DEVELOPMENT OF A MODEL PLAN TO IMPLEMENT WIDE AREA EDUCATIONAL TELECOMMUNICATION NETWORKS FOR VOICE, VIDEO, AND DATA COMMUNICATION

By

MALCOM V. PHELPS

Bachelor of Arts
Oklahoma State University
Stillwater, Oklahoma
1977

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1982

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Thesis Approved:

Thesis Adviser

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

America is in the midst of a revolution in the way in which information is processed and communicated. The term 'Information Age' has been used by Naisbitt (1982), Brand (1986) and many others to describe the current historical period. The term 'Information Age' refers to the idea that new information technologies are dramatically altering many businesses, social institutions, and the ways in which people live and work within them. Both Naisbitt and Morgan (1982) point out that one effect of the information age upon the United States is that the economy is now based primarily upon services rather than manufacturing. The majority of American workers now labor in the information sector of the economy. The imperatives and the opportunities created by the information age are likely to transform education.

Generally, businesses have recognized and responded to the trend toward an information society. Although information technology projects are not always successful, the business community recognizes the inevitable needs of an information economy and expends substantial sums of money on the equipment necessary to remain competitive in the information age. Many businesses complain, however, that education is not providing the skilled workforce necessary to feed the labor needs of business (Naisbitt & Aburdene, 1985; United States Office of Technology Assessment [OTA], 1982). A lack of information technologies, or the misallocation of technological resources supporting education, may be factors which limit the capacity to educate

Americans for the twenty-first century. While most educational decision makers recognize the salient features of the information age, students in many schools have yet to benefit from the capabilities provided by the new educational and telecommunication technologies.

Informational and educational technologies, especially microcomputers, are having an impact upon education. Inexpensive microcomputers have only been available to educators since the mid-1970s yet numerous surveys and reports indicate that the majority of schools in America are now utilizing computers. Survey results reported in Electronic Learning (Bruder, 1989) indicate that virtually all K-12 schools used microcomputers for the 1988-89 school year. This compares with only 18.2 % in 1981-82. Further, despite funding shortages, over 90% of the responding state departments of education reported that schools in their state plan to either increase spending for educational technology hardware, software, and training, or hold expenditures constant.

Although many schools utilize computers and other information technologies, the computers and other information technologies generally found in schools do not represent state of the art technology (National Task Force on Educational Technology, 1986). In particular, schools often lack the communication capability which is representative of the information age (Scrogan, 1987). Further, they often lack the capability to utilize more than a small subset of the available information possible via advanced information technologies.

Brand (1987) describes research being done on advanced information technologies at the Massachusetts Institute of Technology (MIT) Media Laboratory, much of which is relevant to education. A central thesis of the advanced work being done there is that telecommunication equipment and services will be an essential component of the school and business of the future. Another concept central to the research of the MIT Media Laboratory is that all media--voice, video, print, and data--are merging into one super medium in such a way that the traditional distinctions between these media are no longer relevant (Brand, 1987). Many teachers, such as Hay (1984), and researchers such as Negroponte (cited in Brand, 1987), agree that computer and telecommunication technologies are converging. Pool (1983), in Technologies of Freedom, uses the phrase 'convergence of modes' to convey the concept that there is now little distinction among media as diverse as computers, television, and print. Effective planning and resource allocation is required to ensure that those information technologies deemed appropriate to education will be available in school settings and will be utilized effectively (Perelman, 1987).

The need for enhancements to information technology resources, especially the telecommunication infrastructure, available to schools has been recognized at a variety of levels. Numerous federal, state, regional, or local projects utilizing telecommunication strategies in school settings have been implemented or are in the planning stages.

However, costs for the development and implementation of telecommunication projects can be great and some feel that federal, state, or regional partnerships are necessary to implement these projects. Even worse, the substantial financial resources expended on telecommunications can be wasted when unwise investments result in obsolete technologies which eventually have to be replaced with even greater expenditures. According to Morgan (1982), the costs associated with many of the technological developments now possible in education are so great that federal or state assistance is necessary. Several states have provided or begun to provide such assistance and guidance for the development of telecommunication programs in their states (e.g. Benning, 1983; California State Department of Education, 1986; Chion-Kenney, 1984; New York State Education Department, 1985; Oregon Ed-Net Committee, 1988; Romaniuk, 1982). Regional school cooperatives are often formed to provide a structure for innovations in telecommunications (Kitchen, 1987).

There are many different ways in which telecommunication systems can be used in education. Many schools utilize some form of teleconferencing as described by Olgren and Parker (1983). Teleconferences involve interaction via an electronic medium between two or more groups, or three or more individuals, in locations which are remote from each other. Teleconferences may be computer, video, or audio. Telecommunications can also be utilized for electronic mail (Pollard & Holznagel, 1984; Vallee, 1984). Related to a computer teleconference, electronic mail allows an individual to send messages to one or more other individuals at a time by storing the message on a central computer system. Telecommunications can also be utilized for database access. Data to be accessed from the database via the network is almost unlimited; computer programs, teacher lesson plans, statistical data, and reference materials all can be stored and retrieved from a database via a telecommunications system.

Generally, telecommunication systems provide three capabilities; the systems communicate voice, video, and data (Brand, 1987). Each of these, as well as the many combinations of voice, video, and data communications, has different technical requirements and the telecommunication media differ in capacity to carry information. Therefore, some network media are more suited for certain communication requirements than are others. As Brand (1987) states, "The (frequency) bandwidth bottleneck is the eternal bugaboo of communications technology: it governs the amount of data a medium can transmit per second" (p. 67).

There are several commonly cited advantages accruing from the implementation of telecommunication projects in education. These will be elaborated upon elsewhere in this study but are briefly as follows:

(1) Equity--equal access to educational resources regardless of geography, population, or other local conditions which may otherwise limit access by schools to instructional courses, information, or other learning resources.

(2) Information access--improved access to data, information, or subject matter experts.

(3) Interaction--the ability to interact with the instructor in distance education situations.

(4) Continuing education--enhanced professional development and inservice opportunities for staff, faculty, and administrators.

(5) Partnerships--increased school/community partnerships.

(6) Cost savings--improve the cost-effectiveness of specialized courses in small or rural schools.

An example of the attention being given to providing assistance to schools in order to realize the potential of telecommunication networks in education is the Star Schools Program Assistance Act (United States Congress, 1987). This bill provides up to $100,000,000 over a five-year period (1988-1993) for the establishment of telecommunication partnerships that support distance education. The objectives of the program are to enable telecommunication partnerships to (a) develop, construct, and acquire facilities and equipment, (b) develop and acquire instructional programming, and (c) provide technical assistance. For fiscal year (FY) 1988, $20,000,000 was allocated and the Department of Education solicited project proposals for possible funding (United States Department of Education, 1988). Included among the networking media for which support could be sought was microwave, fiber optic, cable television, and satellite equipment capable of serving a wide geographic area. Four telecommunication projects were awarded Star Schools funding on September 1, 1988 (Garnette & Withrow, 1989). These four projects represented a diversity of approaches to distance education technology and organization. Three of the projects were satellite-based, with various options for interactivity, and one was a computer-based program. Withrow (1990) has suggested that the funded programs have proven successful and reported that new program proposals are being solicited for FY 1990.

The number of networking media for which support is provided in the Star Schools Program reflects the number and diversity of media utilized in the many telecommunication projects which have been implemented. These communication media include microwave, satellite, fiber optics, Instructional Television Fixed Services, cable television, switched telephone networks, packet switched networks, and value-added networks. However, as Brand (1987) reports, work at the Massachusetts Institute for Technology indicates that the choice of network media affects the information transmission characteristics of the networks based upon these media. Network media choices also affect the life of the system, for as Negroponte (cited in Brand, 1987) asserts, "all transmission will be digital" in the future (p. 19). Analog-based systems, which are incompatible with digital, may become obsolete for most communication traffic. On the other hand, common sense and accepted principles of program evaluation and planning, such as recommended by Posavac and Carey (1980), require that factors such as cost and existing telecommunication resources be considered when implementing a telecommunication program. Telecommunication transmission media selections have an effect upon cost, system life, network carrying capacity, and the ability to communicate with users of other networks.

This study will examine the technical, educational, and administrative issues relevant to the implementation of wide area telecommunication networks and will provide a guide for educational decision makers implementing such networks.

Statement of the Problem

Many educational decision makers have made, or will make in the near future, the commitment to implement telecommunication networks in the schools for which they are responsible. If successful and cost efficient networks are to be implemented, it is imperative that the relevant characteristics of the various telecommunications media be considered in the implementation decision. There is also a need to realistically be able to identify aspects of the existing telecommunication infrastructure which can be utilized in a proposed network. Finally, there are often unused technologies and sources of support for educational communications of which educators need to be aware.

Currently, information to guide the implementation of wide area telecommunication networks for education is unavailable from a single source and is not in a format which is useful to educators. The problem addressed in this study is the development of a model plan to guide the implementation of a wide area telecommunication network capable of providing voice, data, and video communication for educational applications in settings such as school cooperatives, regional education districts, or state education agencies.

Significance of the Study

Since the introduction of inexpensive microcomputers into the schools in the late 1970s, there has been a great deal of interest and research into the role of computers in the educational process. However, microcomputers represent only one aspect of the broader field of educational technology and the full impact of advanced educational technologies will be the result of the integration of technologies such as telecommunications, mass data storage, artificial intelligence, and optical data media (Brand, 1987; OTA, 1982; Pool, 1983).

Projects which implement telecommunication systems in education settings tend to select the transmission media based on factors other than those which will result in a successful and cost-effective system (Kalba and Savage, 1980; Perelman, 1987; Schramm, 1977) and they fail to utilize all available resources in implementing networks (Kitchen, 1987).

Posavac and Carey (1980), among others, describe principles for program evaluation and decision making useful in the process leading to an educational telecommunication system. Utilization of program evaluation principles will help ensure that decisions leading to the selection and implementation of telecommunication systems are based upon relevant factors and that resources available to support the communication system are utilized.

While many reports point to the need to utilize telecommunication systems in education, information regarding the components of successful systems is scattered. Further, much of the information regarding transmission media is technical in nature and published in other than educational sources. While it is possible for the educator to rely on vendors for information, the systems recommended by vendors may be based on factors other than the best interest of the school. This study is intended to identify the features of available transmission media which affect the successful implementation of an educational telecommunication system.

Purpose of the Study

The purpose of this study is to collect, summarize, and tabulate the relevant data regarding the characteristics of various wide area telecommunication network media and resources of support, and present these data in a manner useful to educators involved in the planning or implementation of a wide area telecommunication network. This study is intended to provide a model for educators to utilize in making sound decisions regarding the technical, financial, service, and administrative aspects of telecommunication media.

Limitations of the Study

Only factors and media relevant to the implementation of a wide area telecommunication network were considered in this study. Factors and media primarily pertinent only to local area networks were not considered.

Assumptions

It is assumed that the general concept of telecommunication-based distance education is an area of interest to educators and that a substantial number of educational projects which utilize telecommunication technologies are in the planning or early implementation phase.

Definitions

Following are operational definitions of key terms which are utilized in this study. A comprehensive glossary of educational telecommunication terms is provided in Appendix A.

Bandwidth: The range of frequencies, within given limits, that is allowable for transmission of a given signal; the difference between the highest and lowest frequencies in a band (Fitzgerald, 1984). The allowable frequencies are determined by technical, legal, and regulatory considerations (Gross, 1983).

Cable Television (CATV): Community television systems which utilize a combination of satellite downlinks, television antennas, and coaxial cable to provide television signals or computer data to home, schools, or other sites. CATV often provides educational access channels and is inherently interactive (Schamber, 1988).

Communication Satellite. An artificial satellite, which is usually in a geostationary orbit about the Earth, utilized for the communication of voice, video, and data information. Most communication satellites provide twenty-four full video channels with forty-eight audio channels and operate in either the C- (4-6 GHz) or Ku- (12-14 GHz) band (Gross, 1983).

Data. Units of binary computer signals which can be combined into useful information according to a particular format, such as the American Standard Code for Information Interchange (ASCII).

Dial-up Telephone Network. The public switched telephone network operated by AT&T, one of the seven Bell operating companies, or one of several competing commercial providers. The dial-up telephone network was designed for voice communication and is not generally acceptable for applications requiring a wide frequency band and/or high volume data rates (Fitzgerald, 1984).

Distance Education. Education in which the following three elements are present: (1) There is no face-to-face interaction between the student and teacher, (2) there is an organization which plans, coordinates, and supervises the instructional program, and (3) a technology-based delivery system is utilized (Batey & Cowell, 1986). Barker, Frisbie, and Patrick (1989) differentiate current distance education practices from traditional correspondence study by placing an emphasis on the use of new and emerging technologies which make live interaction possible.

Electronic Communications. A general term referring to the transmission and reception of information in analog or digital form over a telecommunication channel (Olgren & Parker, 1983).

Fiber Optics. A data transmission medium consisting of glass fibers which utilize laser light impulses to represent information. Fiber optics will be a common medium for telecommunications in the future. Fiber optic systems offer immense bandwidth, reliability, protection from outside interference, and extremely high data rates (OTA, 1989).

Gigahertz (GHz): The abbreviation for one-billion hertz (cycles per second). Used in reference to frequencies (OTA, 1989).

Information Technology. Communication systems such as direct broadcast satellite, two-way interactive cable, fiber optics, low-power broadcasting, computers and television (OTA, 1982).

Instructional Television Fixed Service (ITFS). A group of television channels in the ultra-high frequency range (3 GHz) which have been reserved for educational applications by the Federal Communications Commission [FCC] (OTA, 1989).

Local Area Networks. A data communication network spanning a limited geographical area, a few miles at most, but usually within one building or within a cluster of buildings (Fitzgerald, 1984).

Microwave. High frequency channels (4 GHz and higher) which can be utilized for the transmission of voice, video, or data signals. Microwave is a line-of-sight communication technology normally configured in a point-to-point network (OTA, 1989).

Modem. Abbreviation for modulator - demodulator; a device that modulates and demodulates a signal for transmission over a telecommunications channel (Fitzgerald, 1984). Usually required to communicate via computer on the dial-up telephone network.

Network. An interconnected set of devices capable of transmitting and receiving voice, video, data, or computer-graphic information over a communication circuit. The interconnections may be physical, such as copper wire, or non-physical, such as television signals, or a combination of these (Fitzgerald, 1984).

Synchronous and Asynchronous Communication. Synchronous communications refer to the simultaneous exchange of information, i.e. communication in real time. Asynchronous communications occur when the subjects communicate, i.e. read or write, at times independent of the other participants (Vallee, 1984).

Telecommunication. The use of wire, radio, optical, or other electro-magnetic channels to transmit or receive signals for voice, video, and data communications; communications over distance using electronic means (Olgren and Parker, 1983).

Teleconference. Two-way electronic communications between two or more groups, or three or more individuals, who are in separate locations

(Olgren and Parker, 1983). Teleconferences may employ voice, video, or data transmissions or any combination of these three.

Telecourse. A course of instruction which is provided via distance education utilizing a telecommunication system.

Wide Area Network. An electronic communications network designed to serve an area of hundreds or thousands of square miles. Public and private packet switching networks, the nationwide telephone network, and satellite networks are examples of wide area networks. In the context of this study, wide area networks refers to telecommunication networks linking two or more school districts on a regional or statewide basis.

CHAPTER II

REVIEW OF SELECTED LITERATURE

The purpose of this chapter is to review literature relevant to the implementation and utilization of telecommunication networks in education. An extended bibliography is provided in Appendix B for the reader's reference. The educational needs which can be served by telecommunication networks, appropriate applications of educational telecommunications, existing and proposed projects which utilize telecommunications for instruction, technical characteristics of network media, and project implementation strategies will be examined. Finally, the results of a comprehensive study of distance education in K-12 schools in the United States conducted by the United States Office of Technology Assessment will be reviewed. Substantial background material is provided to ensure that this rapidly changing and technical field is understood. The goal of this chapter is to provide the foundation for the development of a model for educational telecommunication system implementation. The discussion of topics will proceed according to the following outline.

The first section will review the literature related to selected educational needs. Special attention will be given to the needs of small and rural schools. The second section will identify applications of telecommunication technologies where the chances for successful program implementation are maximized. A review of existing or proposed telecommunication programs which have been implemented in elementary and secondary school settings will be given in the third section. The purpose of this review is to examine systems which have been implemented and learn from these experiences in implementing telecommunication systems. Exemplary distance education programs which represent the range of available organizational, funding, and technical options will be examined. Next, a brief summary of current and future telecommunication technologies will be presented. This summary will provide the reader with an overview of the relevant characteristics of the various network media. Other relevant features to be discussed include costs associated with a given medium, future viability, and implementation options, such as the establishment of business partnerships, grants, and contracts. A comprehensive, detailed analysis of telecommunication media is presented in Chapter Three. Such analysis will help ensure that successful and cost-effective projects are implemented. Linking for Learning (United States Office of Technology Assessment [OTA], 1989) will be reviewed in the next section. This comprehensive study of the current status of distance education in American elementary and secondary schools is reviewed separately because of the importance of its conclusions and the anticipated impact they will have on distance education practices. Finally, information and models which can be utilized as the basis for an implementation method for telecommunication systems will be examined.

The Need for Telecommunications in Education

Bond (1987) states a point consistent with common sense, program evaluation strategies, and the bulk of the professional literature; the educational needs of schools should drive the implementation of communication networks. Although as mentioned by Brand (1987), new technologies can often create both new needs and new opportunities, the mere availability of advanced communication technologies should generally not be the primary reason for expending financial resources on expensive technologies if less expensive, but equally effective, teaching methods exist.

The purpose of this section is to provide a rationale for a plan to implement telecommunication networks. This section will describe some of the general needs and challenges of education which can be uniquely met by telecommunication-based educational strategies. It will also detail other rationale cited in the literature in support of the implementation of telecommunication networks.

Within the last decade attention has been focused on perceived weaknesses in American education by reported declines in standardized achievement test scores, by articles and books intended for the general public, such as Megatrends by Naisbitt (1982), and by commissioned reports, such as A Nation at Risk (National Commission on Educational Reform, 1983). A follow-up report to A Nation at Risk prepared by Secretary of Education Bennett (1988) concludes that the American education system remains deficient in adequately challenging students. An implicit assumption in many of these reports is that schools are failing to meet the challenge of educating students for the needs of an information society. In particular, mathematics, science, and foreign languages have been cited as subjects in which student achievement needs to improve.

Many factors have been identified as contributing to the weaknesses in American education and a lack of resources is among the factors often cited. Resources in which schools are said to be deficient include funding, qualified instructors, advanced and specialized coursework, availability of support materials, and access to information. While the problem of providing these resources is certainly not a new phenomenon, the demands of the information society for a highly educated workforce make the provision of information resources more critical than ever before (Naisbitt & Aburdene, 1985). For rural and small schools, difficulties in making sufficient resources available is even more difficult than in other geographic areas (Holt, 1984).

The application of educational technologies has been identified as an effective method of supplementing, substituting for, or even, in certain cases, supplanting traditional methods of instruction and information access (e.g. National Task Force on Educational Technology, 1986; OTA, 1982). The National Task Force on Educational Technology report concluded that educational technologies have the potential to (a) improve the quality of learning, (b) increase equity of access to learning resources, especially in small or rural schools, and (c) ensure greater cost effectiveness.

Barker (1987) concluded that telecommunication networks provide (a) equity of educational opportunity, (b) access to subject matter experts, (c) interaction, (d) information access, (e) staff development and inservice opportunities, and (f) an increase in opportunities for school and community partnerships.

Clippinger and Fain (1980) conclude that advances in telecommunications provide (a) cost reductions, (b) greater cost effectiveness, (c) timely access to information resources, (d) improved outreach to underserved populations, (e) improved distribution of educational materials and programs, (f) improved administrative productivity, (g) savings derived from economies of scale, and (h) specialized services and courses.

In an analysis of needs and technology-based opportunities the New York State Department of Education (1985) recommended that a comprehensive, state-wide telecommunication system be planned and implemented. It was stated in the report that such a system would (a) enhance educational effectiveness, (b) improve efficiency in allocation of resources, and (c) provide a more equitable distribution system, especially to rural schools.

The California State Department of Education (1986) reached similar conclusions and, like New York, recommended a wide area telecommunication system for the state and emphasized the need for long range planning for such a system.

A summary of the educational needs identified in the professional literature which can potentially be met by wide area telecommunication networks can be summarized as follows. There is a consensus among educational technology professionals regarding these potential advantages of educational telecommunication networks:

1. **Equity**. Telecommunication-based distance education has the potential to provide equal opportunities for access to learning resources without regard to barriers imposed by rural isolation, inadequate reference material, or lack of coursework.

2. **Information access**. Access to remote computer databases and other sources of information can be accomplished efficiently via telecommunication networks.

3. **Access to experts**. Specialists, experts, prominent professionals, and, more generally, anyone who would otherwise be unable to communicate with students and teachers can utilize telecommunication networks to reach the target audience.

4. **Interaction**. The utilization of telecommunication networks allows the audience to interact with the presenter. In most other methods of distance education, such as correspondence study, timely interaction is not possible.

5. **Timely access.** Telecommunication networks allow access to computer-based and other information in a shorter time frame than might be possible via other methods.

6. **Pupil or teacher shortages.** Schools, especially rural schools, are often faced with either a shortage of teachers qualified to teach specialized classes or with a lack of a sufficient number of students to make certain courses economically feasible. A communication network can provide the infrastructure necessary to make possible the sharing of these resources among several schools.

7. **Professional development.** It is difficult to maintain currency in many teaching areas, especially in rapidly changing subjects such as science and social studies. Telecommunication networks can provide a medium which can be utilized for the continuing education of faculty.

8. **Cost reduction.** Costs for educating a given number of students can sometimes be reduced and reductions in the cost of administrative activities can occur via the use of telecommunications.

9. **Cost effectiveness.** Cost effectiveness is normally considered in the context of comparing the cost of attaining a particular outcome, such as providing a course of study, to the number of units, such as the number of students taking a course. Since telecommunications allows an instructor to teach a larger number of students, the system can be more cost effective.

10. **Educating the workforce.** A telecommunication network allows educators to reach nonresident learners, such as those in business and industry.

As educators and others have recognized the opportunities offered by educational technologies and, specifically, telecommunication networks, federal, state, and private funds are increasingly being made available for project implementation. As this funding becomes available, Benson and Hirschen (1987) caution that adequate network planning is critical. Many networks are not based upon a sound model of network implementation but upon engineering developments (Carey & Moss, 1984).

Institutions are also expending significant percentages of their operating budgets on telecommunication technology. The Chronicle of Higher Education ("Video and Audio", 1986) reported that 80% of the schools surveyed indicate that they expect expenditures for video equipment, programs, and materials and personnel to either remain constant or increase.

In a survey conducted by Electronic Learning (Bruder, 1989) of each state technology coordinator in the United States, it was found that 38 states (76%) are operating or developing distance education projects at the elementary and secondary school level. Thirty-two states (64%) are starting electronic bulletin boards of some type and 21 states fund the operation of a state system to gather educational data electronically. Bruder states that, "the number one 'trend' that states spent funds on is telecommunications (43 [86%] respondents), followed closely by distance learning (42 [84%] respondents)" (1989, p. 27).

In a Delphi study of educational experts, Combs (1985) found consensus with the proposition that there is either a certain or a high probability that in the next 20 years there will be an emphasis on electronic information storage and retrieval as well as on what Combs referred to as electronic libraries. The experts surveyed by Combs also predicted that the physical barriers of the school building will diminish with a greater reliance on telecommunications.

In summary, there are many advantages to the implementation of telecommunication networks as well as indications that networking will continue to grow in importance as an educational strategy. However, the advantages of representative of the many approaches and technologies which are being utilized. Most of the programs listed below are elementary and secondary implementations although a few are higher education or business projects which are applicable to elementary and secondary education.

There are numerous programs which have been implemented utilizing telecommunications for education. From a state perspective, according to a survey conducted by Electronic Learning (Bruder, 1989b), 38 of the 46 responding state departments of education plan to fund the operation or development of distance learning projects utilizing telecommunications. Seventy percent of the states have plans to fund state-wide electronic bulletin boards for interschool communications. Twenty percent of the respondents said that they intend to fund new distance education projects. Forty-two percent of the states have implemented projects to gather administrative data electronically.

Hezel (1987) conducted a detailed survey of all 50 states in an investigation of educational telecommunications. He found that state-wide planning for telecommunications varied greatly from no state-based planning to detailed and comprehensive plans to implement state-wide educational telecommunications systems. There were even states which were reported to have implemented extensive systems and then found it necessary to substantially restructure. Brown, Kahn, and Zauderer (1987), in a report for the U. S. Office of Technology Assessment listing major educational technology trends, cited "telecommunications ... being incorporated into ... educational technology applications" among their list of trends (p. 68).

Selected distance education programs are summarized in Table 1, which is designed to illustrate the range of telecommunication media, types of coursework, funding sources, and network configurations which are being used in distance education programs.

Table 1

Salient Features of Selected Distance Education Programs

Program	Primary Telecommunication Medium	Type of Coursework	Primary Source of Funding	Network Configuration
CNN Newsroom	Cable television (CATV); lesson plans via E-mail	Enrichment	Corporate funding; basic CATV subscription	Point-to-multipoint
Educational Satellite Network (ESN)	Satellite, C-band, clear	Credit & enrichment	Membership & subscription	Point-to-multipoint
Jason Project	Satellite, C-band, scrambled	Enrichment	Grants	Point-to-multipoint
Learn Alaska	Satellite, C-band, clear	Credit & enrichment	State funding	Point-to-multipoint
National Aeronautics & Space Administration	Satellite, C-band, clear	Staff development for teachers	Government agency	Point-to-multipoint
National Geographic Kidnet	Computer	Enrichment	Subscription	Multipoint-to-multipoint
National Technological University	Satellite	College credit	Tuition & funding from corporate sponsors	Point-to-multipoint
Oklahoma State University	Satellite, C-band, clear	Credit & staff development	Subscription	Point-to-multipoint
Panhandle Share-Ed Video Network	Hybrid: fiber optic & satellite, C-band, clear	Credit	Grant from private enterprise & subscription	Multipoint-to-multipoint & point-to-multipoint

Table 1 (continued)

Program	Primary Telecommunication Medium	Type of Coursework	Primary Source of Funding	Network Configuration
Prince George's County, MD School System	CATV	Credit, enrichment, staff development	Internal	Multipoint (limited)-to-multipoint
Project Circuit	CATV	Credit	State grant	Multipoint-to-multipoint
Sibley County Cooperative	CATV & Facsimile	Credit	State grant	Multipoint-to-multipoint
TI-IN Network	Satellite, Ku-band, scrambled	Credit	Membership & subscription	Point-to-multipoint
Whittle Educational Network	Satellite, Ku-band, clear	Enrichment, staff development	Advertising	Point-to-multipoint

CNN Newsroom

Turner Broadcasting's Cable News Network (CNN) initiated CNN Newsroom in 1990 (Turner Educational Services, undated). CNN Newsroom is a cable-delivered, 15-minute current events and features program designed to be utilized for student enrichment. Each program consists of a review of the day's featured current events with a special report on topics such as business or science. The program is delivered at night and designed to be videotaped by the teacher for use in class the next day. No commercials are shown during the 15-minute program. Lesson plans with additional information about the program are distributed each day via a commercial electronic mail (E-mail) service. For participating schools, the cost of CNN Newsroom is the basic cable rate plus the on-line charges for the E-mail service.

Educational Satellite Network (ESN)

Gardner (1989) has described the Educational Satellite Network (ESN) which is a service of the Missouri School Boards Association and is based in Columbia, Missouri. ESN serves its schools primarily by functioning as a broker of programming obtained from other sources. In addition, ESN sells or leases and maintains the satellite receiving systems which are utilized at member schools in the ESN network. Schools in Missouri participate in ESN through membership fees. The membership fee may be for programming services only, or may include the cost of the sale or lease of a satellite receiving system.

In summary, ESN serves several roles. These roles include brokering group purchases of programming, production of staff development programs in conjunction with the Missouri Department of Elementary and Secondary Education, and the sale/lease of satellite receiving systems. Funding for the services is derived from membership fees. Satellite receiving systems are dual-band and satellite transmission is C-band.

Jason Project

The Jason Project is an example of a satellite-based science enrichment program series for students. In the Jason Project, live satellite transmissions originate from a site where scientific exploration is being conducted. In the pilot program, Jason (a research submarine) explored the sunken ship, Titanic, in the Atlantic Ocean. Through a fiber optic cable from Jason, video transmissions from the shipwreck were transmitted to the mother ship and then via an international satellite to the United States where the signal was retransmitted to a communication satellite. Students were allowed to view the exploration activity as it occurred and were also able to question and interact with the researchers. One noteworthy feature of the Jason Project is that the participating students participate at local museums rather than at school.

Funding for the Jason Project comes from a variety of sources but the educational component is primarily supported by the National Geographic Society. Future projects will involve explorations in other areas, including Lake Ontario.

Learn/Alaska

The Learn/Alaska network has a long and well-documented history described in several sources including the Alaska State Department of Education (1982) and Benning (1983). The Learn/Alaska program dates back to early experiments begun with the Advanced Technology Satellite-Six (ATS-6).

The ATS-6 satellite was designed to demonstrate new communication services as detailed by the National Aeronautics and Space Administration ([NASA], 1983) in Our First Quarter Century of Achievement. Among the new communications services was a demonstration of the potential of satellite systems for improving education for persons living in remote and isolated areas through the use of inexpensive ground receiving stations. Experiments in education utilizing ATS-6 were conducted in several locations (NASA, 1975). In addition to experiments for the Alaska Office of Education, successful satellite education projects were conducted for the Rocky Mountain Educational Television system, the Appalachian Regional Commission, and the Satellite Instructional Television Experiment (SITE) for India. ATS-6 ceased operation in 1979 after exceeding its design life by three years.

The end of the ATS-6 satellite experiment forced Learn/Alaska to utilize a variety of different network media and eventually to reevaluate its educational telecommunications network, as related by Willis (1987). Publications from the Alaska State Department of Education (1982a, 1982b) indicate that the new system is based more on computer networking and data transmission rather than satellite video communications after analysis found data communications to be most effective in meeting the educational needs of Alaskans.

National Aeronautics and Space Administration (NASA)

NASA has produced the "Educational Satellite Videoconference Series for Teachers" since 1987. Four 90-minute staff development programs for teachers are produced each school year on topics related to the research and activities of the space program. Each videoconference includes the following segments: (a) A presentation is given on a NASA program by a NASA scientist, (b) a science teacher demonstrates activities in aerospace education, (c) opportunities to interact with all presenters are provided via toll-free telephone lines, (d) print materials are distributed to each participating school, and (e) an update on current news items, such as space exploration missions, is provided. Approximately 900 schools throughout the U.S. participated in each program during the 1989-90 school year. Teachers may participate live or they may videotape the program for later viewing.

There is no cost to the school for participation in the NASA programming. Funding is provided by NASA as part of its educational efforts.

National Geographic Kidnet

Kidnet is a program sponsored by the National Geographic Society and the National Science Foundation (NSF) and operated by the Technical Education Research Center (TERC). Kidnet is a project which allows students to utilize telecommunication technologies to share data, experiment results, and other information (Tinker, 1987). Students collect data for science experiments at their school and then transmit these data to a computer located at TERC. The students' schools provide the computers and modems, the telephone network is utilized, and TERC provides the central computer and network software.

In summary, Kidnet is a computer-based program designed to enrich the school curriculum. Computers and modems are utilized and the transmission channel may be either one of the packet switched networks (e.g. Telenet) or the public switched telephone network (PSTN). Funding is derived from subscription fees paid by participating schools.

National Technological University (NTU)

The National Technological University (NTU) delivers coursework and grants Master of Science degrees in several engineering fields (National Technological University, 1989). Courses are developed, taught, and produced by a consortium of 29 higher education institutions. NTU was developed to meet the need to provide working engineers opportunities to pursue advanced degrees. An organization of advanced technology companies, including AT&T, IBM, General Electric, Eastman-Kodak, Digital, and Hewlett-Packard initiated and continue to support the concept.

NTU courses are delivered through a network of local site coordinators who check out course videotapes to students, administer examinations, and perform other administrative functions. NTU classes are produced at one of the 29 member institutions. The videotape of the class is then shipped to the NTU headquarters in Fort Collins, CO. From there, the class is transmitted via satellite and videotaped at each of the sites where a student is enrolled in the course. Students check out the tapes from the site coordinator for the initial viewing and subsequent review sessions. Credit for courses is awarded by the producing institution and each course counts toward the NTU degree program. Short-courses and non-credit, professional development seminars are also transmitted over the NTU system. NTU has transmitted approximately 7,000 hours of academic courses for credit and 1,000 hours of non-credit continuing education courses, all via satellite (Fahey, 1989).

NTU estimates that 9,000 students have taken NTU courses and 40,000 persons have participated in seminars. Seven degrees in engineering disciplines are offered. The estimated cost savings in travel and lost work time is $32,000,000.

Several factors contribute to the success of the NTU approach: (a) The employers of the students taking the courses recognize the importance of the classes to the company and therefore support NTU, (b) students are allowed to use work time to pursue classwork, (c) tuition and fees are paid by the sponsoring corporation, and (d) the information taught is perceived by both the student and the sponsoring corporation as being timely and important to the student's job performance.

Oklahoma State University

The Arts and Sciences Teleconferencing Service (ASTS), described by Holt (1989), is based at Oklahoma State University (OSU). ASTS utilizes satellite technology to deliver credit and enrichment courses to Junior High and High School students nationwide. The on-camera teachers for the ASTS courses are faculty members in the OSU College of Arts & Sciences and do not necessarily hold K-12 teaching certificates. Courses are taught two or three days per week and the remainder of the class periods are spent working at the local school on computer software and other study materials under the supervision of a local teacher, referred to as the Teaching Partner.

Nine courses are to be taught by ASTS for the 1990-91 school year. These include Advanced Placement (AP) Calculus, AP Physics, German I, German II, Russian, Basic English and Reading, AP American Government, Applied Economics, and AP Chemistry.

Oklahoma State University is also a recipient, in association with a five-state consortium, of a Star Schools grant. The grant allowed OSU to (a) expand the number of participating schools by providing those schools with satellite receiving equipment, (b) upgrade its production equipment, and (c) add new student and staff development courses.

In summary, ASTS is a university-based programmer which produces satellite-based credit courses for students in grades 7-12. The basic network configuration is point-to-multipoint. Interaction is one-way video, two-way audio utilizing the public switched telephone network. Subjects taught include advanced mathematics, science, and foreign languages. ASTS is supported by course subscriptions paid by receiving schools. Satellite transmissions are C-band. Receiving systems are purchased by the schools and may be either C-band or dual-band.

Panhandle Share-Ed Video Network

The Oklahoma Panhandle Share-Ed Video Network, also known as the Beaver County, OK Interactive Television Cooperative (Interactive Television Cooperative, undated) actually consists of two parallel systems. First, the five school systems in Beaver County which are members of the cooperative receive satellite programming from OSU/ASTS and other program providers. Second, a fiber optic network connects each of the five schools in the Beaver County cooperative. Thus, distance education provides both internally and externally originated programming.

Prince George's County, MD School System

The interactive television and cable television system in the Prince George's County (P. G. County), Maryland schools provides a cable television connection to each of the more than 100 school buildings in the district (Schiller, 1989). P. G. County has the capability of using one channel on the system to make either satellite or locally produced programming available to all school buildings. Additionally, a two-channel, two-way interactive cable television network connects six high schools, allowing them to share various advanced placement or upper level courses as well as professional development sessions for faculty.

Project CIRCUIT

Project CIRCUIT, according to Hagon (1986) and Hartz (1983), is utilized in six rural schools in Wisconsin. The system utilizes eight channels on the cable television network and a microwave network to connect the cities in order to enhance course offerings in these schools with relatively low enrollments.

Funding for the system is both internal and external; a cooperative was formed to share system costs among the schools involved and supplemental funding was obtained with a $512,000 grant from the Kellogg Foundation and a federal Title IV-C grant.

Sibley County Cooperative

Czech (1989) describes the use of a cable television system to link four schools in Sibley County, Minnesota. In addition, the Sibley County system makes an innovative use of facsimile equipment to supplement the video instruction delivered through cable. In the system, the facsimile signals are transmitted using a portion of the video frequency within the cable, which eliminates the need and expense of telephone lines. The system startup costs were funded by a $150,000 grant from the state of Minnesota.

TI-IN Network

The TI-IN Network, described by Batey and Cowell (1986) and others, is one of four major organizations which provide instructional programs to schools via satellite. Programming produced by TI-IN includes credit courses for secondary school students, enrichment programming for students, staff development classes for teachers and other school personnel, and support programs. Student credit courses include foreign languages (e.g., French, German, Latin, Spanish), mathematics (e.g., Algebra, Calculus, Trigonometry), science (e.g., Astronomy, Physics), and other courses (e.g., Art, Computer Science, Psychology, Sociology). Staff development classes include over 230 hours of programming.

A school participates with TI-IN through a membership in the TI-IN Network and the payment of subscription fees for courses. Membership in the organization includes the installation of a satellite receiving system and the right to receive staff development programming. Student credit courses require a subscription fee in addition to the regular TI-IN membership fee.

TI-IN, through a subsidiary organization known as the TI-IN United Star Network, was awarded an approximately $10 million dollar grant for the 1988-90 period from the U.S. Department of Education's Star Schools grant program to enhance the TI-IN network and programming.

Whittle Education Network (WEN)

The Whittle Education Network (WEN) was initiated in 1990 (Whittle Education Network, undated). WEN is an educational service operated by private enterprise. WEN programming is delivered via satellite and includes the following three educational services: (a) Channel One, a 12-minute current events program which includes a total of two minutes of commercial advertising; (b) the Classroom Channel, which provides enrichment programming for students; and (c) the Educator's Channel, which provides professional development programs for teachers (Bruder, 1989b).

WEN grants the satellite receiving system to participating schools in exchange for the school's assurance that the majority of the student body will view Channel One each day. The basic satellite receiving system granted by WEN is a Ku-band, fixed antenna system but, with local funds, it can be upgraded by the school to a dual-band (C/Ku), steerable configuration. Upgrading allows the school to receive a greater number of programs since both C-band and Ku-band programming from more than one satellite can be received.

The WEN has created controversy in the educational community (Moore, 1989, November 6). The main source of the controversy stems from the use of paid commercial advertising to support the service. At least two states, California and New York, have issued regulations prohibiting instructional time from being used for participation in the WEN.

Telecommunication Network Media

The following section will provide a brief overview of the telecommunication media utilized in educational networks. A more detailed analysis of these media is provided in Chapter III.

General Characteristics of Telecommunication Media

The most important technical feature of transmission media is bandwidth, according to Brand (1987). As stated in Chapter One of this study, bandwidth refers to the number of continuous frequencies within specified limits that are allowable for transmission of a given signal. The allowable frequencies are determined by technical, legal, and regulatory factors (Gross, 1983). Pool (1983) shows that bandwidth restrictions are primarily legal/regulatory, not technical. Bandwidth is important because it determines the rate at which information can be transmitted through the network. The ability of a transmission medium to communicate can be limited due to restrictions imposed on bandwidth. For example, Fitzgerald (1984) describes the technical features of the public dial-up telephone network. Phone lines have a bandwidth of only 4,000 hertz. While this bandwidth is adequate for audio-only transmission, data rates on the telephone network are limited to 2,400 bits per second using current technologies. Full motion video transmissions, which require far more bandwidth than is available on the telephone network, are impossible.

The educator should remember that few of the technologies or services used in educational telecommunication systems were developed primarily for education. Schramm (1977) states that media (e.g. radio, television, computers, and telecommunications) are utilized on a continuum of applications ranging from entertainment to information and on to education, as illustrated in Figure 2.

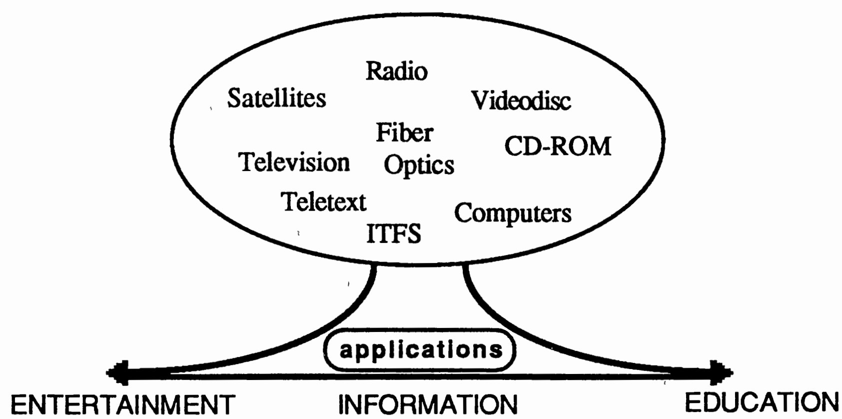

Figure 2. Continuum of applications of communications media (Based upon information in Schramm, 1977).

Many private businesses are now entering the educational market with telecommunication and other educational technologies developed primarily for entertainment or business information applications. These businesses, such as Whittle Communications, Cable News Network (CNN), and the Discovery Channel, have identified a market for their products within the educational community. It is imperative that educators be proactive in identifying useful technologies and guiding the agenda of business in implementing educational technologies. If properly manipulated, the need of business to expand the size of its application market can be used to the advantage of schools and students.

Instructional Television Fixed Service (ITFS)

A major problem with the utilization of ITFS involves regulatory uncertainty, as discussed by Ross (1985). Ross describes the history of ITFS and notes that ITFS frequency allocations have been historically underutilized by educators. Curtis (1979), an early proponent of the use of ITFS, compared ITFS to several other media, including satellite and cable television, and concluded that ITFS was the most efficient and cost effective for most educational applications. A ruling by the Federal Communications Commission (FCC) allowing licensees to lease unused broadcast time for commercial applications resulted in a rush of applications for ITFS licenses. From 1983 to 1986 ITFS applications increased from 626 to 2,240 (Curtis, Stamble, & Ritholz, 1985). Many of these applicants utilized the license to broadcast entertainment rather than educational programming (Woods, Stevenson, & Volkov, 1985). Although Nelson (1985) and the Minnesota Department of Education (1986), among others, have shown that many educators are effectively utilizing ITFS frequencies for instruction, regulatory uncertainty and licensing stipulations ensure that a great deal of work on the part of the educator will be necessary to utilize ITFS frequency bands for education. In fact, Lewis (1983) notes that ITFS, a frequency band reserved by the FCC, may not even be available in the future.

Microwave

Microwave systems are open-air broadcast systems. Microwave networks transmit on various frequencies, ranging from 1 to 23 GHz. There must be a line-of-sight path between each antenna in a microwave network. Generally, the distance between each antenna is from 5 to 30 miles depending upon transmitting power, geography, antenna size, and receiver sensitivity.

Fiber Optics

Brand (1987) has identified some of the advantages and disadvantages of fiber optic transmission. Advantages include multipoint-to-multipoint communications, increased bandwidth compared to other wideband media, resistance to electromagnetic interference, immunity to weather and other atmospheric disruptions, reliability, low noise, and stable availability. Disadvantages include a lack of existing networks, high installation costs, and high infrastructure costs. For rural schools, the most significant problem can be the high costs for last mile installation. That is, since the cost of the trunk line is shared by many users, the cost per mile is relatively low, while the cost per mile increases as population density decreases.

Optical fiber is increasingly replacing other transmission media in the telephone network. Verchot (1985) predicts that the annual growth rate for fiber optic installation will be ten percent or greater for each of the next ten years. Fiber optics allow the transmission of up to 2,000 simultaneous telephone calls and data rates as high as 140 million bits per second (Fitzgerald, 1987). One pound of optical fiber can transmit up to 80 times as much data as an equivalent weight of coaxial cable (Gross, 1983). Brand (1987) states that these capacities will increase with advances in digital data compression and forward error correction. Forward error correction techniques allow data to be transmitted at extremely high data rates since errors which result from these high speeds can be detected and corrected without the need to retransmit the data. Fiber optic strands are especially well suited for point-to-point communications, as compared to satellite communication.

Satellite Communication

Satellite communication can prove to be a risky venture. Even though most educational institutions typically do not launch or own communication satellites, expensive risks are accepted in satellite operations. Losses in satellite operations are inevitably passed on to users. For example, Mordoff and Lenorovitz (1988) report on a communication satellite known as TVSat 1 which was to have been used by the West German government for education and entertainment. Loss of the satellite due to a jammed solar panel resulted in a loss of 230 million dollars, less than half of which was insured.

The cost of satellite communication can be expected to increase in the future according to an analysis by Lowndes (1987). The cost to lease or rent a satellite transponder is currently relatively low due to an overcapacity of satellite space. However, because all of the C-band orbital slots, and most of the Ku-band slots, have been taken, projected increases in satellite utilization by corporate and public users will result in demand exceeding supply during the 1990s. As described by Schertler (1986), new satellites, frequency bands, and satellite communication techniques, such as those utilized for the National Aeronautics and Space Administration's Advanced Communications Technology Satellite (ACTS), are currently in the research phase and are not expected to ease the demand on current satellite service within the next ten years.

Dial-up Telephone Network

Clearly the most ubiquitous telecommunications network is the dial-up telephone network. Nearly every home, business, and school in America has access to the telephone network. The problem with the telephone network for providers of distance education courses is that the amount of information which can be transmitted is restricted due to the relatively narrow bandwidth of the media. The result is that the telephone network is well-suited for its intended purpose of transmitting voice information. However, data rates are limited to a maximum of approximately 2,400 bits per second and video transmission is essentially impossible. The efforts of the telephone companies to install and implement fiber optic circuits which have an almost unlimited data rate will help but there will still be a constriction at the point of connection between the school and the fiber optic network.

Cable Television (CATV)

A survey reported in the Chronicle of Higher Education ("Video and Audio Technologies", 1986) showed that cable television is available as a communication resource in 47% of the higher education institutions contacted. This compares with 23% for satellite reception capability, 2% for satellite transmission capability, and 6% for Instructional Television Fixed Service.

Federal Study of Distance Education

The United States Office of Technology Assessment (OTA) has recently released the most comprehensive study of educational telecommunications and distance education available to date. Because of the importance of this study and its anticipated impact upon the field of distance education, the findings of the report, entitled Linking for Learning: A New Course For Education (United States Office of Technology Assessment [OTA], 1989), which are relevant to this study will be summarized as follows.

After completing its study of distance education, OTA reached the following major conclusions:

1. The utilization of distance education has increased dramatically and continues to grow. However, many areas of the country, especially rural areas, still do not have access to the required resources and telecommunications infrastructure.

2. New telecommunication technologies, such as satellites, Instructional Television Fixed Service (ITFS), microwave, cable, and fiber optics can create powerful educational telecommunication networks. However, **no one technology or network system works equally well for all applications.**

3. Distance education appears to be as effective as face-to-face instruction in the classroom.

4. Teachers require training, preparation, and institutional support to successfully teach with distance education technologies. Educational telecommunication networks also provide opportunities to faculty for professional development and continuing education. Teachers have many

legitimate concerns regarding the process of distance education and its impact upon the teaching profession.

5. State education agencies can both facilitate and hinder the development of distance education programs through regulatory policies and accreditation requirements. State leadership is critical for facilitating the efficient utilization of resources to meet educational needs.

6. Federal and state regulations play a major role in distance education development activities by guiding the development of the educational telecommunications infrastructure and the services which may be offered . The education community should attempt to influence federal and state policies and regulations.

7. Federal funding for distance education has been modest but important. The congressionally mandated Star Schools grant program, which is administered by the U. S. Department of Education, is the major source of direct federal support for distance education. Approximately $35 million has been awarded to four national distance education programs and approximately $15 million for three to five new projects is planned for the 1990 fiscal year. Other major sources of federal support for distance education include funding for infrastructure available from the National Telecommunications Information Administration (Department of Commerce) and the Rural Electrification Administration. Federal agencies, such as NASA, develop distance education programming and contribute in other indirect ways.

OTA found that new organizational structures are being created for the purpose of facilitating the delivery of distance education. These structures include local education agencies (LEAs), state education agencies (SEAs), the federal government, and private enterprises. These new organizations can potentially affect the way that educational services are delivered. It is certain that traditional borders between school districts and states will be altered in response to the changing needs of education. As stated by OTA, "Connections now being established across geographic, instructional, and institutional boundaries provide opportunities for collaboration and resource sharing among many groups for the coming years" (OTA, 1989, p. 26). Of special note, new providers of educational programming for the K-12 community include higher education (e.g. OSU ASTS), private enterprise (e.g. TI-IN Network and Whittle Education Network), and federal government (e.g. NASA).

OTA found that the following four factors will most affect the future of distance education:

1. **Telecommunication policy**. Policies at the federal and state levels will affect all aspects of distance education including, (a) costs, (b) transmission and programming capacity, (c) availability of infrastructure and transmission circuits, and (d) the choices available to educators of different approaches to distance education.

2. **Research, evaluation, and dissemination**. While most researchers agree that distance education is effective, more sophisticated research is now needed. For example, specific instructional approaches should be evaluated and the most cost effective technologies and administrative structures identified.

3. **Support for teachers**. OTA found that teachers need support and training both in how to use distance education programs in their classes and in how to teach via telecommunications. Additionally, OTA notes that educational telecommunications can be an important factor in professional development and continuing education for faculty.

4. **Expansion of the infrastructure**. Both the federal and state governments may have a role in the development of the telecommunications

infrastructure necessary to provide distance education opportunities. Some states, such as Kentucky, Oregon, and Missouri, have already implemented funding plans for educational telecommunications.

Guidelines for the Implementation of Educational Telecommunication Networks

Schramm's (1977) model for the selection of educational media provides a useful starting point for an examination of the literature in search of guidelines for implementing educational telecommunications networks. He cautions that media implementations are too often based upon factors such as (a) ease of availability of the medium, (b) prestige, (c) control issues, or (d) political considerations. However, the recommended course is to base the media implementation on a carefully and logically considered analysis of local needs, situations, resources, and guidelines. Schramm proposes that media implementations be based upon three decision vectors: (a) task, (b) media selection, and (c) cost.

1. **Task Vector**. The task vector is primarily an educational consideration composed of a thorough evaluation of three areas: (a) educational needs and potential benefits, (b) student needs and characteristics, and (c) priorities for action.

2. **Media Selection Vector**. The selection of media should consider (a) the effectiveness of the medium based on the best evidence available, (b) the availability of the technology, and (c) the requirements that the selection of a particular technology will have upon the organization which must use and support the technology.

3. **Cost Vector**. Analyzing the costs of media implementations will consider money, technology, and personnel. Schramm identifies (a) resources, (b) costs, and the (c) economic evaluation of alternate approaches, as being cost-related factors to consider.

Clippinger and Fain (1980) identify four areas in which costs must be estimated and assessed. These are (a) fixed costs, (b) variable costs, (c) recurrent costs, and (d) capital costs. These costs can be spread over what the authors say are four implementation phases. The implementation phases are as follows: (a) project start-up and installation, (b) trial operation of the projects for a designated time period, (c) demonstration of the project, and (d) institutionalization of the project. Clippinger and Fain note that the institutionalization of the program is critical to its long term success.

Kalba and Savage (1980) conducted an extensive study of telecommunication projects funded by the Department of Health, Education and Welfare (DHEW). They reported variations in the extent to which these telecommunication projects had been institutionalized within the system and identified several barriers to technology innovation. In general, the authors stated that an innovation may be considered to be institutionalized when it becomes a routine activity in both the original project site and in other sites. The innovation barriers included:

1. Technologies which were not well established and highly reproducible. Kalba and Savage found that schools which attempted to utilize technologies which were advanced to the point that few personnel had experience with the technology were generally not successful. Programs tended to be more successful when stable, reliable, and proven technologies were utilized.

2. There must be a strong industrial system for commercialization. Technologies for which there is no commercial market where manufacturers and developers can recover costs are often not viable and/or will be expensive to the implementer.

3. There should be no major regulatory or institutional barriers. Technologies which are dependent upon critical regulatory decisions (e. g. Instructional Television Fixed Service [ITFS]) may encounter barriers to implementation. Likewise, an instructional program which has no accreditation or certification mandate can be assured of implementation impediments.

Kalba and Savage list some indicators which may be utilized to identify a telecommunication project which has been successfully institutionalized. These indicators are: (a) the project is now a formal program with its own line item budget, (b) the project has continued after key personnel have left the project, (c) key personnel have been promoted or otherwise rewarded for their work on the project, and (d) the project has been accepted or adapted for use by other agencies.

Kalba and Savage's study highlights the importance of selecting transmission media. They found that successful projects utilized stable technologies, such as wideband cable and microwave, while unsuccessful projects tended to utilize less well-developed technologies such as satellites, which had not been extensively used at the time of the study.

Costs for technological innovations can be evaluated by comparing absolute cost outlays to effectiveness in meeting established needs. Therefore, a technology program can be, (a) high cost/low effectiveness, (b) high cost/high effectiveness, (c) low cost/low effectiveness, or (d) low cost/high effectiveness. It is easy to reject category (a), high cost/low effectiveness, and most people agree that a program in category (d), low cost/high effectiveness, is ideal.

However, category (b), high cost/high effectiveness, within which most telecommunication projects can be said to fall, cannot be analyzed sufficiently according to cost analysis techniques but must be judged according to value judgements (Perelman, 1987).

Kaye and Rumble (1981) developed a model for the implementation and operation of distance education programs. Although Kaye and Rumble's model is based upon their work with adult students learning from a print-based distance education format (i. e. correspondence study), their model is instructive for this study. Kaye and Rumble recommend that distance education be evaluated from a systems analysis perspective. From this perspective, they identify four subsystems of distance education:

1. **The course subsystem**. In the course subsystem, distance education programs of study are designed, produced, and distributed. Course design also implies the definition of a need for the course and approval from the regulatory body to offer the course. The production of the course may be accomplished by a content specialist, a content specialist working in conjunction with an editor, a content specialist working with a transformer, an instructional design team, or a course team. The transformer role serves the varied functions of educational technologist, media producer, and editor. The instructional design team is composed of several people including a content expert, an educational technologist, a curriculum/instructional designer, and a writer. The course team is similar to the instructional design team but relies more on group consensus among the various team members.

2. **The student subsystem**. The student subsystem includes all those services primarily designed to provide support to the learner, such as counseling, tutoring, and assessment/grading.

3. **The regulatory subsystem**. This subsystem relates to the governing bodies of the relevant agencies which set course standards and assessment criteria. In the United States the regulatory subsystem is normally centered on the local school board or state government.

4. **The logistical subsystem**. The logistical subsystem ensures that adequate resources, such as supplies, equipment, and transmission circuits, are available and maintained .

In the view of Kaye and Rumble (1981), by "analyzing distance-education projects into these four subsystems--courses, students, regulatory, and logistical--it is possible to gain valuable insights into the criteria both for adopting distance-learning solutions and for deciding on the particular form a given solution might take" (p. 22). Albright (1988) bases his framework for the design of satellite-based distance education classes on the work of Kaye and Rumble.

Kaye and Rumble (1981) have also developed a set of steps to follow in determining the need for, and format of, a distance education program. These steps are shown in Figure 3.

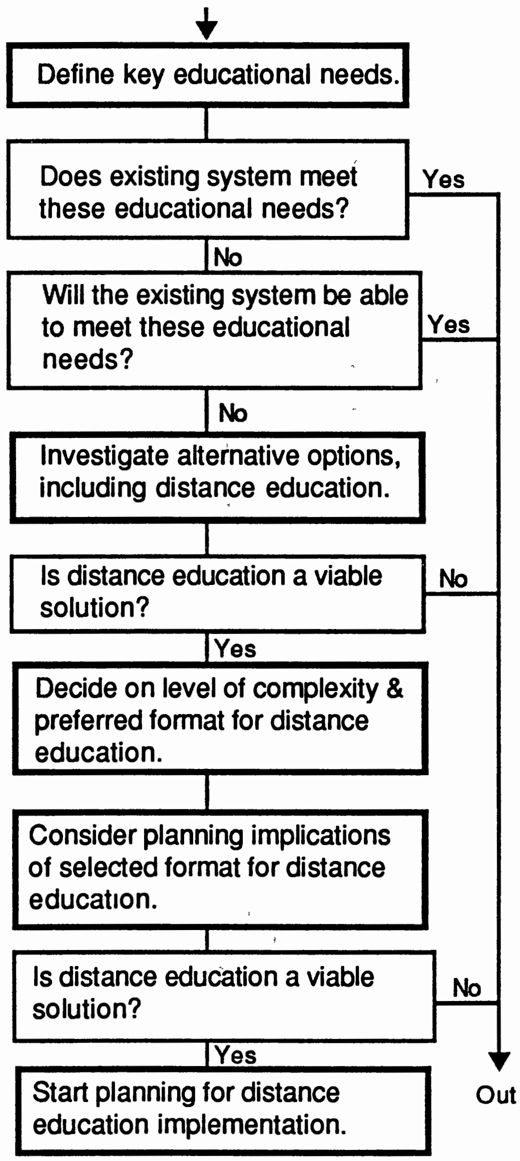

Figure 3. Decision steps in evaluating the need to implement a distance education program (Adapted from Kaye & Rumble, 1981).

In each of the decision steps in Kaye and Rumble's (1981) model, the four distance education subsystems (course, student, regulatory, and logistical) should each be considered. The point to be made is that the decision to implement a distance education program, the technologies to be used, and the format of the program should each be carefully considered without predetermined solutions. As Rumble (1986) states, the implementation, technology, and format decisions are too often decided by political or administrative fiat. In Rumble's words, "All too often ... those charged with setting up a distance education system are not given the choice to recommend against it" (p. 87).

The systems approach to the implementation of data communications networks, developed by Fitzgerald (1984), although specifically designed for businesses, is equally useful for educational networks. Fitzgerald emphasizes the need to keep the requirements of the users of the network in mind, as they are crucial to the success of the system. "The key ingredient for success lies in planning based on the 'system's interface with the users' " (Fitzgerald, 1984, p. 293). Fitzgerald recommends the following 13 steps:

1. **Conduct a feasibility study**. The primary purpose of the feasibility study is to determine whether network planning should proceed or if alternative solutions can be implemented. Another purpose is to define the problem clearly and put it in writing. Fitzgerald states that it is sometimes possible to eliminate this step since various factors, such as a clear and compelling requirement for a network, may dictate that network planning proceed.

2. **Prepare a plan**. The plan should be one which considers three factors: (a) technical feasibility, (b) operational feasibility, and (c) economic feasibility.

3. **Understand the current system**. The purpose of this step is to understand in detail all aspects of the organization. In the case of a school, this might include an analysis of courses offered or regulatory requirements. It

would also include an examination of any existing telecommunication resources.

4. **Design the network.** The purpose of this step is to develop a prioritized list of the general system requirements.

5. **Identify the geographic scope of the network.** Identification of the geographic scope is important to network design. For example, a network which must reach a large geographic area may benefit from a satellite-based solution, while a network within a city may be able to utilize the cable television.

6. **Analyze the messages.** This step is specific to the implementation of a data network. Within a data network, it is useful to understand the size and characteristics of data files and other transmissions which will be sent.

7. **Determine circuit loading.** The purpose of determining the circuit loading is to identify the number of telecommunication channels which will be required.

8. **Develop a control matrix.** The control matrix is a listing of possible threats to the network from such factors as vandalism, equipment malfunctions, or theft. Security and control issues are addressed in the control matrix.

9. **Develop network configurations.** This step is primarily relevant to wired networks, such as a cable television system. The purpose is to organize the stations and associated switching computers on the network as efficiently and cheaply as possible.

10. **Consider software.** Software components, such as interactive video programs or electronic mail systems, are selected in this step.

11. **Consider hardware**. At this stage, equipment specifications are established and vendors are selected.

12. **Perform a cost analysis**. The three major categories of costs which must be considered are: (a) implementation costs for hardware, software, and similar acquisitions; (b) investment costs for software to run on the system; and (c) operational costs for the network, such as satellite time.

13. **Sell and implement the network**. Finally, the key personnel, such as administrators, faculty, school board, and parents must be convinced that the network will be successful and they must be committed to it.

Steele (1984) developed a model for a satellite network for a national organization. Steele's model incorporates six phases which can be described as follows:

1. **Prepare a plan**. The purpose of this plan is to identify key sources of information and to organize working groups for activities which follow. The goals, objectives, and philosophy which will guide the network and its operations should be established. A unique feature of Steele's model is the recommendation to organize for both internal and external network planning. Internal planning is conducted utilizing personnel within the organization while external planning is conducted by outside consultants. In subsequent phases, the best features of the reports and recommendations of each planning group are merged into a single plan.

2. **Analyze the situation**. Both the internal and external working groups analyze needs of the organization and identify existing telecommunication resources. The purpose of phase two is to develop an information database to support network planning. Such a database would include an analysis of existing telecommunication infrastructure components.

3. **Develop alternatives**. Each of the working groups identify all possible ways in which the plan developed in phase one can be implemented in a manner consistent with the constraints and opportunities identified in phase two.

4. **Select a plan**. Utilizing the information and recommendations of the two working groups, the decision makers at the school select the most feasible implementation plan from among the various alternatives. It is often desirable for the decision makers to select the best features of the proposed plans.

5. **Implement the plan**.

6. **Evaluate the plan**. Evaluation of the plan should be ongoing and formative.

Blythe (1986) describes four factors which should be considered in the analysis of a proposed network. First, the implementer should consider the applications for which the network will be utilized. Voice, video, and data transmissions have different network requirements. Second, geography needs to be considered. Population density, topography, and climate will all have an impact upon the network. Current and projected needs, as well as the required system lifespan, form a third consideration. Finally, costs of the proposed network need to be compared to available resources.

Hirschen (1987), in a document published by the New York State Department of Education for the planning of a state telecommunication system, identified a list of components to be considered in a technical feasibility analysis. These components include an analysis of the following: (a) existing telecommunication systems, (b) relevant legal and regulatory mandates, (c) current and future technologies which might be appropriately applied to current or future needs, (d) compatibility of the planned system with respect to existing networks, and (e) other technologies which can be utilized as alternatives to a telecommunication system. System design should include a consideration of (a) transmission technology, (b) interactive capacity, (c) operator requirements, and (d) hardware and software requirements.

Kitchen, Pellant, and Lloyd (1987) have developed guidelines for the implementation of telecommunication projects. The guidelines include the following:

1. **Conduct a thorough needs assessment.**

2. **Plan the curriculum.** In distance learning projects, faculty, courseware, and certification will require special attention.

3. **Conduct a technical feasibility study.** The purpose is to assess the availability of extant and future telecommunication capacities. Technical, legal/regulatory, compatibility, and operational issues all must be considered.

4. **Prepare a network design plan.** The plan must consider the (a) transmission technology, (b) technologies to be installed at school sites, (c) hardware and software requirements, (d) operator requirements, and (5) interactive capabilities.

5. **Identify human and fiscal resources.** These resources may be currently available or may have to be obtained.

6. **Plan for staff development in the operation and use of the network.** Staff development should include both support and instructional personnel.

7. **Prepare an evaluation plan.**

Kitchen and Kitchen (1988) have also developed a process approach to telecommunications development. They state, "The most successful projects are those with concrete, specific, and pragmatic plans that first address the instructional and organizational needs the system is intended to serve; technological concepts are of secondary importance" (p. 49). Kitchen and Kitchen (1988) recommend planning for three components: (a) technical, (b) educational, and (c) financial.

Funding is a major consideration when planning a network. Perelman (1987) identifies a major problem to consider when implementing an educational telecommunication system. He calls the problem the "add-on syndrome", referring to the fact that technology innovations are typically funded via soft money, such as grants. Thus the innovation is simply added on to the existing system without altering the organization significantly. Often when the funding is reduced or eliminated, the technology innovation is reduced or eliminated concomitantly. The National Task Force on Educational Technology (1986) identified the add-on syndrome as being a major barrier to the successful implementation of technological innovations.

Many argue in favor of an expanded role by federal and state government to fund and initiate technology innovations such as telecommunication systems. Morgan (1982), for example, stated that the costs and technological requirements are so great that federal or state intervention is required. Hezel (1987) concludes that the state department of education is one of the most effective agencies in the government of most states to place responsibility for educational telecommunications. Hezel cites the following reasons for recommending control within state education departments: (a) they tend to focus on equity issues and are not as likely as other governmental agencies to give preference to certain constituencies over others, (b) they have technical resources such as experts in educational telecommunications, and (c) they are on a relatively equal standing with schools and are not as likely to be perceived as interfering with school business.

Others agree that schools need help in implementing telecommunication networks but advocate the formation of educational cooperatives and partnerships between private enterprise and the schools. Kitchen (1987), for example, has demonstrated through several implementation sites that partnerships between school cooperatives and local telephone companies is feasible.

Bond (1987) has published a guide for educators, Telecommunications-based Distance Learning: A Guide for Local Educators. She identifies three key lessons derived from experience with communication networks which should be integrated into plans for network implementation. These include the following:

1. **Interaction**. Interaction between the instructor and the learner is critical to the success of distance learning programs. According to Bond, effective interaction stimulates the interest of the learner and reinforces instruction. It should be noted that Tinker (1987) has extended this concept to include interaction among learners in addition to interaction between instructor and learner, a concept demonstrated in implementations such as described in Tinker, as well as in Katz, McSwinney, and Stroud (1987). Douglas and Bransford (1990) have stated that interaction is the most essential and critical element in a successful distance education program.

2. **Flexibility**. Adequate access to the communication resources must be provided for both faculty and students. Technology should be both available to use when needed and easy to use. Also, adequate training in the utilization of the resources must be provided.

3. **Programming**. In the words of Bond (1987), "technology is only as effective as the programs or materials that it presents" (p. 4). Bond identifies the development of sufficient quantity of high-quality programming as being the most critical requirement for a successful system. Providing this programming

can also be the most difficult requirement but if adequate distance education programming is available it can justify the expenditure of funds for technologies to provide interaction and flexibility.

Bond proposes the following strategic steps which she recommends for the planning phase of the implementation of an educational telecommunication system.

1. Clearly identify curricular and instructional needs for expansion. Often these needs will be consistent with those of neighboring districts which may allow for the kind of resource sharing recommended by Kitchen, Pellant, and Lloyd (1987).

2. Identify administrative needs which can be facilitated through telecommunications and integrate these needs into the educational planning.

3. Assess the potential of existing telecommunication resources such as educational television networks, cable television, fiber optic cable installed by the local telephone company, or satellite communications.

4. Ensure that the lessons, resources, and recommendations documented in the professional literature are incorporated into planning. These materials can help ensure that the most effective telecommunication method is selected.

5. Identify those teachers who are willing and able to participate as teachers or in a support role in the distance education program. The experience of the Open University of South Florida (1987) shows that major problems can result when instructors are used in a distance education program who are not committed to the teaching method, such as one based upon distance education.

6. Assemble a team representing expertise in the following areas: (a) legal--to ensure that regulatory requirements are met, especially if licensing

from the Federal Communications Commission will be required; (b) engineering--to design the system, advise on technical matters, and perform a cost analysis; (c) financial--to research funding opportunities and apply for grants; (d) instructional design--to ensure that educational objectives and teaching strategies are compatible with the technology and specific distance education techniques; and (e) teacher training--to provide local faculty and staff with the skills necessary to operate the system and perform simple maintenance.

Bransford (1988) describes some of the variables which influence the process of technology adoption in education. He states that, "the issues that inhibit adoption of technology are essentially economic and political" (p. 431). The implication is that financial and political support are as important to network viability as other factors.

Bransford goes on to list major independent and dependent variables in technology adoption. Independent variables include (a) **cost**--the technology must be perceived as affordable; (b) **adaptability**--the organization must be able to adapt the technology, which was most likely developed for commercial applications, to educational requirements; (c) **competition**--technologies must be viable in relation to competing technologies; (d) **reliability**--the network must work reliably and be relatively easy to repair when malfunctions occur; and (e) **obsolescence**--the rapid pace of technological change makes outmoded equipment inevitable. Dependent variables include (a) **commitment**--the institution must consider the technology to be important enough to make a long term commitment, (b) **politics**--political support helps ensure legislative support and funding, (c) **advocacy**--a person to serve as an advocate helps ensure adoption, (d) **attitude**--positive attitudes within all user groups is essential, (e) **resources**--both hardware and software resources must be available, (f) **time**--release time for faculty and staff to learn about and support the network is necessary, (g) **training**--personnel will be prepared and have positive attitudes if adequate training is provided, and (h) **integration**--the network cannot be considered an adjunct but must be integral to the school system.

Dede (1989) has prepared a useful list of planning guidelines for the implementation of emerging instructional technologies which is especially relevant to network implementation. Generally, Dede states telecommunications implementations in schools will be based upon (a) the power of technology development and the decline in cost, (b) workplace changes due to technological advances and market competition, (c) the resources available to schools to train teachers and to purchase equipment and software, and (d) the resistance of educators to a modification of their professional roles and organizational structures. The author recommends that technology implementation decisions be made by a team of educators and technology specialists. The team should be selected to include both advocates of the technology and skeptics. Dede's planning suggestions are as follows:

1. Determine why the technology is wanted prior to acquisition, i. e. conduct an adequate needs analysis.

2. The technology should actually be available, not just in the development stage.

3. Do not be the first to utilize a technology since there are usually hidden costs associated.

4. Equipment should be tested for compatibility with existing systems.

5. No one technology or vendor is best for all situations.

6. Software development is usually more difficult, time-consuming, and expensive than expected.

7. Evaluate and select vendors carefully while negotiating the most favorable purchase terms possible.

8. Innovations require a critical mass--enough users to make the technology viable--in order to be successful.

9. Startup costs are only one component of total costs; other components will include software, training, supplies, upgrades, and maintenance.

10. Institutions will change in response to technology innovations, although the change is usually slower to occur than anticipated.

11. Availability of the technology in the school is usually less than anticipated, since its presence usually causes increased usage over expectations.

12. Never taking risks by investing in new technologies guarantees failure.

The reasons for the failure of many information technology projects has been described by Gayeski (1989) after an analysis of technologies, such as instructional television, which failed to reach expectations for success. Reasons for failure include a (a) fear of technology, (b) lack of human interaction, (c) disruption of the organizational status quo, (d) lack of planning, (e) unreliable technology, (f) presence of cheaper alternatives which work well, (g) lack of local control, and (h) absence of standardization. She recommends that a broad-based planning and design group be involved in all phases of the implementation. Additionally, Gayeski recommends that technologies be utilized which have reached standardization and that the implementation be locally controlled.

Rogers (cited in Harris, 1989) describes six factors which influence the diffusion of technology. These factors are: (a) **perceived advantage**--the technology must be viewed as having a distinct advantage over current technologies or methods of instruction, (b) **compatibility**--the technology must be compatible with existing systems and practices, (c) **complexity**--the system must not be too difficult to use, (d) **trialability** [sic]--it is helpful if the technology can be introduced gradually to allow a trial implementation, (e) **observable benefits**--the benefits which result from the innovation should be manifest, and (f) **re-invention**--technologies which can be most successfully implemented and diffused within the school are those for which the users can invent new uses which suits their purposes and needs.

The National School Boards Association and Jostens Learning Corporation ([NSBA & Jostens], 1989) have developed a set of policy planning guidelines for educational technology which have relevance to the planning and implementation of distance education networks. The authors recommend the following steps as critical to successful policy development related to educational technology:

1. Identify the need for new and revised policies regarding technology planning.

2. Establish priorities for dealing with critical issues such as funding, teacher relations, and equipment access.

3. Gather information from a variety of external and internal sources.

4. Study the problem (related to educational technology), consider alternative solutions, and decide on the general purpose, position, and key points of policy.

5. Focus on areas of consensus and draft a policy statement.

6. Communicate with key persons and groups affected by the policy or who will have to implement the policy to seek their input to the draft policy; revise the policy as needed.

7. Formally present the revised policy to the school board meeting and receive comments; revise the policy as needed.

8. Adopt the policy and inform the staff and public. Document the policy as needed and train faculty.

9. Implement the policy, evaluate its impact, and revise as needed.

NSBA and Jostens state that , "The key to successfully integrating educational technology is to balance planning efforts and action. While planning may reduce the possibility of failure or waste, it can also stifle innovation, creativity, and risk-taking" (p. 40). Therefore, as Perelman (1987) suggests, reliance on policy that results in an impediment to the implementation of innovations such as those created by educational technologies actually reduce the opportunity for successful implementation. The point both authors make is that the purpose of planning for distance education is not to eliminate risk but to reduce the risk of failure to an acceptable level.

Planning guidelines recommended by the NSBA and Jostens (1989) include the following:

1. Identify educational needs which can be solved via technology.

2. Obtain sufficient support of key faculty, staff, parent, and community leaders.

3. Develop goals and objectives which are realistic and practical.

4. Prioritize equipment needs.

5. Maintain perspective and be prepared for those either overly enthusiastic about the technology or overly critical.

6. Ensure that flexibility is maintained to adapt policy and plans to changing circumstances.

The National School Boards Association and U. S. West Communications ([NSBA & U.S. West] 1989) have produced a distance education planning document for school administrators. The NSBA and U. S. West document recommends a three-stage systematic approach to implementing educational telecommunications. The three stages are (a) vision, (b) policy, and (c) architecture.

The vision stage involves the identification of educational needs and developing solutions to those needs. As stated by the NSBA and U. S. West (1989), "the place to start is with education, **not** with technology" (p. 2). Douglas and Bransford (1990) make a similar point by writing, in reference to technologies for distance education, "In planning for technology, educators must address concrete issues like partnerships, interconnectivity, financing, and training, but they must also convey a broader vision of how technology will transform education in a positive way" (p. 19). Thus, the culmination of the vision stage is the development of an educational plan which sets objectives for distance education and outlines a basic approach for achieving those objectives.

The policy stage develops an institutional mandate to achieve the plan prepared in the vision stage. The policy stage (a) determines and documents personnel responsibilities, (b) assures financial commitment and accountability, (c) coordinates resources, and (d) defines standards.

The architecture stage operationalizes the vision and policy by building the educational telecommunication networks. NSBA and U. S. West consider that the technologies selected for the program are critical to its ultimate success. "Decisions about the telecommunications project's architecture serve as a blueprint for planning a network that meets present and future needs ... " (NSBA & U. S. West, 1989, p. 8). The proposed educational telecommunications network should be evaluated in relation to considerations in each of four areas, (a) education, (b) organization, (c) technology, and (d) finance. Various telecommunication media will affect each of these areas in different ways. Solutions to course availability, cost, organizational requirements, and staff training vary substantially depending on the network architecture which is developed. Costs are both crucially important to long-term success and difficult to analyze according to the NSBA and U. S. West planning document. "The most difficult part of technology is its cost", but, " ... there are no simple formulas to help estimate the cost of a technology system" (NSBA, & U. S. West, 1989, p. 10). The authors do, however, provide a useful list of some of the variables which determine the cost. These variables are (a) the existing infrastructure, (b) business/education partnerships, (c) funding possibilities, (d) distance and topography, (e) leasing and ownership, and (f) system maintenance.

Ostendorf (1989) has developed a publication providing guidance on the implementation of distance education. She makes the following points:

1. Although there are many configurations of distance education, there is no one best model. Examples of these configurations range from two-way interactive television (multipoint-to-multipoint) to one-way television (point-to-point) with asynchronous interaction via electronic-mail. The specific configuration selected should be based upon the requirements of students and subject matter.

2. There are numerous telecommunications media available but no superior technology for all situations. Each system has pros and cons.

3. It is not necessary to produce and originate programming. The majority of schools participating in distance education acquire programs from third party sources; only a small number actually produce courses.

4. Do not proceed with a telecommunications project until a long term political and financial commitment has been obtained. It is imperative that key persons and groups (e.g. administrators, teacher organizations, parents,

school boards, and state education officials) are committed to and supportive of the program.

To summarize, although numerous experts have enumerated items to be considered in planning telecommunication networks, a comprehensive model for the development of a wide area telecommunication network for education has not been developed. Models which have been proposed have either been limited to a specific communication medium (e.g. Bond, 1987; Kitchen & Kitchen, 1988) or have been developed for a specific school or organization (e.g. Albright, 1988; Steele, 1984). The purpose of this study is to synthesize the results and recommendations of the previously described models into a model plan for the implementation of wide area educational telecommunication networks.

Summary

This chapter has reviewed the professional literature relevant to the implementation and utilization of telecommunication networks in education.

Several authors have listed the needs of schools which can potentially be met through the implementation of telecommunication networks and distance education strategies. These needs include (a) equity of educational opportunity for rural or isolated students; (b) information access through databases; (c) access to experts, such as scientists or prominent professionals; (d) interaction with remote teachers, students, experts, etc.; (e) timely access to information; (f) pupil shortages which make it difficult to justify some educational programs for the small number of students served; (g) teacher shortages, especially in high-demand subjects such as science, mathematics, and foreign languages; (h) professional development for faculty, staff, and administrators; (i) cost reduction; (j) cost effective programs; and (k) education of persons in the community who can utilize the system.

It was found that educational telecommunication networks can be utilized for (a) distance education, (b) teleconferencing, (c) data communications, and (d) electronic mail. Distance education, the predominant use of telecommunications, was defined as non-face to face instruction which is planned, coordinated, and supervised by a school. Distance education can be facilitated through telecommunications.

In evaluating the current status of activities in educational telecommunications, great interest was found in the educational community, ranging from local schools to the federal government. For example, Bruder (1989a) found that 83% of responding state departments of education fund the development or operation of distance education programs. Numerous operational distance education programs were found and selected exemplary programs were described. These programs were the (a) CNN Newsroom, (b) Educational Satellite Network [ESN], (c) Jason Project, (d) Learn Alaska, (e) National Aeronautics and Space Administration [NASA], (f) National Geographic Kidnet, (g) National Technological University [NTU], (h) Oklahoma State University, (i) Panhandle Share-Ed Video Network, (j) Prince George's County, MD School System, (k) Project Circuit, (l) TI-IN Network, and (m) Whittle Education Network. Telecommunication media used for these projects include cable television, C-band and Ku-band satellites, fiber optics, and computer networks. Coursework delivered includes enrichment, credit, and staff development. Funding comes from corporate partnerships, subscription fees, internal funds, state allocation funding, and federal grants. Network configurations include point-to-point, point-to-multipoint, and multipoint-to-multipoint.

A brief overview of telecommunication network media showed that satellites, Instructional Television Fixed Services (ITFS), fiber optics, microwave, and the dial-up telephone network are the media utilized in distance education systems. Each of these media have unique features which affect the design of the distance education system and its capabilities.

Linking for Learning: A New Course for Education (United State Office of Technology Assessment [OTA], 1989) is an important study of distance education and telecommunications. The report concludes that (a) distance education is a growing field, (b) many technologies are being used although no one technology is best, (c) distance education is as effective as face-to-face instruction, (d) there is a need for increased teacher training, (e) state education agencies both facilitate and hinder the growth of distance education, and (f) federal funding of educational telecommunications has been modest but important. OTA also concluded that the future of distance education will be affected by (a) federal and state telecommunications policies; (b) research, evaluation, and dissemination; (c) support and training for teachers; and (d) expansion of the telecommunication infrastructure.

Finally, numerous sets of guidelines for the implementation of educational telecommunication networks were identified. Although none of these was comprehensive or appropriate to the majority of educational settings, they serve as the basis of a model synthesizing their results.

CHAPTER III

ANALYSIS OF TELECOMMUNICATION MEDIA

Introduction

In its study of distance education, the United States Office of Technology Assessment ([OTA], 1989) reached the following conclusion:

> **Many technologies are being used to provide education over a distance.** Transmission systems include: satellite, fiber optics, Instructional Television Fixed Service (ITFS), microwave, the public telephone system, and coaxial cable. Any of these technologies can be interconnected to form "hybrid" systems. **No one technology is best for all situations and applications.** Different technologies have different capabilities and limitations, and effective implementation will depend on matching technological capabilities to educational needs [italics added]. (OTA, 1989, p. 53-54)

Further, OTA concluded that:

> In the most fundamental sense, what distance learning systems try to do is to connect the teacher with the student when physical face-to-face interaction is not possible. **Just as highways move vehicles or pipes carry water, telecommunications systems carry instruction, moving information instead of people.** How these systems affect the educational setting/instructional process depends on the types of technology used and their design [italics added].... Together

> these technologies affect how interaction takes place, what information resources are used, and how effective a distance learning system is likely to be. (OTA, 1989, p. 54)

Because the telecommunication technologies upon which the distance education system is built affect all aspects of the educational services which can be provided, a review of the salient features of the major media is needed. The purpose of this chapter is to analyze the telecommunication media which are currently being utilized to deliver distance education or which will be used in the future.

General Characteristics

Transmission of Information

Telecommunication networks transmit three basic types of information--voice (audio), video, and data. Computer graphic images are considered data rather than video.

Bandwidth is an important variable in determining the type of information which can be transmitted. A standard video signal requires the most bandwidth, and audio, the least. Data can be transmitted at a variety of rates depending on the available equipment and telecommunication channel. New technologies, such as data compression, allow video to be sent on a circuit with less than full bandwidth.

Table 2 summarizes the capacity of the telecommunication technologies which are discussed in this chapter to transmit voice, video, and data.

Table 2

Transmission Characteristics of

Selected Telecommunication Technologies

Telecommunication Technology	Voice	Video	Data
Satellite	* (simplex)	* (simplex)	
Fiber optics	* (duplex)	* (duplex)	* (duplex)
Instructional television fixed service (ITFS)	* (simplex)	* (simplex	
Microwave	* (simplex or duplex)	* (simplex or duplex)	* (simplex or duplex)
Cable television (CATV)	* (simplex)	* (simplex)	
Public switched telephone network (PSTN)	* (duplex)		* (duplex; limited rate)

Notes:

1. Duplex: A telecommunication channel over which it is possible to transmit and receive signals in two directions simultaneously (Fitzgerald, 1984).

2. Simplex: A telecommunications circuit over which signals can be either received or transmitted, but not both.

Interactivity

The ability of teachers and students to effectively interact differentiates current methods of distance education, which are facilitated by telecommunication systems, from correspondence-based education. However, some technologies are more suited to facilitate interaction than are others. Generally, two-way fiber optic systems, computer networks which use either the public switched telephone network (PSTN) or a packet switched network (PSN), a few cable television (CATV) systems, and very small aperture terminal (VSAT) networks provide full two-way interactivity. Satellite networks, the majority of CATV systems, and microwave configurations have limited interactive capabilities. In these types of networks interactivity occurs via audio telephone line.

Interaction may occur either synchronously or asynchronously (Mason & Kaye, 1989). Synchronous interaction occurs when the communication is happening in real time, i. e. simultaneously. Asynchronous communication is established when a computer is utilized to store messages for reading and response at a later, more convenient, time. Asynchronous communication is usually associated with electronic mail and computer bulletin boards. Asynchronous communication may be likened to correspondence study and it is similar in the sense that participants are not compelled to convene at a designated time and place to communicate. However, the "information float ... the amount of time that information spends in the communication channel" (Naisbitt, 1989, p. 23) is drastically reduced by the electronic media. From the time a message is sent until it is available for reading by the receiver is typically a matter of seconds in an electronic mail system.

Cost

Costs vary widely among different distance education technologies and projects and are difficult to estimate. "There are no simple formulas to help estimate the cost of a technology system. Each is unique--in design and cost"

(NSBA and U. S. West, 1988, p. 10). The technologies which are used, the organizational structures which are formed to share expenses, external funding possibilities, geographic isolation and topography, the existing infrastructure, maintenance, and variable usage costs are among the factors which ultimately affect cost.

Costs for telecommunication systems are dropping. Further, the increase in telecommunication infrastructure is making it possible to spread the cost of delivering distance education across a greater number of students to reduce the per pupil expenditure (Barker, Frisbie, & Patrick, 1989).

OTA (1989) identified the following major factors which affect the total cost of the educational telecommunications network:

1. **Instructional design**. For example, a design which requires intensive interaction may require a more expensive technology solution than one which can rely upon the limited interaction of the telephone network.

2. **Scope of the network**. The number of students, school buildings, and classrooms which must be connected complicate the network and have an impact upon its total cost.

3. **Existing infrastructure**. The telecommunications resources, such as equipment (e. g. satellite receiving system), services (e. g. cable television), and personnel (e. g. educational technology specialist) which are available may reduce the high startup costs.

4. **Partnerships**. Many times school systems can form cooperative agreements with other schools, regional education agencies, or businesses to share equipment, services, and personnel.

5. **Engineering requirements**. Rural isolation and rough terrain are examples of factors which can complicate engineering requirements and thereby increase costs.

6. **Financial arrangements**. In addition to partnerships, leasing of equipment or transmission channels can be used to reduce costs.

7. **Programming**. Schools will essentially have two options for the acquisition of programming: (a) obtain programming from an outside vendor, or (b) produce programming either in-house or in partnership with other schools. In most cases outside programming will require a subscription fee. For example, the annual subscription fee for Oklahoma State University high school courses is $2,900. In the case of in-house programs, significant production expenses will be required.

8. **Training**. Professional development and operational training will be necessary for all formats of distance education.

Table 3 summarizes estimated costs for the major components of selected telecommunication media.

Table 3

Approximated Costs of Telecommunication Media

Instructional television fixed service (ITFS)	Transmission tower, antenna, and system	$ 85,000 - 95,000
	Receiving system	$5,800 - 58,000
Satellite	Satellite transmitting system (STS)	$500,000 - 1,000,000
	C-band satellite transponder time	$200 - 500 (per hour)
	Ku-band satellite transponder time	$200 - 600 (per hour)
	C/Ku-band satellite receiving system (SRS)	$8,000

Table 3 (Continued)

Cable Television (CATV)	Coaxial cable installation	$18,000 - 25,000 per mile
	Transmission equipment	$6,000 - 9,500
Microwave	Transmission equipment	$40,000 - 65,000 (per channel)
	Antenna tower	$100,000 - 150,000
Public switched telephone network (PSTN)	Line installation	$100 (per line; varies widely)
	Audio bridge	$1,000 - 2,000 (per port)
	Audio bridge	$0.25 (per port, per minute)
	Access charges	(usage sensitive, vary widely)
Fiber optics	Cable installation	$1,500 (per school)
	Electronic components	$46,000 - 99,000

Note. Compiled from data in NSBA and U. S. West (1989) and OTA (1989).

Frequency Bandwidth

In an electromagnetic transmission system, the available bandwidth forces an upward limit upon the amount of information which can be transmitted per unit of time. Systems which operate within a relatively narrow bandwidth transmit at slow data rates while those which operate within a wide bandwidth can transmit much larger amounts of data in a given period of time.

Voice (audio), video, and computer data each have different transmission speed requirements. For example, the public switched telephone network (PSTN) has developed audio circuits which work well for voice-only traffic. These circuits have a bandwidth of approximately 3 KHz and are adequate for audio communication. However, the PSTN is less well suited for other applications. For data transmissions, maximum rates of only 1,200 bits per second are possible (although compression algorithms have effectively increased the maximum rate to 2,400). Whether this rate is fast enough to be acceptable is dependent upon the application. Regarding video requirements, 3 MHz is required to transmit an NTSC television signal. Therefore, it is technically impossible to transmit a television signal over the PSTN. Broadband networks using technologies such as CATV, fiber optics, or satellites are required.

Network Architecture

An important dimension of network technologies is the standard architecture. The architecture refers to the capability of each point on the network to (a) transmit, (b) receive, or (c) transmit and receive information. The standard terminology refers to networks of three types: (a) point-to-point, (b) point-to-multipoint, or (c) multipoint-to-multipoint.

In a point-to-point architecture the network media connects two, and only two, locations. Normally, each of these locations can both send and receive data to the other. Microwave systems illustrate the point-to-point architecture. In a microwave system, antennas at each location transmit or receive a high-frequency, highly focused signal. A distribution system to route the signal from the receiving antenna to the various school buildings must then be constructed.

In the point-to-multipoint architecture one location is the only point which can transmit information. All other locations on the network can receive but cannot transmit. The best example of a point-to-multipoint architecture is a satellite network. Because of the expense, equipment, and expertise required each satellite network has a single satellite transmitting system from which all programming originates. Receivers on the network can acquire the signal but cannot initiate a return signal. Interaction on a satellite network is normally handled through a supplementary audio-only telephone line.

The multipoint-to-multipoint architecture allows the greatest amount of interactivity. Each location on the network can send a transmission to any other location. The public switched telephone network illustrates the multipoint-to-multipoint architecture; each location with a telephone can establish a circuit with another location with a telephone.

Regulation

The Federal Communications Commission (FCC) is the primary regulatory authority regarding telecommunication networks. The FCC develops regulations designed to establish fair and equitable access to a restricted resource, the airwaves, through which satellite, radio, and television signals are transmitted. FCC rulings have a profound effect upon certain educational telecommunication technologies. ITFS, satellite, microwave, and broadcast television are especially affected by FCC decision-making.

Instructional Television Fixed Service (ITFS), which is a microwave frequency band, was originally set aside by the FCC for educational applications. FCC licensing is required to operate an ITFS system and approval can take up to two years. Thus, the school which seeks to install an

ITFS system must be prepared for a difficult licensing process. Additionally, many of the ITFS channels are being given to non-educational programmers, such as operators of cellular phone systems, making these frequencies impossible to obtain in many areas of the country.

Maintenance and Operation

Any technological system requires personnel and funds for maintenance and operation. When the system is to be utilized for full course delivery, as compared with supplementary or enrichment programming, there is a tremendous burden to ensure that the equipment is maintained, operated, and repaired in a proper and timely manner.

Life Expectancy and Expandability

New technological developments, an uncertain marketplace for those developments, and evolving regulatory issues make predictions about the future viability of telecommunication systems difficult. There are, however, some major trends and issues, as follows:

1. Digital transmission. There is a trend toward digital rather than analog systems. "Digital is a noise-free medium, and it can error-correct ... I can see no reason for anyone to work in the analog domain anymore--sound, film, video. All transmission will be digital" (Negroponte, quoted in Brand, 1987, p. 19). A major advantage, in addition to its resistance to distortion and noise, is the ability to manipulate the data. Utilizing a computer to manipulate data allows data compression, encryption, and enhancement.

2. Regulations. The 1983 judicial decision which split the American Telephone and Telegraph (AT&T) and the seven regional Bell operating

companies (BOCs) prevented AT&T and the BOCs from originating programming. Further, AT&T and the BOCs are prevented by the Cable Act of 1984 from originating video programming. These restrictions impede the ability of the BOCs from providing distance education services. If, however, these restrictions were relaxed and digital technologies such as ISDN (integrated services digital network) were implemented, AT&T and the BOCs could prove to be a major force in distance education, resulting in enhanced quality and options for school personnel.

Technologies

Satellite

Satellite communications has become the predominant medium for distance education involving full-bandwidth video transmitted to a wide area network. This is illustrated by the fact that three of the four Star Schools grantees were primarily satellite based.

Satellites function as relay stations, taking a video, audio, or data transmission sent from the Earth and rebroadcasting it back where it is received by an antenna and associated display equipment. For U. S. domestic communication satellites, the area on the Earth within which the satellite signal can be received, called the footprint, typically includes most of the continental United States. For this reason, satellite technology is especially appropriate for educational telecommunications applications in which the size of the audience needs to be maximized.

Satellite-based distance education programs are generally point-to-multipoint and one-way video, two-way audio. In most programs, a full video program is transmitted and the telephone network is utilized for audio interaction. Interaction is often supplemented through electronic mail, computer bulletin boards, print materials, and various combinations of local teaching faculty and computer-based media.

Currently, U. S. domestic communication satellites operate within two frequency bands. The majority perform within the C-band, the range of frequencies from two to four GHz. The Ku-band (12 - 14 GHz) is being utilized by the newer satellites and is preferred for many applications because low-cost, small receiving antennas can be utilized. C-band transmissions generally, (a) require larger receiving antennas than do Ku-band systems, and (b) are subject to interference from various electromagnetic sources, such as telephone company microwave facilities. Ku-band systems are vulnerable to interference from rain.

The satellite receiving system (SRS) required by the school in order to receive satellite signals consists of several major components including, (a) a satellite antenna, (b) an antenna mounting and tracking mechanism, (c) a receiver, (c) coaxial cable from the antenna to the building, (d) a distribution system [optional], (e) a television/monitor, and (f) a videocassette recorder [optional]. Total system costs range from $2,500 to $10,000 including installation; approximately $6,500 is a reasonable budget planning figure for an SRS.

There are several major equipment issues for the school to consider in planning the acquisition of a satellite receiving system. These include the following:

1. **Frequency band**. As noted above, both the C- and Ku-bands are used by major producers of distance education programming. Therefore, it is possible for the school to identify the program provider from which it will obtain courses and specify an SRS which is compatible with the provider's

transmissions. However, the school will be limited in program options and upgrading of equipment will be necessary if, (a) the programmer changes frequency bands, or (b) the school wishes to acquire programs from sources which operate in a different band. Since, a dual-band SRS can be installed for less than $500 in addition to a single-band system, it is advisable to install a dual-band system initially.

2. **Steerable mount.** A fixed SRS can be installed which is aimed at a single satellite and cannot be adjusted to other satellites. However, as with single-band systems, the school will be limited to programming available on that satellite. While a fixed system has the advantage of being highly reliable it unnecessarily limits the educator's options in selecting programming. Therefore, it is recommended that a steerable SRS be specified. Of the two types of steering mechanisms, azimuth/elevation and polar, the polar is the most automated and easy to use and is recommended.

3. **Satellite coverage.** There are a large number of satellites which may transmit educational programming. These satellites extend from roughly the east to the west coasts of the United States. To receive each of these satellites, it is essential that there be no physical impediments to the ability of the antenna to receive a signal. Examples of impediments might include buildings, trees, or signs. Additionally, there should be no interference from sources of electromagnetic radiation, such as microwave transmitters, telephone equipment, or high-voltage power lines. Careful planning and a site survey conducted by a qualified installer can usually locate a site on the school grounds which is free from both physical and EMR interference.

4. **Signal strength.** Various parts of the country are more ideally situated than are others for receiving an acceptable satellite signal. The site

survey can determine the size antenna which is needed for acceptable reception.

Appendix C provides a checklist of features which the school should consider and specify when purchasing an SRS.

A potential problem which should be considered is the possibility of a shortage of transponder space in the future. Due to the high costs associated with launching and operating a satellite there are relatively few launches occurring and, as satellites go out of service and are not replaced, the total availability of satellites and transponders becomes limited. Concomitantly, the number of users of satellites is increasing. These two factors, reduced supply and increased demand, are expected to result in major increases in the price of satellite time which will result in increased costs to schools participating in satellite programming.

A summary of the characteristics of satellite systems includes the following:

1. There is a large geographic area (i. e. footprint) within which the transmission signals can be received.

2. The reception equipment is relatively inexpensive while the transmission equipment is expensive.

3. There are a large number of channels and program providers available.

4. There is no licensing required for reception systems.

5. Satellite receiving systems are easy to use; no specially trained personnel are required.

6. Maintenance costs are low.

Fiber Optics

Fiber optic systems are a relatively new development, especially in education, having been introduced in the early 1980s (Organization for Economic Co-operation and Development [OECD],1988). Fiber optic cables consist of hair-thin glass strands through which laser light impulses are transmitted to represent information.

The information which is transmitted may be either analog or digital, although the trend is clearly toward digital (OTA, 1989). Digital transmission allows data compression and the multiplexing of several signals on one channel.

A summary of the salient characteristics of fiber optics includes the following:

1. Reliable operation.

2. Extremely high data rates.

3. Digital transmission capability; capable of voice, video, data, and audiographic communications.

4. Free of noise and distortion; unaffected by weather.

5. Expensive to install but the telephone companies are in the process of upgrading the public switched telephone networks with fiber optic circuits.

6. Difficult and expensive to repair if damaged.

7. Usually owned by one of the public switched telephone network companies and leased by the educational organization.

Fiber optic installation and availability has the potential to have a profound impact upon distance education. As previously stated, the public telephone network is generally unable to transmit information, such as video, which requires a wide band circuit. However, as the telephone companies continue to upgrade their networks with fiber optic cable the required bandwidth is becoming available. This creates opportunities for schools to form partnerships with the telephone company to gain access to telecommunication capacity and form networks with other schools to share educational programming. Typically, these distance education networks consist of three to five schools within the service area of a single telephone company. The resulting network is a multipoint-to-multipoint system providing full two-way voice, video, and data communications. For example, see the description of the Panhandle, OK Shar-ed Video Network (Interactive Television Cooperative, undated) in Chapter 2. The networks which schools operate based on fiber optics are usually closed systems. In other words, all programming which is communicated among the schools on the network must be produced by one of the schools since there is no way to feed programming from alternative providers.

Instructional Television Fixed Service

The instructional television fixed service (ITFS) is a band of microwave frequencies in the 2.5 GHz band which were reserved for educational programming by the FCC. Currently there are 20 channels assigned to ITFS. According to OTA (1989), "In 1983, there were 88 ITFS systems operating 644 channels; in 1989, that figure rose to 745 licenses to operate 2,358 channels. In the last year, applications have increased dramatically, with more and more applications coming from rural areas" (p. 62). Clearly, ITFS is useful for educational telecommunications as shown by these growth trends, However, the 745 systems cited by OTA still reach only a small fraction of the total number of school districts. A national network, based on ITFS and modeled on the Public Broadcasting Service (PBS) network, has been proposed by Curtis, Stamble, and Ritholz (1985) but little progress has been accomplished toward the creation of such a network.

Systems which utilize ITFS usually employ an omnidirectional antenna with a transmission radius of approximately 20 miles and is configured as a point-to-multipoint system. Most ITFS networks function in a manner similar to satellite networks except that the reception footprint is vastly smaller for the ITFS system.

Major impediments to ITFS utilization include the following:

1. **Regulatory uncertainty**. First, since ITFS frequencies are generally underutilized by educational organizations, the FCC is receiving pressure from various sources to release those frequencies for commercial applications. The ITFS frequencies are commonly used for cellular telephone applications. Second, ITFS systems are difficult to license and may involve waiting periods as long as two years. OTA (1989) states that FCC approval can take as long as two years.

2. **Regulatory complexity**. The complications involved with licensing, constructing, and operating an ITFS system is beyond the capacity of most school systems.

Microwave

Microwave is a point-to-point network medium which utilizes transmissions in a wide range of frequencies (900 MHz - 23.0 GHz). Typically, microwave antennas are simplex systems which are utilized to transmit from the program origination source to a receiving system. Duplex systems are sometimes employed also.

Microwave systems are profoundly affected by terrain since they require a clear line of sight between antennas.

A summary of characteristics include:

1. FCC licensing required.

2. Requires high startup costs and extensive financial and personnel resources.

3. High maintenance costs.

4. Approximately a 10-year life expectancy.

5. Equipment required includes (a) antenna towers, (b) wave guides, (c) antennas, (d) transmitters, (e) receivers, and (f) monitors.

Cable Television

Cable television (CATV) systems utilize coaxial cable to transmit programming from a single point, called the headend, to multiple points (e.g. houses, schools, businesses, etc.). CATV is normally configured as point-to-multipoint but it is also possible to design a system from which all points on the network can transmit and receive.

Although the Cable Television Act of 1984 deregulated the CATV industry and freed it from many service requirements, most CATV systems operate through a franchise agreement with the community which it serves. Often, these franchise agreements include a provision for an educational access channel. In communities without such a channel, educators should vigorously encourage the CATV franchise to provide one and then work to see that the channel(s) given to the school are utilized maximally to deliver educational programming. Further, many cities have reached an agreement with the cable system to wire each school building as a provision of the franchise contract (Douglas & Bransford, 1990).

The educational access channel can be used in at least two ways to provide distance education opportunities. First, the CATV system can be requested to utilize its satellite receiving system to receive satellite programs and feed them over the cable. Since interaction is most likely handled by an audio-only telephone line, the school would have essentially the same capability using the CATV that a school equipped with an SRS would have. The second way that the CATV system could be used is as a telecommunication channel to transmit programming which originates within the school.

A summary of the salient features of CATV includes the following:

1. Few channels, usually only one, available for dedication to educational applications--depends upon local community cable franchise agreement.

2. Low cost for cable drop at building; low recurring subscription costs.

3. Limited expansion potential.

4. Reliable; relatively unaffected by weather.

5. Maintenance and operation by cable franchise personnel.

6. Any cable subscriber in the community can watch programming.

7. School must be located in a cable franchise area.

Public Switched Telephone Network and Packet Switched Network

Clearly, the most ubiquitous and familiar telecommunication network is the public switched telephone network (PSTN). The PSTN connects virtually every school building in the United State, forming a multipoint-to-multipoint network for voice and slow-speed data as well as audiographics. The PSTN is a hybrid network composed of copper twisted-pair wire, coaxial cable, satellite, microwave, and fiber optic cable.

It is somewhat ironic that relatively few classrooms have a telephone line or phone equipment. This situation makes it difficult for the teacher wishing to utilize the PSTN for telecommunications applications.

The packet switched networks (PSN) are networks designed to transmit data. In a PSN, data are organized into standard sized packets. These packets are sent to the destination via different paths to help ensure efficient use of the network. Examples of packet switched networks include Telenet, Tymenet, Datapac.

In educational telecommunications networks the PSTN and PSN are typically utilized for voice or data transmissions. Both networks are available for use by the public. Rates are based upon usage. The available bandwidth is too restricted for video applications.

A summary of the telephone network includes the following:

1. Easily available.
2. Addressable, switched, multipoint-to-multipoint configuration.
3. Inexpensive startup but expensive recurring usage fees.
4. Fiber optic installation and integrated services digital network (ISDN) implementation will enhance capacity, perhaps allowing video services. "Future development of PSTN is closely tied to the implementation of fiber optics" (OTA, 1989, p. 75). However, "broadband capabilities ... are not expected to be widespread for 5 to 20 years" (OTA, 1989, p. 74).
5. Easy to use; no special training required.
6. Low maintenance costs.

Summary

The purpose of this chapter has been to analyze the salient features of the major educational telecommunication technologies. The general characteristics which are common to all telecommunication media were reviewed prior to an analysis of selected technologies.

The salient characteristics of educational telecommunication technologies include the following: (a) transmission of information, (b) interactivity, (c) cost, (d) frequency bandwidth, (e) network architecture, (f) regulation, (g) maintenance and operation, and (h) life expectancy and expandability.

Telecommunication media were shown to transmit three basic types of information: (a) voice [audio], (b) video, and (c) data. Further, each of these may be transmitted either one-way (i. e. simplex) or two-way (i. e. duplex). Interactivity was found to be an important factor in telecommunication systems but the design of some technologies limit their interactive capacity. Interaction may occur in both real time (i. e. synchronous) and time delayed (i. e. asynchronous) formats. Costs were found to vary widely among different systems and were found to be affected by a variety of factors making it difficult to estimate the total cost of a telecommunication system. Frequency bandwidth, the range of frequencies which a telecommunication technology can transmit, has a major influence on the network by indirectly determining the kind of information which can be transmitted. Network architectures are of three types: (a) point-to-point networks, in which there is a direct connection between two sites; (b) point-to-multipoint networks, in which transmissions emanate from a single site but can be received by numerous sites; and (c) multipoint-to-multipoint networks, in which each location can both send and receive. Regulations affect many aspects of educational telecommunications. In particular, regulatory factors (a) affect the network options available to educators, (b) place burdens upon the educator to obtain licenses, etc., and (c) have an impact upon the technologies which will be available in the future. Maintenance and operation are important factors which must be addressed to ensure reliable and simple utilization of the system. Finally, factors affecting life expectancy of the network were addressed, including the trend toward digital communications.

The major telecommunication media in use in education are: (a) communication satellites, (b) fiber optics, (c) instructional television fixed service [ITFS], (d) microwave, (e) cable television [CATV], and (f) the public switched telephone network and the packet switched networks. Currently, satellites represent the most commonly utilized medium for transmitting distance education.

CHAPTER IV

AN IMPLEMENTATION MODEL FOR WIDE AREA EDUCATIONAL TELECOMMUNICATION NETWORKS

Introduction

The following model plan for the implementation of wide area educational telecommunication networks is designed to direct the development of a network which will be effective in meeting the educational needs of local education agencies (LEAs), regional education agencies, regional educational cooperatives, state education agencies (SEAs), and other educational organizations. The intent is to outline and describe an organized sequence of planning steps which, if followed and the recommended considerations addressed, will result in a network which has been developed based on the best information available and which fits available personnel and financial resources. The purpose of the implementation model is not to recommend that specific telecommunication technologies be utilized nor that particular organizational structures be implemented.

The proposed model organizes the activities for educational telecommunication network implementation into three components. These three components are the (a) curriculum component, (b) organizational and financial component, and (c) technical component. The curriculum component addresses educational and instructional factors which must be considered in planning for distance education. Within the curriculum component: (a) educational needs are specified, (b) instructional opportunities are identified, (c) sources of programming are selected, and (d) faculty training is conducted. The organizational and financial component is concerned with the relationship of the school to other schools, the state education agency (SEA), the United States Department of Education, businesses, and public or private funding agencies. It is also concerned with the financial and budget package which supports both the startup and operation of the network. The technical component deals with the equipment, facilities, and software which are required to operate the educational network. A key step in the technical component is the selection of the primary telecommunications technology which will be utilized, since the technology will have a direct impact upon the instructional format and programming options which will be available.

These three components are listed in priority order. That is, the educational component should receive primary consideration through all phases of implementation. It is essential that the needs of the learners--students, teachers, or others--be the driving force in the development of the telecommunications network. The financial and organizational component receives second priority, while the technical component should receive the lowest priority.

The model plan proposes three phases of implementation for educational telecommunication networks. These are the (a) feasibility phase, (b) implementation phase, and (c) institutionalization phase. The feasibility phase assesses and documents the need for an educational telecommunication system and considers, in general terms, the parameters of a feasible solution within the context of the school. The culmination of the feasibility phase is the preparation of a planning document detailing the "vision", as proposed by the National School Boards Association and U. S. West (1989, p. 1). The implementation phase puts the planning document into action through such activities as (a) developing curriculum, (b) organizing partnerships, (c) securing funding sources, and (d) acquiring and installing equipment. Generally, the implementation phase will last through the operation of the network for the first school year. Finally, the institutionalization phase is a continuing process which integrates the distance education program into the total services of the school. One way to look at this process is to recognize that distance education through telecommunications is transformed from a project to a program in the implementation phase.

The reader should not infer from the model that there is always a clear delineation between either the components or the phases of the model. Although each step has been listed in its approximate level of priority, in practice there will be substantial overlap between steps in the model plan. In general, however, the feasibility stage occurs first and proceeds until its conclusion with the creation of the planning document. The implementation phase follows the completion of the feasibility phase, using the planning document as a guide. Finally, the ongoing institutionalization phase commences. Within each phase, the components are intended to be dealt with sequentially. That is, the curriculum component is addressed first, then the organizational and financial component, and finally, the technical component.

It should also be noted that a model such as the one which follows is almost never fully implemented as intended. The reality of expensive, fund-driven technological innovations in the public sector is that programs tend to be implemented in response to either a legislative imperative or to a funding opportunity. As Schramm (1977) puts it:

> Unfortunately there is reason to believe that the choice [of technology] is not always completely professional or scientific. It depends ... on what is most immediately available, or on the media system for which a donor wants to give money. It depends sometimes on noneducational reasons such as political incentives ... [or on] prestige considerations (p. 263).

Although, as Schramm (1977) warns, the telecommunications system may not be logically based upon all aspects of the following model, successful systems can still be implemented. For example, if a donor institution is found which is willing to fund the development of a satellite network which meets the school's curriculum requirements, but is not willing to fund an alternative communication technology, then a lengthy analysis and comparison of one technology (e. g. satellite) versus another (e. g. fiber optics) is a waste of time.

A summary of the components, phases, and action steps of the model plan follows in Table 4. The reader is urged to remember that there is overlap among the components and phases. Therefore, it is not possible to view each of the steps below as occurring in sequence.

Table 4

A Model Plan to Implement Wide Area Educational Telecommunication Networks for Voice, Video, and Data Communication

Feasibility Phase

CURRICULUM COMPONENT	ORGANIZATIONAL & FINANCIAL COMPONENT	TECHNICAL COMPONENT
Identify specific curriculum needs	Obtain outside planning assistance	Identify & evaluate existing infrastructure
Identify specific administrative needs	Review internal funding options	Specify the types of information to be transmitted
Prepare a statement of goals & objectives	Review external funding options	Evaluate the potential of current and future communication technologies
Study local & state curriculum requirements	Specify criteria for partner(s)	Consider interactive requirements
Evaluate all options to meet needs	Consider lease/purchase options	Evaluate network infrastructure options
Form a preliminary distance education committee	Identify party responsible for maintenance	Consider implications of hardware and software selection
Evaluate educational telecommunications applications		Prioritize equipment needs
Thoroughly review literature & learn from other projects		Prepare bid specifications for hardware & software
Consider policy or regulatory barriers		

Table 4 (Continued)

CURRICULUM COMPONENT	**ORGANIZATIONAL & FINANCIAL COMPONENT**	**TECHNICAL COMPONENT**
Make site visits to other projects		
Complete a planning guide		
Develop an evaluation plan		
	Implementation Phase	
Finalize membership of distance education committee	Identify partners	Accept bids
Distance education committee meets regularly	Obtain commitments of political support	Sign vendor contracts
Design courses (if locally produced)	Obtain commitments of financial support	Monitor contractor(s)
Subscribe to programming	Consult faculty & staff; communicate & seek support	Train staff
Identify faculty or staff who will operate or supervise the system	Prepare grant application(s)	Contract for maintenance services
Identify faculty who are willing and able to teach	Request state & federal agency assistance &/or support	
Conduct inservice education	Influence legislation & regulations	
Collect data for evaluation	Prepare budget	
Prepare evaluation report	Disseminate results to constituents	

Table 4 (Continued)

CURRICULUM COMPONENT	ORGANIZATIONAL & FINANCIAL COMPONENT	TECHNICAL COMPONENT
Institutionalization Phase		
Revise curriculum as required	Continue to develop funding sources	Maintain equipment
Seek new courses & sources of programming	Continue to influence policy & regulations	Amortize equipment
Add enrichment programs as needed	Attempt to influence legislation	Upgrade equipment as needed
Continue professional development for faculty		Add new equipment as necessary

Curriculum Component

A key premise of the model plan for educational telecommunications is that systems will be most effective if the design is driven by educational factors. Virtually all recommendations for network implementation begin with the admonition to base the technology upon a foundation of educational need. Although it is clear that many successful educational telecommunications projects have been developed with an impetus from various external factors, such as external funding or the availability of a particular technology, the implementation model presented in this paper advocates the primacy of the curriculum component. Generally, the curriculum component is addressed first during each implementation phase.

The purpose of the curriculum component is to address issues directly related to education. One important issue to be addressed is instructional design. In planning for instructional design questions, the need of the students to have opportunities for interaction is crucial. Interaction may take place through the telecommunications system or alternative arrangements using teachers or assistants can be developed.

Another fundamental issue will be the type of programming which is needed and which is available. Distance education programming will fall into one of the following categories:

1. **Curriculum enhancement**. Telecommunications can provide full courses for graduation credit. For example, there are several national satellite program providers which teach full courses in a variety of subjects. Alternatively, the educational organization can produce its own programming, as is often the case with fiber optic or cable networks. For example, the Oklahoma State University Arts and Sciences Teleconferencing Service provides 11 science, mathematics, foreign language, and basic reading courses to students in grades 7-12.

2. **Curriculum enrichment**. In addition to full courses, a great deal of programming is available to enhance specific courses. These programs are both regularly scheduled and ad hoc. For example, the Cable News Network (CNN) produces a 15-minute current events program each day which can be used on a regularly scheduled basis in social studies classes.

3. **Information resource**. Telecommunications can provide access to information and databases. This type of activity normally occurs where a computer, using the telephone network, connects to an information database. For example, the National Aeronautics and Space Administration (NASA) operates a database called SpaceLink which contains information about the space program and which can be accessed by students or teachers as an information resource.

4. **Professional development**. Finally, telecommunications can provide significant opportunities for faculty to participate in teleconferences on topics to enhance their professional competency. For example, the Oklahoma State University College of Education has produced nearly 100 satellite-delivered professional development programs on a variety of topics relevant to classroom teachers, administrators, or other school faculty.

Organizational and Financial Component

The purpose of the organizational and financial component is to:

1. **Form partnerships and groups to accomplish work and distribute effort**. These groups may consist of regional consortia, small networks of two or more schools, or partnerships composed of elementary schools, secondary schools, and higher education.

2. **Develop sources of funding**. Funding may come from local line item budget designations, bond issues, state funding, or grants from public or private sources. As stated by Otterman and Pease (1989), "Public agencies alone are rarely able to fund a DLS [distance learning system] without receiving special funding or corporate sponsorship" (p. 7).

3. **Provide support, lobbying efforts, etc**. Important issues such as accreditation and certification need to be monitored to ensure that guidelines are compatible with telecommunication opportunities.

Specific major tasks to be accomplished will include writing grants, finding and inviting partners, and specifying staffing plans.

Technical Component

The technical component involves issues related to the selection, operation, and maintenance of the telecommunication media and equipment. Within the technical component, equipment specifications are written, bids for equipment and services are solicited and awarded, and the installation work is performed. The technical component is critical to the long term success of the network.

Summary

This chapter has described a model plan for the implementation of wide area educational telecommunication networks. The model proposes three components. These are: (a) the curriculum component, (b) the organizational and financial component, and (c) the technical component. Priority is given to the curriculum component. Implementation activities to address each of the three components are suggested to be performed in three phases. These phases are: (a) feasibility, (b) implementation, and (c) institutionalization.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Educational telecommunication networks represent a tool which can be utilized by educators to enhance educational opportunities for students, especially those in rural areas. Distance education networks can also be utilized to serve a variety of information needs.

The problem addressed in this study was the development of a model plan to guide the implementation of a wide area telecommunication network capable of providing voice, video, and data communication. The model was designed to be implemented by school districts, school cooperatives, regional education districts, or state education agencies.

Literature was reviewed which documented the need for telecommunications in education. Needs which can be addressed by telecommunication systems include (a) equity, (b) information access, (c) access to experts, (d) interaction, (e) timely access, (f) pupil and teacher shortages, (g) professional development, (h) cost reduction, (i) cost effectiveness, and (j) education of the workforce.

Applications of educational telecommunications include (a) distance education, (b) teleconferencing, (c) data communications, and (d) electronic mail. These applications were categorized along the dimensions of interaction and learner independence.

The current status of educational telecommunications was reviewed. Numerous programs were found and the salient features of these programs were identified. A variety of technologies, such as satellites, fiber optics and microwave are being employed. Coursework may be credit, enrichment, or staff development, Funding comes from local, corporate, state, and federal sources.

The various technologies were analyzed. These technologies include satellites, fiber optics, microwave, instructional television fixed services (ITFS), cable television, and the telephone networks. Each technology has strengths and weakness.

Finally, various models and guidelines related to telecommunications development were investigated. The resulting model plan proposes three components. These are: (a) the curriculum component, (b) the organizational and financial component, and (c) the technical component. The curriculum component is the primary consideration in all design and implementation questions. The components are dealt with in three phases: (a) the feasibility phase, (b) the implementation phase, and (c) the institutionalization phase.

Recommendations are as follows:

1. Although this model plan has been designed based upon the best guidelines and information available, its efficacy cannot be determined until projects are implemented which follow the model. Therefore, it is recommended that the model be adopted for network implementation in a variety of settings and utilizing a variety of different technologies. One way that this could be done is to use the model as the basis for grant proposals to funding agencies.

2. Research should be conducted to determine the most efficient and cost-effective technologies which can be utilized in distance education networks. Also, hybrid telecommunications programs which utilize two or more technologies (e. g. satellite and fiber optics; cable television and computers) should be implemented and evaluated.

3. Funding possibilities should be explored. It is recommended that state and federal educational agencies and personnel use their influence and funding to encourage the development of wide area educational telecommunications networks.

4. There is substantial evidence that students learn equally well using distance education techniques as they do using traditional instruction. Future research should focus on more specific issues such as instructional design, student learning styles, and specific teaching strategies. For example, the appropriate amount of interaction that is required, and the format that the interaction should be in, are important areas of research. In designing educational telecommunications programs, it is essential to maintain the educational component as the foundation of the program. The needs of the learner should always guide program development.

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APPENDIXES

APPENDIX A

GLOSSARY OF EDUCATIONAL TELECOMMUNICATION TERMS

Advanced Communications Technology Satellite (ACTS): A next-generation communications satellite designed by a contractor team led by the National Aeronautics and Space Administration (NASA). ACTS will demonstrate applications in the Ka-band (20 - 30 GHz) and utilize a scanning spot beam with on-board signal processing. One purpose of ACTS is to explore solutions to the satellite transponder crisis in the C- and Ku-bands by, (a) demonstrating the viability of a new frequency band, and (b) using on-board computer processing to maximize data transmission rates.

Analog transmission: Transmitting voice, video or data in the form of a continuously variable waveform signal. Information is normally represented by modulating either the frequency or the amplitude of the signal. Currently, most telecommunications systems, such as the telephone and television networks, utilize analog transmission. Compare with digital transmission, which is commonly predicted to be the predominant format in the future.

Asynchronous communication: Communication in which a period of time elapses between the time when a message is sent and when it is received. Asynchronous communications allow messages to be sent or received at times which are most convenient to the participants. In a typical asynchronous communication, a conference participant, using a personal computer, stores a message on a host computer. The message may be either private, i.e.

addressed to a specific individual, or it may be public. At some later time, another conference participant accesses the host computer, reads the message and leaves a reply. This process continues until conclusion. Examples include electronic mail and most computer conferencing applications.

Audio bridge: An electronic component that connects and controls multiple inputs from two or more telephone lines allowing each caller to hear and speak to other callers simultaneously. A mid-range audio bridge allows up to 64 simultaneous callers. See also, audio conference.

Audioconference: A voice-only teleconference format in which telephone circuits are linked via an audio bridge so that all teleconference participants can hear and speak simultaneously.

Audiographics: A telecommunication application in which voice and data signals are multiplexed on a single circuit, typically a telephone line. In most audiographic systems computer data (e.g. graphics, text, statistical results) are exchanged among computers along with simultaneous voice communication.

Bandwidth: The number of continuous frequencies within the high and low limits that are compatible with the transmission of a given signal. Generally, the more information the signal contains, the greater will be the bandwidth required to send the information. As an example, 3 MHz (3,000,000 cycles per second) is required for a television signal while only 3 KHz (3,000 cycles per second) is required for an audio telephone circuit. The frequency limits are determined by technical, legal, and regulatory considerations.

Broadband channel: A telecommunication channel which can accommodate a wide frequency bandwidth, usually at least 4 KHz. A broadband channel can transmit at least one full video signal. CATV is a example of a broadband medium.

Cable television (CATV): Television systems which utilize a combination of satellite downlinks, television antennas, amplifiers, modulators, and coaxial cable to provide television signals or computer data to homes, schools, or other sites. Typical CATV systems have several SRSs and standard television antennas used to receive the video signal. When received, the signals are transmitted via coaxial cable to the receiving sites. CATV systems can be designed which allow receiving sites to transmit back to the cable headend. CATV systems often provide educational access channels for use by schools. The typical network configuration is point-to-multipoint but point-to-point and multipoint-to-multipoint configurations are also possible.

C-band: The frequency range between 4 and 6 GHz within which most communication satellites operate.

Coaxial cable: Shielded cable commonly utilized to connect electronic components. Coaxial cable is used in cable television (CATV) systems as well as many computer networks.

Codec: Abbreviation for COder-DECoder (or COpression-DECompression). An electronic component that codes and compresses a digital electromagnetic signal, such as video, for more efficient and economical transmission. A codec must be located at both the receiving and the transmitting ends of the telecommunication circuit.

Common carrier: A communications service characterized by, (a) regulation by the FCC, and (b) development, ownership, and operation of the network must be separate from the production of the information transmitted. The PSTN is a common common carrier.

Communication satellite: An artificial satellite, which is usually in a geostationary orbit about the Earth, utilized for the communication of voice, video and data information. Most communication satellites provide 24 full video channels with 48 audio channels and operate in either the C (4-6 GHz) or Ku (12-14 GHz) frequency band. Communication satellite networks are usually point-to-multipoint.

Compressed video: A video signal which has been modified to be compatible with transmission via a telecommunication circuit with a reduced bandwidth. In the compressed video format, non-essential information has been removed. In practice, static images in compressed format look similar to a normal video signal but motion video appears to flicker due to the fact that fewer video frames are being transmitted per second.

Computer conference: A teleconference in which three or more individuals in separate locations communicate utilizing computers and communication software via a telecommunication channel, such as the PSTN. Computer conferences may be asynchronous or synchronous but asynchronous conferences are the most common.

Data: Units of binary computer signals which can be combined into useful information according to a particular format, such as the American Standard Code for Information Interchange (ASCII).

Data base: Data stored in an accessible, electronic format on a computer which can be accessed by other computers.

Dial-up telephone network: The public switched telephone network operated by AT&T, one of the seven Bell operating companies or one of several competing commercial providers. The dial-up telephone network was designed for voice communication and is not generally acceptable for applications requiring a wide frequency band and/or high volume data rates. The network configuration is multipoint-to-multipoint.

Digital transmission: Transmitting voice, video or data in the form of binary signals representing ones and zeros (i.e. bits). See also, analog.

Direct broadcast satellite (DBS): A communication satellite characterized by Ku-band transmissions which operate at high power with a highly focused footprint. An antenna as small as one-meter is possible with DBS. DBS systems are predicted to be operational in the mid-1990s but there are no currently operational systems.

Distance education: Education in which the following three elements are present: (1) There is no face to face interaction between the student and teacher; (2) there is an organization which plans, coordinates and supervises the instructional program; and (3) a technology-based delivery system which allows and facilitates interaction is utilized to connect instructors and students who are in two or more remote locations.

Downlink: A satellite antenna system and associated electronic components capable of receiving, but not transmitting, satellite signals. See also, TVRO and satellite receiving system (SRS).

Duplex: A telecommunication channel over which it is possible to transmit and receive signals in two directions simultaneously. See also, half duplex and simplex.

Electronic communications: A general term referring to the transmission and reception of information in analog or digital form over a telecommunication channel.

Electronic mail (E-mail): An analog of the regular mail system, electronic mail applications utilize computers and software to exchange messages over telecommunication circuits. Messages may be addressed and accessible only by a specific person or by groups of people. Numerous commercial systems can be utilized on a subscription or usage fee basis and private systems are also relatively easy to implement.

Facsimile (FAX): An electronic communication component which converts an image, such as text or graphics, on paper into a digital format and then transmits the digital image via a telecommunication circuit such as a telephone line to another fax machine where a paper copy is printed out.

Federal Communications Commission (FCC): The FCC is the regulatory agency of the U. S. Government which is responsible for the administration and legal enforcement of rules pertaining to telecommunications issues. The FCC coordinates the use of the airwaves and oversees the broadcasting, telephone and cable industries. The charter for the FCC is derived from the Communication Act of 1934 which gives the commission authority to regulate all interstate electrical communications.

Fiber optics: A data transmission medium consisting of one or more glass fibers through which light impulses are transmitted to communicate data. Fiber optics is predicted to be a common medium for telecommunications in the future. Fiber optics offer the advantages of immense bandwidth, reliability, protection from outside interference, and extremely high data rates.

Footprint: The area on the Earth's surface within which the signal from a communication satellite can be received.

Geostationary: An orbit approximately 22,300 miles above the Earth's equator at which the speed of the orbiting body (such as a communications satellite) matches the rotational speed of the Earth and therefore appears to remain stationary above a fixed geographic point. Satellites in geostationary orbits allow a large geographic area to be covered by the communication signal and also allow receiving antennas to remain fixed rather than having to track a moving satellite. Most U. S. communication satellites are in geostationary orbits, as compared to the Soviet Union which, because of the extreme northern latitudes which must be served, uses a network of non-geostationary orbiting satellites.

GHz: The abbreviation for one-billion hertz (cycles per second). Used in reference to frequencies.

Half duplex: A telecommunications channel over which it is possible to send and receive, although not simultaneously. See also, duplex and simplex.

Hybrid system: A network which utilizes two or more communication technologies. For example, a satellite/fiber optic system.

Information technology: Communication systems such as direct broadcast satellite, two-way interactive cable, fiber optics, low-power broadcasting, computers and television.

Instructional television fixed service (ITFS): A group of television frequencies in the ultra-high frequency range (3 GHz) set aside for educational applications. The standard ITFS network configuration is point-to-multipoint.

Integrated Services Digital Network (ISDN): A digital communication format which allows voice, video and data to be sent simultaneously over the same communication circuit. ISDN is being developed by the telephone companies and is not expected to be fully implemented before the mid-1990s.

Interaction: Communication through voice, video and/or data of participants connected by a telecommunication network. Many experts in the field of distance education believe that interaction is one of the most critical components of a successful network. Some telecommunication media are better able to facilitate interaction than others due to inherent characteristics of the medium.

Ka-Band: A frequency band for next-generation satellites (e.g. ACTS) between 20 - 30 GHz.

KHz: The abbreviation for one-thousand hertz (cycles per second). Used in reference to frequencies.

Ku-Band: A frequency band between 12 - 14 GHz which is increasingly being utilized for satellite communications, especially VSAT applications.

Local area network (LAN): A data communication network spanning a limited geographical area, a few miles at most, but usually within one building or within a cluster of buildings.

MHz: The abbreviation for one-million hertz (cycles per second). Used in reference to frequencies.

Microwave: High frequency channels (4 GHz and higher) which can be utilized for the transmission of voice, video or data signals. Microwave is a line-of-sight communication technology. Microwave-based network configurations are normally point-to-point with approximately 15 - 30 miles between antenna towers.

Modem: Abbreviation for MOdulator - DEModulator; a device that modulates and demodulates a signal for transmission over a telecommunications channel. Usually required to communicate via computer on the dial-up telephone network.

Multipoint-to-Multipoint: Telecommunications network configuration in which each point on the network can transmit and receive communications with any other point on the network. An example is the PSTN in which each site has a unique, addressable identity (telephone number) and all points can both transmit and receive.

Network: An interconnected set of devices capable of transmitting and receiving voice, video, or computer-graphic information over a transmission medium. The interconnections may be physical, such as copper wire, or non-physical, such as television signals or a combination of these.

Packet switched network (PSN): A network which is designed to carry digital information in the form of packets. Each packet consists of arbitrarily sized units of digital information with associated addressing and sequencing information. Packet switched networks allow efficient use of the available data handling capacity of a telecommunication network. Examples include Telenet (public), ARPANET (Department of Defense), and NPSS (U. S. government).

Point-to-Multipoint: Telecommunications network configuration in information in transmitted from a single point (location) to multiple points (locations) which do not have the capability of transmitting but can only receive. Most satellite networks are point-to-multipoint; there is a single STS which transmits to the satellite which relays the signal to a wide are where it can be receive.

Point-to-Point: Telecommunications network configuration in which there is a connection between two sites and other points cannot participate in the network. Microwave links are normally point-to-point in which on antenna transmits to another in relay fashion.

Public switched telephone network (PSTN): Public switched telephone network (PSTN): The PSTN is the telephone network developed by Bell Telephone and now operated jointly by the regional Bell operating companies and AT&T. The PSTN is utilized primarily for voice communication although analog data and video can be transmitted at a relatively slow transmission speed. Since each node on the PSTN is addressable (i.e. has a unique phone number), it is a multipoint-to-multipoint network.

Satellite receiving system (SRS): A satellite receiving system consists of all the components necessary to receive and display a satellite signal. Major components of an SRS include, (a) a steerable or fixed receiving antenna, (b) a receiver to tune the frequencies, (c) cabling from the antenna to the receiver, and (d) a television/monitor. Typically, SRSs also include a videocassette recorder. See also, TVRO and downlink.

Satellite transmitting system (STS): STS refers to the package of components required to transmit a signal to a communication satellite. See also, uplink.

Simplex: A telecommunications circuit over which signals can be either received or transmitted, but not both. See also, duplex and half duplex.

Subcarrier: A portion of a broadcast channel reserved for the transmission of information which may or may not be related to the primary carrier signal. For example, satellite communication channels include two or three audio subcarriers in addition to the primary video channel. In applications where only one audio channel is necessary, the other subcarrier can be utilized to transmit data or other information.

Synchronous communication: Synchronous communications refer to the simultaneous exchange of information, i.e. communication in real time.

Telecommunications: The use of wire, radio, optical, or other electro-magnetic channels to transmit or receive signals for voice, video, and data communications. Communications over distance using electronic means.

Teleconference: Two-way electronic communications between two or more groups, or three or more individuals, who are in separate locations. Teleconferences may employ voice, video or data transmissions or any combination of these three. The four major types of teleconference, categorized by the predominate type of communication, are, (a) audio, (b) audio-graphic, (c) computer, and (d) video.

Telecourse: A course of instruction which is provided via distance education utilizing a telecommunication system.

Transponder: The electronic component on a communication satellite which, (a) receives a signal, (b) changes, or modulates, the frequency of the signal, (c) amplifies the signal, and (d) transmits the signal back to Earth. Modern communication satellite have 24 transponders which is roughly equivalent to 24 television channels.

TVRO (Television Receive-Only): A satellite dish capable only of receiving, not transmitting, information. See also, downlink and satellite receiving system.

Uplink: A satellite antenna and associated electronic components which transmits signals to a communication satellite. See also, STS.

Vertical blanking interval (VBI): The VBI is the normally unused portion of a standard television signal. The VBI is displayed as a black band at the top or bottom of the television picture. The VBI can be utilized for the transmission of supplementary information, such as closed captioning for the deaf or for computer data.

VSAT (Very small aperture terminal): A VSAT is a special-case SRS consisting of a Ku-band antenna and associated electronics which are designed to receive high-power signals from a communication satellite. VSATs are commonly utilized to receive information in a relatively narrow bandwidth, such as computer data or compressed video. The combination of high power, focused energy, and narrow bandwidth allow VSAT antennas to be as small as 1.8 meters.

Videoconference: A teleconference in which a video component is included, usually full-motion video.

Wide area network (WAN): An electronic communications network designed to serve an area of hundreds or thousands of square miles. Public and private packet switching networks, the nationwide telephone network, and satellite networks are examples of wide area networks. Wide area networks can refer to telecommunication networks linking two or more school districts on a regional or state basis.

APPENDIX B

BIBLIOGRAPHY

The following bibliography is compiled from references which were useful in the preparation of this study, Development of a model plan to implement wide area educational telecommunication networks for voice, video, and data communication. Not all were specifically cited in the references and, therefore, this bibliography of references pertinent to distance education, educational telecommunications, and related subjects is provided as an aide to the reader seeking additional information regarding these topics.

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APPENDIX C

SATELLITE RECEIVING SYSTEM CHECKLIST

1. Steerable, polar mount.

2. Dual frequency bands (C/Ku).

3. Remote operation with programmable satellite locations.

4. Building distribution system serving multiple locations.

5. Full-arc coverage of all U. S. domestic communication satellites.

6. Adequate antenna size for geographic location.

7. Solid mounting base, preferably on ground (with security fence).

8. Classroom equipment; high-resolution monitor and VCR.

9. Warranty and maintenance/service agreement.

10. Decoder for any programming services operating coded (scrambled) signals.

11. Special equipment such as printer, computer, or data controller for any programming services using such equipment.

12. No interference from electromagnetic sources such as microwave transmitters or power lines.

13. No physical blocks, such as buildings or trees, between the antenna and satellite.

VITA

Malcom V. Phelps

Candidate for the Degree of

Doctor of Education

Thesis: DEVELOPMENT OF A MODEL PLAN TO IMPLEMENT WIDE AREA EDUCATIONAL TELECOMMUNICATION NETWORKS FOR VOICE, VIDEO, AND DATA COMMUNICATION

Major Field: Curriculum and Instruction

Emphasis: Information and Communication Technology

Biographical:

Personal Data: Born in Mexico, Missouri, May 15, 1953, the son of Dr. Joseph M. and Faye Phelps. Married to Debra Ann Grayson, 1977. Daughter, Jessica Lea Phelps, born 1977.

Education: Graduated from El Reno High School, El Reno, OK in May, 1971; received Bachelor of Arts degree in Psychology from Oklahoma State University, in December, 1977; received Master of Science degree in Applied Behavioral Studies from Oklahoma State University, in July, 1982; completed requirements for the Doctor of Education degree at Oklahoma State University, in July, 1990.

Professional Experience: Director, Midlands Consortium Star Schools Project, Oklahoma State University, 1988 to present; Educational Technology Specialist, NASA Aerospace Education Services Program, Oklahoma State University, 1986 to 1988; Research Associate, Office of Education Research, Oklahoma State University, 1985 to 1986; Graduate Teaching Associate, Oklahoma State University, 1983 to 1985; School Psychologist and Prescriptive Teacher, Oklahoma State Department of Education, 1980 to 1983; Diagnostic and Prescriptive Teacher, Cushing, OK Public Schools, 1979 to 1980.