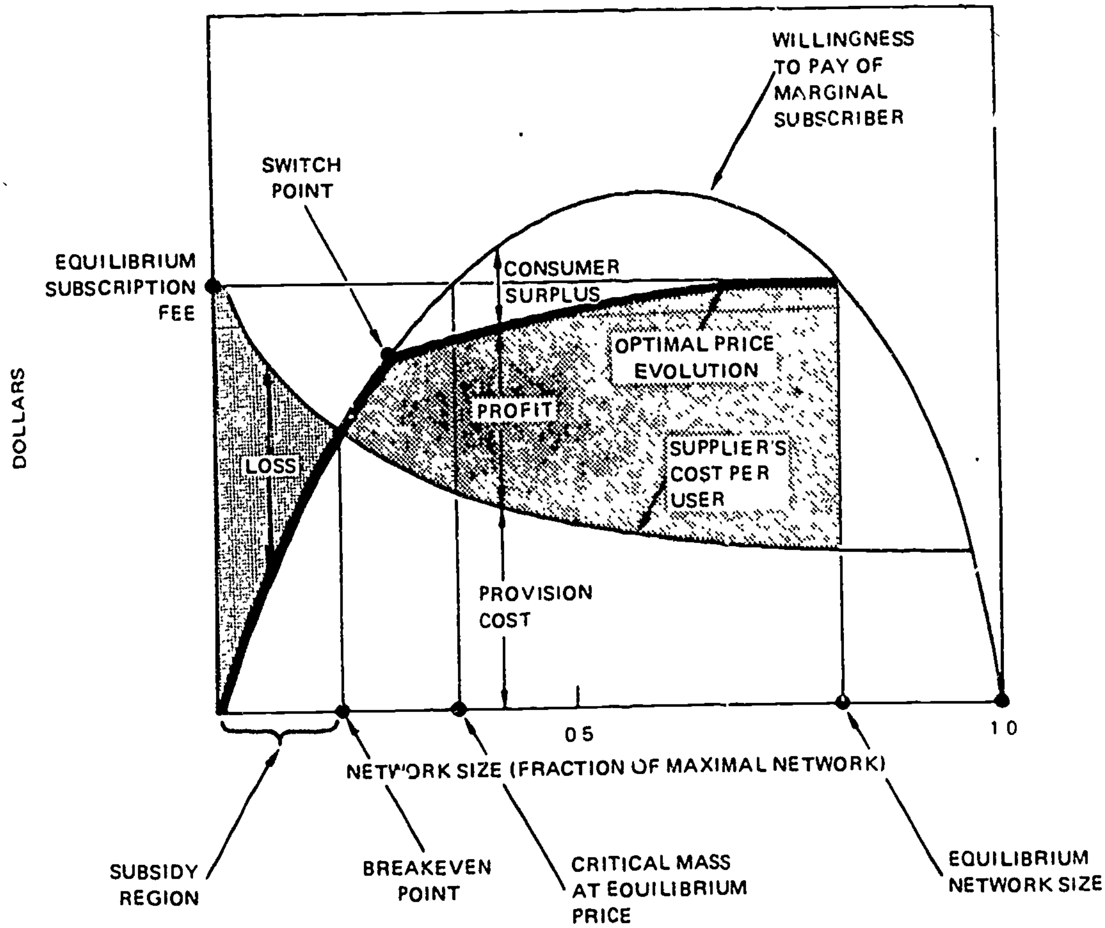

FIGURE VIII-1 OPTIMAL SUBSCRIPTION PRICE EVOLUTION

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The way in which service is implemented will depend critically on the number of subscribers in a community. For example, if only one user subscribes in a particular region, the most economical way of extending him service may be to provide him a direct link to a VAN. The supplier may have to take a loss in this case by absorbing the difference between the cost of the VAN and the charges to the user. As the number of subscribers in the community increases, the supplier will switch modes of provision where each successive mode involves a higher fixed cost of equipment but a lower marginal cost. The lower marginal cost will be achieved by more effective utilization of the VAN lines and by other economies of scale in provision of services. Figure VIII-2 illustrates the resulting cost function obtained as the lower envelope of the costs of the different modes of provision in a community. The supplier will proceed along that curve as the number of subscribers increases.

In summary, many factors are involved in determining how much subsidy will be needed. Costs, revenues, prices, and the way in which the network expands are primary economic determinants. But the success of DNAS will depend ultimately on the users themselves and on their own leadership in fostering its growth.

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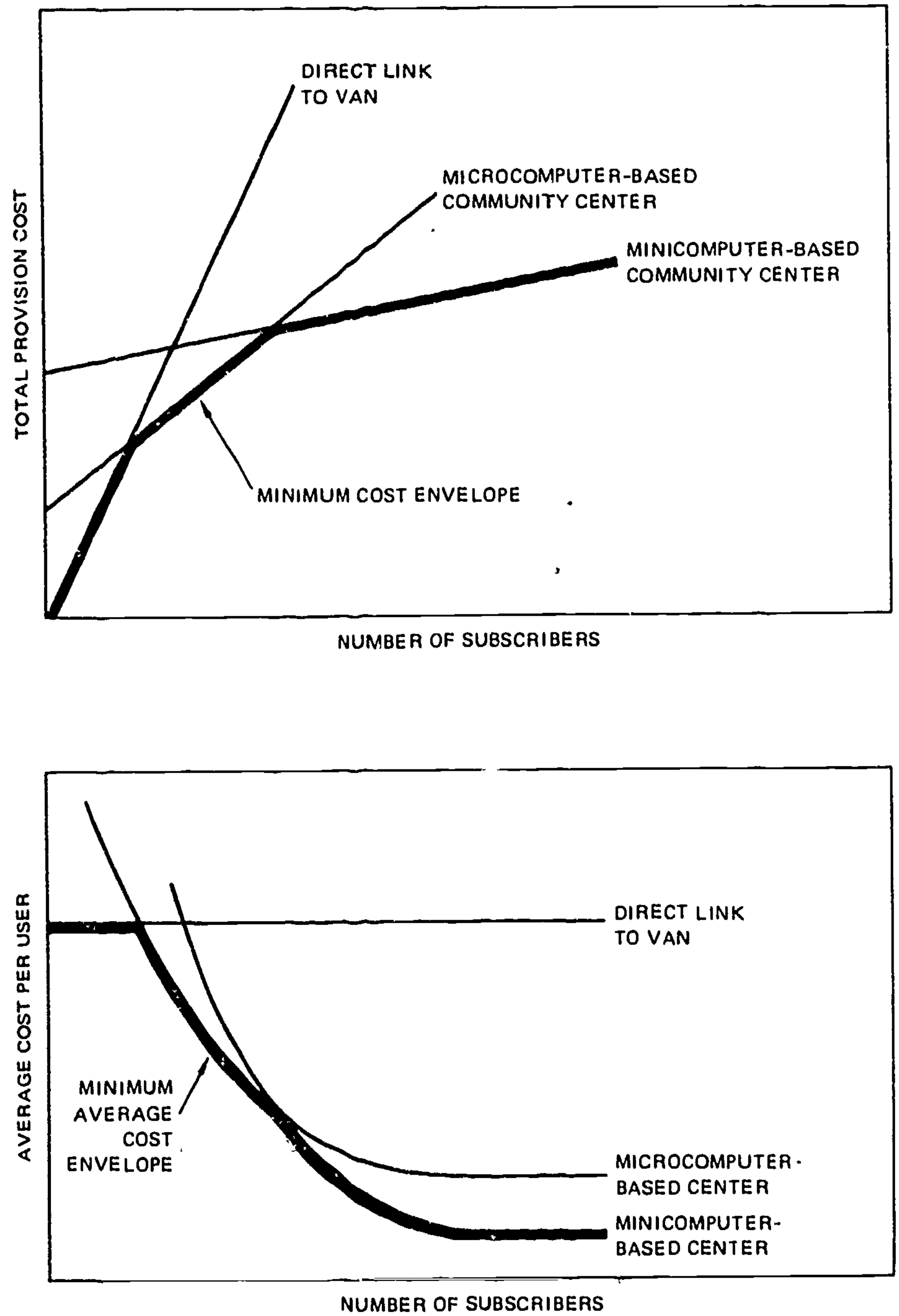

FIGURE VIII-2 SUPPLIER'S COST EVOLUTION

Appendix

THE SHIFT TO COST BASED PRICING

Several factors are responsible for the telephone industry's shift to cost-based pricing. The FCC's Carterfone decision of 1968, for example, marked the first time that telephone users could interconnect equipment purchased from non-Bell manufacturers to the telephone network[24]. Carterfone represents nothing less than the birth of today's thriving market for terminal equipment. The telephone industry received a healthy dose of competition.

The industry was to become still more competitive. By 1978, the Commission or the courts had approved competitive private line and long-distance services[25]. As one might expect, AT&T fought these decisions, claiming that such competitive services threatened both the technical quality of the telephone network and, perhaps more important, reasonable local rates. According to Bell, local telephone service was priced below cost, while long-distance and business service was priced above to make up the difference. Thus, if long distance and business customers were diverted to the new, competitive services, Bell would have no choice but to raise local rates.

While the Commission was taking a series of steps to heighten competition in the telephone industry, it was also trying to develop a consistent policy for the new computer-communication services which were entering the market. On the one hand, if the new services were a form of communications, the FCC could be obliged by statute to regulate the heretofore unregulated computer industry. On the other hand, if such services were not a form of communications, AT&T could be barred from offering them. Under the terms of its 1956 Consent Decree with the Justice Department, Bell is restricted to offering only regulated communications services or those incidental to them. After wrestling with its dilemma for 13 years, the Commission reached a decision in May, 1980[5]. Computer Inquiry II, as the FCC's action is called, makes a distinction between terminal equipment and transmission services. As of January, 1983, all terminal equipment is to be detariffed and fully competitive. Basic transmission service will remain regulated as it is now. But enhanced services, such as electronic mail systems or low-cost, long-distance services, will be fully deregulated. AT&T will be allowed to participate in the new deregulated markets so long as it establishes a separate subsidiary to do so.

The FCC's authority to deregulate so broadly is being challenged in the courts. However, the Commission's decision received important support in August, 1981, when the New Jersey court ruled that Computer Inquiry II did not violate the terms of the 1956 consent decree. Thus, unless the D.C. Circuit Court reverses the FCC's action in whole or part, AT&T will be free to participate in new unregulated markets. Indeed, just a few months after the FCC's original action, AT&T announced that it was reorganizing to comply with the new policy.

Computer Inquiry II could have several important consequences for the deaf and hearing impaired. First, as noted above, Bell's leasing of TDDs is now offered under tariff as one of the costs of providing basic telephone service. In those states in which Bell is not allowed to recover both purchase price and the associated costs of leasing TDDs, all customers must subsidize to one degree or another this service for the deaf.

But as of January, 1983, all terminal equipment is to be detariffed--including TDDs offered by telephone companies. To date, Bell, the state public utility commissions, and the FCC have not formally considered the question of providing TDDs in a detariffed environment. However, in the near future both the telephone industry and the regulatory agencies will have to determine whether or not that arrangement can or should be maintained under the terms of Computer Inquiry II.

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The deregulation of enhanced services will only accelerate the diversion of long-distance and commercial revenues from the Bell operating companies to competitive service providers. As a result, the Bell operating companies will be under even greater pressure to ensure that they recover the costs of providing local service. For consumers, the shift to cost-based or usage sensitive pricing could mean higher rates. Or, to be more precise, consumers will be forced to pay for the individual telephone services which they use.

In Maryland, for example, (Chesapeake and Potomac), a Bell operating company, justified its proposed increase in installation charges on precisely these grounds:

> "The Federal Communications Commission has ordered us to begin charging telephone installation and connection costs directly to expenses instead of borrowing money to pay for these costs...This is a tremendous change from the way we've been doing business for almost 100 years. It's the way our competitors conduct business, and how we must begin doing it from now on in order to survive in this new competitive environment."

C&P also proposed tariff revisions in the District of Columbia. Indeed, the proposed tariffs illustrate vividly the type of change represented by usage sensitive pricing[26].

In its filing, C&P emphasized that its proposed tariff was merely one more option for customers. The various types of flat rate charges now offered would continue to be available. Customers who elected the new pricing schedule, however, would be charged for local calls on the basis of distance, duration, and time of day--the criteria now used for long-distance service.

Under the proposed option, the Washington metropolitan area would be divided into four zones, moving out in concentric circles or bands from the District of Columbia. Rates would increase with the number of bands crossed when placing a call. For example, a five-minute daytime call from one point in downtown Washington to another would cost 12 cents. However, it would cost 15 cents to place a call of the same duration to someone in the second band; 18 cents to someone in the third; and 21 cents to a party in the fourth band.

Critics of what Bell calls "measured service" claim that it will increase rates for the poor, elderly and handicapped--precisely those people who might be most dependent on the telephone. C&P argues, however, that measured service will be more economical than current flat rates for customers who do not use the telephone often, or who place most of their calls within a single band. More important, the proposed option for measured service is a direct result of FCC decisions encouraging competition in the telephone industry. As the Washington Post reported:

> "The effort to extend measured local service to customers here and elsewhere in the nation was triggered largely by the competition that the giant Bell System now faces. In the past, company policy was to keep local service charges low by subsidizing them with long distance rates...Because of deregulation, Bell has begun adjusting long distance charges to compete with other companies like MCI and Western Union for long-distance customers. That has led to the Bell campaign to reprice other services."

For example, C&P recently raised telephone installation charges from $25.90 to $32.40 for Washington, D.C. customers. In response to the detariffing of terminal equipment mandated by Computer Inquiry II, the company also has separated charges for the telephone instrument from its wires; thus, a Washington customer who wants service for one residential telephone line with unlimited local calls is charged $8.18 per month. C&P charges an additional 80 cents for leasing the telephone instrument.

GLOSSARY

Maximal Network Size
- The largest possible size of the network
- The number of subscribers if there were no charge for subscription (zero entry fee)
- The potential market
- All potential subscribers

Equilibrium Network Size
- The ultimate actual size of the network
- All actual subscribers in a fully mature service
- The number of subscribers, Q, at the intersection of the demand and supply curves

Critical Mass
- The network size (number of actual subscribers) needed to assure that the network will grow spontaneously to its equilibrium size
- The initial coalition of potential subscribers needed to make it worthwhile for anyone to actually subscribe

Potential Usage
- Maximum volume of network traffic
- Traffic volume, assuming that both usage and subscription are free (i.e., at maximal network size, with a flat rate tariff

Realizable Potential Usage
- Traffic volume, assuming that usage is free, but subscription is not (i.e., at equilibrium network size, with a flat rate tariff)

Actual Usage
- Traffic volume actually obtained for a given price structure at equilibrium network size

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Net Revenue	- Profit before taxes (supplier surplus)
Consumer Surplus	- The "windfall" gained by all those subscribers willing to pay more than they are charged - Total subscriber benefit (willingness to pay) minus total subscriber cost - Subscriber net benefit
Supplier Surplus	- Profit before taxes (net revenue) - Revenue accruing from a service minus the cost of providing it - Supplier net benefit
Total Surplus	- Consumer Surplus plus Supplier Surplus - Consumer Surplus plus profit before taxes - Combined net benefit to both consumers and providers - Social Surplus (total net benefit to society)
Willingness to Pay	- The amount of money a person would pay for the service if it were offered - The demand curve (subscriber demand as as a function of price) - The area under the demand curve for a given aggregate of subscribers

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