Distance education: a cost analysis

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Distance education: A cost analysis

by

Judy Irene Book Jones

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Signatures have been redacted for privacy

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CHAPTER I. INTRODUCTION

The concept of distance education is enlarging our definitions of how students learn, where they learn, and who teaches them (U. S. Congress, 1989). The subtitle to the Online Journal of Distance Education and Communication states: "In the industrial age, we go to school. In the information age, school can come to us" (Barron, 1989, p. 28).

In the past, distance education has been directed to adults, but recently has found increased utilization by all school system levels. Elementary and secondary school educators are discovering what college educators have known for years, that mixing conventional education with distance education can accelerate and expand individual academic programs (U. S. Congress, 1989).

The first section of this chapter gives background information including a definition of distance education and a general history. Of significant importance are the economics involved in distance education systems. Information about costs are summarized in the second section. The third part of the chapter discusses the technologies used in distance education and includes a discussion on interactive technologies. The fourth section states the problem of this research, followed by the purpose of the study, and research questions. Definitions of terms follow. A summary concludes the chapter.

Background

Distance education definition

Distance education has become increasingly sophisticated since the first educational radio programs. In (1989a) Barker referred to distance education as a "catch all" phrase for any form of instruction in which the learner and instructor were separated
geographically and were linked by telecommunications that permitted live, interactive audio and/or video exchanges. It is this interactive approach that most people refer to today when they speak of distance education.

Definitions of distance education usually include Keegan's (1986) characteristics:

- quasi-permanent separation of teacher and learner
- influence of an educational organization
- use of technical media
- provision of two-way communication
- quasi-permanent absence of group learning.

Keegan also includes the following as optional characteristics:

- presence of industrialized features
- privatization of institutional learning. (p. 49-50)

The definition of distance education for this paper follows the characteristics of Keegan. The instructor will be at an origination site and students at a remote site; students will also be possible at the origination site. The instruction will be influenced by an educational organization—the school. These sites will be connected point-to-point with the technical media of fiber, microwave, or compressed video, which will allow two-way communication. This will permit live interaction between instructor and students. Instruction will be directed to one or more students. The optional characteristics will be utilized depending upon the strategy of course development.

Distance education history

Distance education is not a new concept. Initially, it was limited to print-oriented material and called correspondence study. Later it was also known as home, independent, or external study. Today print-oriented studies are still a basic distance education method.
The invention of the radio and accompanying enthusiasm to use this new technology as an educational medium, molded the beginnings of a broadcasting model of distance education (Zigerell, 1984). The invention of television followed in the 1950s, which fostered the beginning of educational television (Gray, 1988).

The 1960s was a period of experimentation in instructional technology, much of it applicable to distance education today (Giltrow, 1989). Instructional television (ITV), a planned, formal method of instruction was introduced. The mainstay of ITV was the telecourse—a learning system broadcast to students that used video programs, textbooks, and study guides (Zigerell, 1984). Also in the 1960s, the term "open learning" appeared (Giltrow, 1989). Typically "open" referred to open entry with few restrictions of age or past educational experience (Gray, 1988).

In the 1970s, television production standards improved. There was an emphasis on color videotaping and location filming/taping. These factors significantly changed the planning and quality of telecourses (Giltrow, 1989). During this time, distance education became the common term to describe "various study forms not under continuous, immediate supervision of teachers present in the lecture room" (Holmberg, 1977, p. 9).

During the 1980s, successful consortia were formed for cooperative production of telecourses. Throughout this period, there was a rapid increase in the number of distance education institutions around the world. The application of microcomputers and videocassette recorders in distance education flourished. Satellite technology became affordable and telecourses were broadcast from satellites to various schools. The term distance education had become a generic one referring to education at a distance. It included
home study, correspondence, open learning, telecourses, and teleconferencing (Giltrow, 1989).

Economics of Distance Education

One of the most significant factors when developing a distance education system is the cost. A large portion of the expenses comprise of start-up costs, which in effect, can be the equivalent of five years worth of teacher costs. Paying these costs before receiving enrollment revenues is unsettling (Giltrow, 1989). These costs are more acceptable if they can be amortized over the life of the equipment (Perraton, 1982). Distance education may prove to be cost-effective in the long run, but high initial costs are out of reach for some schools. Key factors that affect start-up costs of a system are: (a) type of technology, (b) distance and topography, (c) existing infrastructure, (d) possible partnerships, (e) engineering requirements, (f) remodeling, and (g) lease/purchase arrangements.

Operating and maintenance costs are also significant (Shobe, 1986). These costs, sometimes referred to as recurring costs and fixed costs, include service and repair, license fees, maintenance fees, and lease fees. The level of funds required to establish the system or to meet fixed costs can be seriously underestimated (Rumble, 1986b).

Several other elements affect the cost of a distance system. These include course development, recruitment, salary, and training. These costs, although significant in the total cost structure, are not discussed in this paper. The costs for inclusion in this study are start-up and operating costs for transmission and classroom hardware.
Distance Education and Technology

Telecommunications, the basic delivery system of many distance education programs, is defined as using electronic technology to distribute information over a distance. Rapid advances in technology, deregulations of these technologies, and decreases in technology costs have made telecommunications attractive to schools.

Telecommunication systems are often referred to by the medium, the type of information (signal) transmitted, and the direction flow. The type of information includes audio, video, and data signals. The media of exchange are usually radio waves through the air or electronic impulses over transmission lines. The flow is defined as one-way (simplex) or two-way (duplex).

One-way communications are usually referred to as broadcast systems and are usually "top-down" communications in which the information is transmitted by electromagnetic waves to anyone with a receiver. Signals may also be beamed to a satellite and then broadcast to receivers on the ground. There is uniformity in the programs offered and usually no direct interaction. These one-way systems are also referred to as point-to-multi-point. Television broadcasts are examples of one-way communications.

In a two-way system, points are linked through a network and tend to encourage "bottom up" and lateral communications. They often involve live, real-time interaction between individuals at two or more places. This communication, referred to as point-to-point or narrowcasting, is directed to a specific audience. Two schools communicating live over fiber optic cables are a type of this technology.

There are several transmission systems for both broadcast and narrowcast
communications. The transmission techniques for sending video, audio, or data signals through the air include satellite, radio and television broadcast, and microwave. The transmission of video, audio, or data signals over lines use copper wire and fiber cable. The signals (whether voice, data or video; whether transmitted by air or over lines) are either analog or digital. Analog signals take on a continuous set of values, imaging the source. Digital signals take on discrete on-off values. Finally, video signals may be classified as full motion or compressed motion—full motion being the highest quality and most natural format. Full motion requires a large bandwidth. Compressed video is a digital technology that removes redundant material and compresses the signal that enables the use of a smaller bandwidth. Compressed video signals lose some quality in color and resolution. Fast movements may appear jerky.

The narrowcast technologies (point-to-point) permit two-way interaction, one of the fastest growing and most promising distance education alternatives (Barker, 1987). The goal of distance education systems is to be as natural as possible. The technology closest to duplicating the conventional classroom is point-to-point, two-way audio and video.

Two-way interactive television in distance education

The term ITV originally referred to instructional television, but today has become synonymous with interactive television rather than instructional television. Today’s ITV technologies allow for live, two-way communication between sites. In the ITV classroom, the students and teacher see and hear one another from their respective sites. ITV has been shown to be comparable to the traditional method of instruction, in both teacher and student acceptance, and achievement (Hughes, 1988). The Office of Technology Assessment reported
that video-based interactive instruction is the distance education format that most closely resembles the traditional classroom. This has been the format of choice for many distance education systems (U.S. Congress, 1989).

Bates (1988), Feasley (1983), and Gray (1988) state there is a clear movement away from using broadcast methods for distance learning systems. "In the 1990s, it is no longer a question of whether ITV is going to become a major factor in the delivery of education. ITV is here, and there is obvious value in its use as a delivery tool" (Moore & McLaughlin, 1992, p. 76).

The means of transmission for the narrowcast ITV classroom are fiber, microwave, and copper telephone lines. Either full motion or compressed motion video are employed. This type of interactive classroom and the technologies of fiber, microwave, and compressed video, are the subjects of this paper.

Statement of the Problem

Today, the technical capabilities exist for all schools to provide effective distance education opportunities. While the technologies do offer solutions to enable school districts to improve their curricula and learning experiences, they also create new problems. They are expensive and complicated. There are a growing number of efforts to make telecommunication infrastructure and information resources available; however, access to telecommunication resources varies considerably in different locations (U. S. Congress, 1989).

There can be large differences in estimated costs and actual expenditures (Feasley, 1982). There are price and quality variances (Eicher, 1987). It is difficult to analyze and
compare costs because of the differing variables among the technologies. Currently there is not a large body of valid data concerning the costs of various systems (Jefferson & Moore, 1990).

One major question asked by administrators, school boards, and policymakers is, How much does distance education cost? Distance education systems involve cost commitments that are not easily modified. The purchases must be used for a number of years. Those responsible for making these large capital investments should have reliable evaluation data available to make sensible decisions.

There are few studies that specify detailed costs for the three transmission methods. Current cost studies are general in nature. These studies do not specifically compare transmission costs by specific distances. Few studies compare compressed and full motion video costs. There is abundant technical information regarding the specific technologies, but it is not written in the context of distance education. It is difficult to find in one location, complete, nontechnical information listing major cost variables affecting each transmission system and classroom equipment.

Educators desiring to execute distance education systems in Iowa are unfamiliar with sources to aid in planning. Educators lack information on expert sources to supply cost and installation details. A study detailing specific variables contributing to the total costs of creating a distance education system would be helpful to distance educator planners.

**Purpose of the Study**

This study determined the cost of creating a distance education system using narrowcast technologies. The study presented cost comparisons for three types of technology. Two of the
technologies deliver two-way, full motion video and two-way audio: (a) microwave and (b) fiber optics. The third technology, compressed video, delivers two-way audio and two-way video, but in compressed motion. Links connecting hypothetical sites of varying distances were created. Costs were collected from point A to point B for each set, applying each transmission method. The major cost considerations of each of the transmission methods were identified. Lease costs for the transmissions were also collected. The costs were then compared.

Second, this study described costs of equipment and installation for the distance education classroom. An interactive classroom was designed. This design detailed the equipment needs for the origination teaching site. Lists of equipment and prices for the classroom were supplied for both state-of-the-art equipment and more basic equipment.

This paper was a cost comparison of three narrowcast, duplex audio and video technologies. It was not a cost-effectiveness study of the distance education technologies.

**Research Questions**

This research explored and analyzed the following questions:

1. What does it cost to put into place a point-to-point, distance education system using: microwave, fiber, and compressed video?

2. What are the major cost considerations for the three transmission methods?

3. Is it usually better to lease or purchase?

4. How do the costs vary for distances of: 3 miles; 10 miles; 20 miles; 30 miles; 50 miles; 75 miles?

5. What does it cost to equip distance education interactive classrooms?
(6) How much does it cost to remodel standard classrooms?

(7) What are recurring and maintenance costs for the classroom equipment?

(8) What are the recurring and maintenance costs for the transmission equipment?

(9) What are the characteristics, advantages and disadvantages of the three transmission technologies?

**Definition of terms**

Bandwidth refers to the width of frequencies required to transmit a communications signal without undue distortion. The more information a signal contains, the more bandwidth it requires.

Broadcast refers to the transmission of information one-way from a central point that is received by anyone in range of the transmitter.

Codec is the abbreviated form of coder-decoder. This electronic device converts analog video signals into digital form for transmission and converts the signals back again at the destination. In compressed video systems, this unit also compresses the signal.

Compressed video refers to digital video, audio, and data signals that are processed to reduce the amount of information required for transmission, reducing the bandwidth.

Fiber optics refers to a system that uses laser light signals to transmit audio, data, and video signals in an extremely high bandwidth through flexible glass rods.

Full motion refers to a standard video signal that can be transmitted by a variety of means including television broadcast, microwave, fiber optics, and satellite. It is the highest quality and most natural format.
Interactive refers to technology that permits at least some form of two-way communication between two or more individuals. It identifies live communications providing a question and answer interactivity capability.

Microwave refers to a high-frequency radio wave used for point-to-point transmission that transmits video, audio, and data signals through the air over relatively short distances.

Narrowband refers to technologies that require limited amounts of bandwidth spectrum such as that available over a telephone line.

Narrowcast refers to transmitting information to a specified audience rather than the general public.

Summary

While distance education will not fix all that is wrong with American education, it is a viable way to enrich and improve the quality of the curriculum. Distance education can link all educational levels--elementary, high school, and college, along with business and community--to bring a wide variety of experts and information to the classroom. Higher costs can be justified by an increase in educational opportunities (Giltrow, 1989).

This study determined the costs for the distance education classroom. It identified major cost variables for each technology. It determined the costs of purchasing and leasing media for transmissions. It also determined the costs to equip the interactive classroom. It provided equipment lists and costs for state-of-the-art equipment and more basic equipment. This paper provided specific answers to the questions, How much does distance education cost?
CHAPTER II. REVIEW OF LITERATURE

This review of the literature presents information and research relating to distance education and key variables of this study. The information in this chapter is organized in the following categories: (a) a brief description of theories of distance education; (b) the impact of distance education in Iowa today; (c) distance education costs; (d) the technology aspect of interactive television, including specific aspects of fiber, microwave, and compressed video technologies; and (e) the interactive television classroom.

Theory of Distance Education

Distance education has been characterized in such a variety of ways that global or general statements are rarely valid. Distance has different connotations, not necessarily restricted by geographical distance (Rumble, 1986b). Distance also refers to psychological, economic and cultural separations (Burge, Snow & Howard, 1989). Distance education has been shaped by a society's needs and resources, and politicians have seen distance systems as a means to promote particular values or to achieve social, economic, and political objectives (Daniel, 1988; Foks, 1988; Giltrow, 1989; Rumble & Harry, 1982; Zigerell, 1984).

Distance education—distinctive form or parallel form?

Distinctive form There are two views on the concept and theory of distance education. The first perceives distance education as a distinctive educational form based on individualized study. Many autonomous universities teach only by distance, and follow the theory that distance education is an alternative way of teaching (Moore, 1988; Peters, 1988).

Considerable effort has been spent trying to formalize a theory specific to distance

Keegan (1980, 1986) analyzed the theories presented by Moore, Peters, and Holmberg to create a descriptive definition. These characteristics are widely used today to define distance education:

- quasi-permanent separation of teacher and learner
- influence of an educational organization
- use of technical media
- provision of two-way communication
- quasi-permanent absence of group learning
- presence of industrialized features (optional)

Rumble (1989) and Garrison (1989) suggested Keegan's characteristics were too narrow. Keegan's characteristics excluded certain methods and limited target audiences. Rumble included teleconferencing capabilities and excluded industrialization as critical factors. Garrison stated that distance education included elements that were not precise. Vague elements were necessary in order not to restrict the activities of the distance education systems.

**Parallel form** The second school of thought perceives distance education as parallel to traditional education. Garrison (1989) asserts that distance education is not unique. The techniques appropriate for educational goals and distance education goals are the same. Foks
(1988) states that technologies blur the distinctions to identify distance education as a separate mode of learning.

Most educators in the United States adopt the philosophy that distance education does not differ from conventional education in any real structural sense, but is distinctive only in the delivery system (Zigerell, 1984). Most U.S. educators see distance education as a tool or resource to promote the learning process (National Governors' Association, 1986).

Impact of Distance Education Today

Popularity

Distance education applications have increased dramatically over the last five years. In 1987 fewer than ten states were promoting distance education. Today virtually all states have an interest or effort in distance education (U. S. Congress, 1989). Distance education programs exist in the majority of countries in the world. This growth has resulted because educational requirements have coincided with the expanding capabilities and services of telecommunications (Giltrow, 1989). The quality of distance learning has been recognized with increasing respect and credibility (Turnbull, 1988). Distance education has been seen as a viable and cost-effective way to meet the challenges of teacher shortages, low student enrollments, and decreased fundings.

In 1987 U.S. Senator Edward Kennedy sponsored a bill for $100 million in grants to improve the elementary and secondary instruction of mathematics, science, and foreign language. The primary goal of Star Schools was to develop and deliver courses to students in specific areas of the curriculum that suffered from a lack of faculty expertise. The Star Schools program provided a great impetus for funding distance education (Barron, 1989;
Jefferson and Moore (1990) predict that by 1995, all rural schools will have distance education service. A UCLA study predicts that by the year 2010, 50 percent of the educational instruction in the United States will be "mediated education" (cited in Pelton, 1990).

Today the movement in distance education is to utilize the live, two-way interactive classroom (Gray, 1988). Research indicates that distance students not only learn from course materials, but also from interaction with instructors (Holmberg, 1981). This real-time instruction simulates a method that is similar to "being there."

**The popularity of interactive television (ITV)** Quality distance education is dependent upon interaction and participation of learners. Interactive methods are the most "educationally effective and accepted alternative methods of delivering distance education" (Kitchen, 1987, p. 7). Two-way, interactive audio and video systems are popular because they require little change in instruction methods. When technology mimics the traditional classroom and allows for immediate student-teacher verbal and visual interaction, student frustration is reduced (Hobbs, 1990).

**Benefits of ITV systems** There are numerous benefits of ITV systems: the interaction capabilities, the local control, and the increased student responsibility (Barker, 1991; Lewis, 1983; Minnesota State Dept. of Education, 1990; Nelson, 1985). ITV allows school districts to offer a wider range of elective courses and permits students access to subject matter that would otherwise have been difficult to access or unavailable (Kitchen & Kitchen, 1988). ITV extends the geographic area served and also provides unique opportunities for
guest speakers. Partnerships are formed that are beneficial to schools, businesses and communities. ITV does not affect the effectiveness of teachers, nor does it dramatically affect the learning outcomes of students (Kitchen & Kitchen, 1988).

**Disadvantages of ITV systems**  Disadvantages of interactive technology listed by Lewis (1983) and Barker (1991) are: (a) Opportunities for interaction are reduced as the group size increases, (b) the faculty may not know how to elicit participation, (c) students may be intimidated by speaking on the system, and (d) opportunities to provide ITV systems vary from district to district.

**Research studies**

**The success of ITV classes**  Many studies have been completed concerning interactive distance education classes leading to the following conclusions: (a) Students involved with the interactive classes have had positive feelings about their experiences (Barker, 1989b; Catchpole, 1988; Kitchen & Kitchen, 1988; Nelson, 1985; Nelson, Cvanca & Peters, 1989; Pirrong & Lathen, 1990; U. S. Congress, 1989); (b) after teaching in an interactive distance education system, faculty have had positive responses (Barker, 1989b; Bowman, 1986; Hobbs, 1990; Kitchen, 1987; Randall & Valdez, 1988; U. S. Congress, 1989); and (c) students' achievements in interactive distance education classes have been as good or better as with traditional teaching (Batey & Cowell, 1986; Hobbs, 1990; Kabat & Friedel, 1990; Minnesota State, Dept. of Education, 1990; Pirrong & Lathen, 1990; Randall & Valdez, 1988; U.S. Congress, 1989).

**Cost studies of distance education systems**  Evidence shows that distance education can be cheaper per capita than conventional education (Eicher, 1987; Wagner, 1982). Rumble (1982) states, "studies show that unit costs of distance education at the higher educational
Distance education has the potential for a high degree of cost-benefit and cost-effectiveness (Holmberg, 1981; Nelson, 1985). The most costly technologies may not result in high costs per students (Batey & Cowell, 1986; Hudson & Boyd, 1984).

In general, three factors bear on the economics of distance education: choice of media; size or type of program, and number of students (Batey & Cowell, 1986; Rumble, 1982). Rumble concludes that "distance learning is not necessarily a cheap way of teaching" (p. 137). The large capital investment will pay off in cost-efficiency if there are sufficient students. Markowitz (1990) maintains distance education programs are predominantly self-sufficient. According to the 1986 [Minnesota] Governor's Report on Education, "among the available technologies, the only ones that can be viewed as cost-effective, both in terms of research findings and practical organizational issues, are automated drill and practice and telecommunicated instruction/distance learning" (Kitchen & Kitchen, 1988, p. 8).

Conclusions The weight of evidence points to the conclusion that teaching and studying at a distance is effective when effectiveness is measured by achievement of learning, by attitudes of students and teachers, and by cost-effectiveness. The primary conclusion is that interactive telecommunication is effective. ITV is so promising to the states' and the nation's educational systems, that investment of money, time, and human resources in a national research program on the dynamics of learning and teaching by telecommunications is warranted (Moore & Thompson, 1990). "Cost is not the only criterion for evaluating the effectiveness of telecommunications--educational value is the important criterion" (Hezel, 1991, p. 18).
Iowa Communications Network (ICN)

Brief history In 1986 the legislators of the Iowa General Assembly decided it was important to have statewide direction for a telecommunications system. Legislators allocated $200,000 to develop the long range plan. This project was headed by L. Patten, former head of Iowa Public Broadcasting. Patten examined the use of a statewide telecommunications network for the enhancement of education in Iowa. The final report of this project was presented to the Iowa General Assembly in August 1987.

On June 5, 1987, Iowa's Governor Branstad signed into law Senate File 162 that established the Iowa Public Broadcasting Board and gave the Board authority for the ICN (Iowa General Assembly, 1987b). In this coordinating role, the Iowa Public Broadcasting Board will provide assistance in planning, establishing, and operating the ICN (Iowa. Code of Iowa, 1991, §303.77). To assist in filling this mandate, the Narrowcast Advisory Committee was created. The Committee insures proper linkages between the state coordinating body, Iowa Public Television, the local coordinating body, the community colleges, and users of the system. Also signed into law at this time was Senate File 333, which provided policies and procedures for the telecommunications delivery system (Iowa General Assembly, 1987a).

ICN construction and use The Iowa Communications Network (ICN) will utilize live, two-way interactive, full motion video that will connect students and teachers across the state. The ICN is to be built in three phases (Iowa. Code of Iowa, 1991, §18.136(2)).

Phase I extends from the hub at Camp Dodge to the state's 15 area community colleges, the three state universities, and Iowa Public Television (IPTV). It utilizes a fiber optic backbone. Phase II extends from each area college to a single point in each of the state's 99
counties. Phase III connects the county point to about 1,000 individual state agencies, schools, and libraries in surrounding areas, using Instructional Television Fixed Service (ITFS). ITFS is a special low power, one-way broadcast set aside for educational use. Completion date for the ICN is set for fall 1993; the completed network will be 2,600 miles in length (L. Schatz, personal communication, April 14, 1992). Future expansion possibilities include the connection of any public or private school, college, library, or service organization.

The Iowa Department of Education published Chapter 15 Use of Telecommunications for Instruction by Schools, adopted June 6, 1990. These rules give guidance and direction for the use of telecommunications as an instructional tool for students enrolled in kindergarten through grade 12. These rules specify that courses delivered via telecommunications shall employ live, interactive systems which allow, at a minimum, one-way video and two-way audio communication (Iowa Administrative Code, 1990).

Currently the Iowa Department of Education offers no standards, mandates, designs, or criteria for the distance education classroom. However, the future role of the Iowa Department of Education in assisting school officials with distance education systems will expand. The department's focus and mission towards distance education is increasing (E. Eriksen, Iowa Department of Education, personal communication, February 6, 1992). In its State Plan for Educational Excellence (Iowa Department of Education, 1991), there is recognition for the importance of distance education. "One of the most promising [technology] for use in Iowa is distance learning technology" (p.20).

Schools in Iowa developing distance education systems must first send a plan to the Narrowcast Committee for approval. The plan must be consistent with the existing state
system (Iowa. Code of Iowa, 1991, §18.136 (8)). Connection to the ICN will be implemented through local area community colleges. Schools in phase I and II are currently being surveyed concerning hookup. Site teams are currently visiting these locations checking ICN termination points, completing fiber path studies, completing designs for approval, and setting time tables for installation completion (L. Schatz, personal communication, May 18, 1992).

State funding allocations for the ICN In 1989 the Iowa Legislature appropriated $50 million over fiscal years 1990-95 to fund the system (Iowa General Assembly, 1989). Because of budget deficiencies, Iowa lawmakers, in 1990, cut the funds to $30 million for fiscal years 1990-96 (Iowa General Assembly, 1990).

Financing the ICN The Iowa Code (1991, §18.136 (3)) defines financing for the ICN. The State will pay the entire costs of phase I. Phase II and III will utilize an 80/20 percent financing plan for procurement and maintenance. The State will furnish 80 percent of the costs, and 20 percent of the costs will come from the community district being served. Because of the availability of existing technology and the variables of distance, there will be substantial cost differences for phase III installations. The Iowa Code (1991, §18.136 (3)) states that phase I and phase II must be completed before matching funds will be provided for phase III sites.

Classroom equipment is not part of the financed state project, but is a local cost. House File 774 provides for construction costs, not operation costs (Iowa General Assembly, 1989). Construction costs include fiber installation and transmission terminal equipment (codecs). Classroom costs such as cameras, monitors, and audio equipment are the responsibility of the local or regional district.
Controversy surrounding the ICN: Controversy concerning need, financing, and technology has plagued the ICN since its inception. The Narrowcast Committee emphatically stated the superb quality of the optic fiber with minimal distortion of color, sound, and motion was essential for learning.

On December 19, 1990, Kiewit Network Technology was notified of the intent to award the contract for construction of the ICN fiber backbone. Before the contract was signed, however, the Iowa Telephone Association (1990) presented to the General Assembly their opposition to the proposed contract for the ICN. Their opposition centered around the use of optic fiber. Their alternative, compressed video, utilized existing copper telephone lines, which was currently available for lease to many schools.

Before entering into a contract agreement, the Legislative Council on Jan 10, 1991, requested a comprehensive financial analysis of the ICN project by the independent consulting firm of Ernst & Young. The Ernst & Young (1991) report found compressed video unacceptable for educational purposes. "Full motion video will continue to be superior to compressed video for educational purposes for the foreseeable future" (p. ES-2). Ernst and Young recommended that key issues as the financial analysis period, the future availability of services from telephone carriers, and phase III technology options, be reviewed as the system progresses.

On April 15, 1991, Kiewit Network Technology and Iowa Department of General Services signed a contract for construction of phase I and II of the ICN. Their bid was for over $89 million. The Legislature passed a budget bill that deauthorized funds for the ICN for 1992. Iowa's Governor Branstad item-vetoed this portion of the bill on May 31, 1991, but decreased the appropriation to $3 million. Construction began in October 1991.
Current status  Controversy continues on the cost and necessity of the ICN. On October 14, 1991, Des Moines Area Community College abandoned the ICN plan, citing lack of funds (Roos, 1991, October). In November 1991, the Governor’s Committee on Government Spending Reform, commonly referred to as the Fisher Commission, recommended to proceed with phase I and II of the network (Roos, 1991, December). Also in November, the Iowa Association of Community College Trustees gave their continued support for the network (Yepsen & Roos, 1991, November 9). In May 1992, the Sioux City, Iowa, City Council voted to deny permission for Kiewit to lay fiber in their city. This would affect connections to five other counties (Fogarty, 1992, June 18).

Currently construction continues on the fiber backbone of phase I and II. A 20-year bond has been issued to pay Kiewit Network Technology construction expenses. Phase III of the ICN project is currently on hold. IPTV is not implementing construction of any phase III sites at this time (L. Schatz, Narrowcast Telecommunications, personal communication, May 18, 1992). Currently the transmission method specified for phase III sites is ITFS, but this method will be reevaluated at a future date. Officials have concerns that ITFS may not be a satisfactory medium for the phase III points.

The 80/20 financing plan specified in the Iowa Code for phase III sites is contingent upon ITFS usage. Unless the current law is changed, schools wanting a transmission medium other than ITFS, would need to finance the system 100 percent (T. Crandall, personal communication June 29, 1992).

State funding for the phase III schools currently seems remote and completion of the ICN, phase III, is not imminent (T. Crandall, Iowa General Services, personal communication, June 4, 1992). Crandall related that these schools are looking at other
options for interactive communications. Des Moines schools are creating a digital cluster, leasing fiber from public utilities. Other schools are looking into microwave, fiber lease, and compressed systems.

For schools that are not one of the original 103 points, other options may need to be explored. One solution that has had success in other states, is the cluster concept (Sarrazin, Tele-Systems, personal communication, May 21, 1992). These schools form their own small groups. The clustering facilitates the implementation of the program and serves as a support network. These cluster schools cooperate with funding and utilizing facilities. Many clusters get financial support from utilities or telephone companies. These clusters may be microwave, fiber, or compressed video (multipoint), analog or digital.

Analog microwave, analog fiber, and multipoint compressed video clusters can all hook into the ICN with the correct interface. These sites can successfully receive signals and interact on the ICN. However, these sites will not be able to be originate. Origination sites have camera control and other functions (T. Crandall, Iowa General Services, personal communication, June 29, 1992).

Distance Education Costs

Rumble states economic implications of using distance education methods can be generalized as follows: (a) significant costs are incurred irrespective of student numbers, (b) transmission and duplication costs are high for video systems, (c) conventional system costs are traditionally recurrent costs, variable with the number of students; while distance system costs can be regarded as fixed costs, amortized over the life of the course, (d) from an economic point of view, investment where student numbers are small, is normally not warranted, and (e) administrative functions are more clearly
differentiated from the academic functions in distance education systems; distance systems are more complex (Rumble, 1982, p. 119).

A large portion of the significant costs incurred in distance education systems are start-up costs. Feasley (1983) reports that interactive systems cost more and represent a delivery mode that is more difficult to share with other schools. It is anticipated that there will be an escalating of expenses for nontraditional, extended learning programs.

Start-up equipment, in the long run, can be the least expensive element of the distance education system. Although these costs appear very significant, the costs are capital expenditures that can be amortized over a long period (Giltrow, 1989; Perraton, 1982; Wagner, 1982).

In contrast, operational costs or recurrent costs can add up to be substantially larger costs over the longer term (Shobe, 1986). These are costs of goods and services that are consumed within a budgetary period. These recurrent costs are those needed to run the system each year, as those associated with maintenance, salaries, or lease fees (Rumble, 1986a). Many districts underestimate these recurring costs (Eicher, 1987; Foks, 1988; Weeks, 1987). Learn Alaska Network, a telecommunications-based educational project, was undertaken by the Alaska Department of Education and the University of Alaska. This system closed after six years, in 1986, a determining factor being the underfunding of operating costs (Hersfield, 1986).

The purpose of cost analysis is to identify the main generators of cost and to study how costs change as input and output variables change (Kaye & Rumble, 1981). A cost analysis endeavors to discover all the costs involved in a particular activity (Perraton, 1982). Adams, Hankins and Schroeder (1978) defined cost analysis as any manipulation of cost data
that provides relevant information for those who make decisions. A common method is simply "a direct comparison method between or among the costs of specific decision alternatives, e.g., a make or buy decision" (p. 24). Other terms used frequently in cost studies are cost-effective and cost-benefit.

Cost-effectiveness studies measure the various costs of different ways of achieving the same end. Cost-effectiveness involves calculating unit costs by the number of students or number of courses (Markowitz, 1990). In this method, it is assumed that all students learn equally.

Cost-benefit analysis measures the benefits in terms of money; a value is put on worth. In cost analysis and cost-effectiveness analysis, concern is with costs of education. In a cost-benefit analysis, besides dollar costs, there are time and social costs (Batey & Cowell, 1986).

The Technology Aspect of Interactive Television

Setting up the system

Choice of any interactive distance education system should focus on the education provided and needs met, not the technology (Batey & Cowell, 1986; Ostendorf, 1989a). Successful efforts result from systems created in response to real teaching/learning problems (Ely, Januszewski & LeBlanc, 1988). The technology should play a supporting role (Daley, 1991). Emphasis should be on benefits, not costs (Kitchen & Kitchen, 1988; National School Board Association, 1989).

Technologies for interactive systems are complex, with a larger reliance on external contracting for services (Rumble, 1986b). There are few true "package" systems. There are various pieces and multiple components. The best approach is to contact others who have
experienced success (Barker, 1987; Ostendorf, 1989a). A recommendation from experienced administrators is that it is prudent to buy the most versatile equipment possible (Kober, 1990). The cheapest and quickest solution is not always the best solution (Giltrow, 1989).

Realistically, school districts must accept technology that is available and feasible (Kitchen & Kitchen, 1988). Infrastructure currently in place may be feasible to lease. Choice of technology is based on: (a) purpose, (b) cost, (c) geographic location, (d) topography, (e) distance, and (f) personal preference. System reliability, low maintenance cost, assured accessibility, and cost containment are factors that make some technologies more suitable than others (National School Board Association, 1989).

Digital or analog technology?

Fiber and microwave transmission methods are capable of sending either analog or digital signals. Analog is usually less costly because equipment needed to convert the signal to digital is not necessary (D. Takkunen, Todd Communications, personal communication, April 27, 1992). Analog signals require about one-tenth the capacity of digital signals. But, analog signals degrade over long distances.

The advantage of using digital signals is higher picture quality and higher transmission speed over long distances; digital is more rugged and immune from degradation caused by noise and distortion (Carter, 1992; Currer, 1991). Digital is versatile and can hook into available networks. The digital transmitter acts as a multiplexor, combining video with data, facsimile, or audio, and then transmitting everything over the same fiber. Analog signals do not permit this capability. The move is towards digital, driven by the evolving all-digital telecommunications network (Freeman, 1991).
Consultants

Fiber, microwave, and compressed video systems require complex installation schemes. Because each system requires a somewhat custom design, it is best to seek technical advice. A study completed by Hobbs (1990) found nearly all districts depended on outside consulting services to implement distance education technology. This consulting was either through the Department of Public Instruction, an equipment dealer or supplier, the local telephone company, a private consultant, or a nearby university. Technical problems were still encountered in 70 percent of these systems, and implementation costs varied widely. Findings indicated a need for readily and widely available information and technical assistance for those operating distance education systems.

It is advisable to hire consulting services to handle the entire procedure of installing a distance education system. A consulting firm should perform: (a) informal discussion and planning, (b) system design, (c) Federal Communication Commission (FCC) engineering and license applications, (d) site surveys, (e) path profiles, and (f) expansion of existing systems. The firm usually should take total responsibility for the system including: (a) products, (b) installation, (c) testing, (d) training, (e) warranty, and (f) maintenance (Todd Communications, 1992).

Purchase or lease

Purchase System ownership has these advantages: (a) known costs over life of system, (b) use of the full transmission capabilities of the system, (c) ability to modify equipment, (d) complete system control, (e) ability to upgrade as technology changes, and (f) no future rate increases.
Disadvantages to purchase are: (a) large capital expense, (b) maintenance of the facility, and (c) liability of ownership (Todd Communications, 1992).

**Lease**

There are several lease advantages: (a) maintenance is usually included in a lease, (b) no ownership liability, (c) ability to terminate from lease at end of a period, (d) smaller start-up costs, and (e) predictable payment rates.

The disadvantages to a lease arrangement are: (a) difficulty of changing facilities during the lease, (b) bandwidth restrictions, and (c) maintenance response is dependent upon an outside party (Todd Communications, 1992).

Each media system for lTV has its own distinct advantages and disadvantages, capabilities and limitations. Compilation and analysis of data confirmed that there is no one best method (Barker, 1989b). Existing environmental factors and infrastructures can make each technology a possible "best" solution. The next section will present a discussion of each transmission medium.

**Fiber optics technology**

Fiber optics is one of the newest two-way, interactive technologies. The cable, made of glass or plastic, transmits light signals instead of electrical signals. An optical fiber consists of an inner cylinder called the core, surrounded by a cylindrical shell of glass or plastic called the cladding. The cladding layer keeps light from leaking out. An outside coating provides protection against the elements. Light rays travel in straight lines, but optical fiber guides them around corners. The number of fibers is unlimited, creating virtually an unlimited capacity. Optical fibers are capable of transmitting far more information than copper wires or coaxial cables the same size.
Equipment required for a fiber system

The main components of a digital fiber system are: (a) multiplexor; (b) codec; (c) optical transmitter; (d) optical receiver or photodetector; (e) fiber cable; and (f) repeaters (see Figure 1).

The multiplexor converts the signal to/from an electrical signal. The codec changes the signal to digital. The optical transmitter converts the signal to an optical signal, and the receiver reconverts the optical signal. Transmitters are of two types, lasers (ILD) or light emitting diodes (LED). The receivers are either positive-intrinsic-negative (PIN) or avalanche photodiode (APD). Generally speaking, the APD is used for systems greater than 100 km (.62 miles) and PINs are preferred for shorter distances. The repeater is a signal amplification device often used along cables to extend transmission distances. The fiber cable carries the optical signal. Single mode and graded index fiber is best suited for long distances. An analog system would eliminate need for the codec. A modulator/demodulator would replace the multiplexor unit; additional amplifiers would be necessary. Life expectancy of this equipment is 20-25 years.

Advantages of a fiber system

- The large bandwidth of fiber allows audio, video, and data to be combined on one line which results in a lower cost per channel.
- Fiber permits full motion broadcasts.
- The low attenuation rate allows for transmissions over long distances without distortion.
- The large capacity for channels means the system can be easily expanded.
- There is high security with no possibility of tapping, eavesdropping, jamming or metal detecting.
- The small, lightweight cables are easy to handle and install.
- Fiber is unaffected by weather, corrosive liquid, or gas.
- Fiber is unaffected by electromagnetic currents, static interference, electric motors, fluorescent lights, and radiation.
- Durable fiber results in low maintenance costs.
Disadvantages of a fiber system

• Systems require high start-up costs.
• Special tools and tests are needed to install the fiber.
• Repairs can be lengthy and costly.
• Light sources have limited lifetimes and associated system reliability problems.
• Future expansion to a new school is expensive if no fiber exists.
• Right-of-way acquisitions for placing cables in the ground can be costly.

Successful users of fiber systems

The following groups have reported on successful fiber based systems: (a) MSET Mid-State Educational Telecommunications Cooperative, Minnesota (Giltrow, 1989; Kitchen, 1987; Kitchen & Kitchen, 1988; Lanier, 1986); (b) SHARE-ED Oklahoma Panhandle Video Network (Barker, 1989b; Currer, 1991); (c) Mississippi 2000 (Currer, 1991); (d) Bergen County, New Jersey (Daley, 1991); (e) FOCIS Fiber Optics Communication Instruction System, Des Moines, Iowa (Ostendorf, 1989a; Schoenenberger, W., personal communication, April 14, 1992).

Positions relating to fiber systems

"It is possible to confidently claim that this [fiber optics] is one of the more important technological advances of the past 20 years" (Giltrow, 1989, p. 55). Fiber optics is increasingly being chosen as the preferred method of transmission by Minnesota schools because of the possibility of future expansibility (Minnesota State Dept. of Education, 1990). Fiber lends itself well to two-way, interactive television due to high channel capacity (Kitchen, 1987). The cost of fiber cable is widely expected to fall below coaxial or copper cables in the early 1990s (U.S. Congress, 1989); it will be competitive with microwave and coaxial cable (Kitchen, 1987). The cost/performance ratio for fiber continues to improve. In the last ten years, fiber transmission has become the medium of choice in telephony applications (Szentvesi, 1991). Fiber is the technology that most closely duplicates the normal classroom. To use a network to the fullest capacity and get the most for your money, use digital fiber (Currer, 1991).
Fiber offers the best audio transmission quality (Barker, 1989b). Fiber should be chosen over microwave, ITFS, and coaxial because of the image quality (Lanier, 1986).

**General costs for fiber systems**  The Office of Technology Assessment (OTA) reported the following general costs for fiber optic hardware: (a) analog transmitter and receivers, $12,000; (b) repeater, $24,000; (c) laser modulator, $2,000-$3,000; (d) codec, $8,000-$60,000; and (e) additional termination equipment, total $45,000. To purchase fiber for a 134 mile network would be approximately $8,955/mile (U. S. Congress, 1989, p. 174).

Maintenance costs are one percent per year of system cost (National School Board Association, 1989). These costs refer to those needed to keep the system operating once it has begun. The costs include equipment service and repair. Fiber systems, once installed, are low maintenance; however, if the fiber is accidentally cut by a backhoe, for example, repairs are very expensive and slow.

**Microwave technology**

Microwave signals are transmitted through the air on electromagnetic waves. Microwave is similar to standard broadcasting, except it transmits on a much higher frequency, has a shorter wave length, and is point-to-point. Each tower in a microwave relay system picks up the signal, amplifies it, and retransmits it to the next line-of-sight tower on the way to the destination point. Prior to the development of satellite communication, microwave transmission represented the only reliable form of intercity and coast-to-coast communication (Hart, 1986).

Long haul systems use a number of repeaters and cover hundreds of miles. Short haul systems are used where traffic loads are relatively light, or the length of the route is short.
The typical range of 5 to 15 miles is suitable for local communication between two schools. The distance between repeaters depends upon: (a) topography, (b) antenna size, (c) transmitter power, and (d) receiver sensitivity. A good rule of thumb is to consider microwave if two sites are more than one-half mile and less than 15 or 20 miles apart. A good use of a microwave system is to link two buildings in the same metropolitan area. Short-haul systems are relatively simple to construct and operate and do not require state regulatory approval or right-of-way clearance (Ostendorf, 1989a).

**FCC regulation** To set up a private microwave system, it is necessary to file FCC Application Form 402, *Station Authorization in the Private Operational Fixed Microwave Radio Service* (Appendix H). Depending upon the frequency, it can take three to nine months to get the FCC license approved (T. Crandall, personal communication, June 29, 1992). The Code of Federal Regulations (CFR), Chapter 47, (1991) lists all the necessary information needed in applying for the microwave license. The following are sections of Chapter 47 most useful: Part 1 details general rules for applications. Part 17 gives tower and antenna specifications. Part 94 lists rules for private point-to-point systems.

CFR §1.1112 (c) lists general exemptions to charges and specifies noncommercial education. CFR §73.503 defines noncommercial educational broadcasting as, "transmit programs to specific schools in a system for use in connection with the regular courses as well as routine and administrative materials pertaining thereto."

When setting up a microwave system, it is necessary to check with the Federal Aviation Administration (FAA) regarding airport safety. This is the first clearance needed before proceeding with the system. FCC applications that include antenna structures over 20 feet need to attach FCC Form 714, which specifies FAA clearance. If constructing a tower over
200 feet, a proposed construction FCC Form 7460-1 must be filed (CFR, 1991, §17.2)

Equipment required for a microwave system. The main components of a microwave system are: (a) tower, (b) antenna, (c) antenna feed line, (d) transmitter/receiver, (e) modulator/multiplexor, and (f) power unit (see Figure 2).

The antenna is one of the most important components because system performance is dependent upon antenna characteristics. The antenna takes a signal and reflects it in a narrow beam. Receiving antennas reflect scattered low-energy signals back into a focal point. The transmitter is a device that produces a wave of power and frequency suitable for conveying the information through the atmosphere. The receiver produces a signal from the wave it receives so that it can be used by the demodulator. The modulator raises the signal to microwave frequencies. A demodulator reverses the process. The transmitter uses waveguides or coaxial lines as antenna feeds to carry the signal from the radio equipment to the antenna and vice versa (Freeman, 1991). A digital microwave system uses a multiplexor unit; the analog system uses a modulator/demodulator. A battery unit is necessary for power. The size of the power unit is dependent upon distance.


A repeater station receives a weak signal on a specific frequency, increases its power, and then retransmits the signal to the next station. If the distance between two points is over 30 miles, the link is established in several hops using relay stations. The path from
transmitter to transmitter is a hop (see Figure 3 (a)). This figure illustrates a two hop transmission. FCC applications are based on transmitter sites (Burt, Electronic Engineering, personal communication, June 9, 1992; Microwave Branch, personal communication, June 24, 1992). A two hop system requires three license applications for points A ↔ B; BA ↔ BC; and C ↔ B. A passive repeater is used to go to the top of a mountain and back into a valley or to go around a building obstructing the path. Passive repeaters are used only for short distances. Passive repeater stations do not require transmitter and receiver equipment, as they reflect signals rather than retransmit (see Figure 3 (b)). The use of repeater stations is complex and expensive, and is rarely employed in school systems (Ostendorf, 1989a). The life expectancy of microwave equipment is 7-10 years.

**Advantages of a microwave system**
- Microwave allows for full-motion video broadcasts.
- There is control over who receives the signal.
- Audio and video signals have excellent signal-to-noise ratios.
- Numerous data and audio signals can be transmitted along with video channels.
- A properly designed system can have 99.999% reliability (Todd Communications, 1992).
- No right-of-ways are required.
- Maintenance costs are low.

**Disadvantages of a microwave system**
- Systems require high start-up costs.
- Transmissions are affected by weather, especially fog, rain, and lightning.
- Atmosphere differences can cause fading of signals.
- Equipment can fail and power outages can occur.
- Adding channels to a system is not easy.
- 30 miles is the maximum distance between towers.
- An FCC license is required
- A limited number of frequencies are available for high traffic areas.
- Towers are almost always needed and space or location is difficult to obtain.
- Adverse terrain can increase equipment and tower costs.
- Special building permits may be needed.
Successful users of microwave systems  The following groups have reported on successful microwave systems:  (a) WHETS The Washington Higher Education Telecommunication System, Washington State University (Nelson, Cvanca & Peters, 1989; Oaks, 1986); (b) TWIT Two-Way Instructional Television at Morning Sun, Iowa (Nelson, 1985); (c) TIE Televised Interactive Education Eastern Iowa Community College District (Kabat & Friedel, 1990, Wallin, 1990); (d) TAGER Texas Association for Graduate Education and Research at Dallas-Ft Worth, University of Texas at Dallas (Hart, 1986); (e) KTS Kirkwood Telecommunications System at Kirkwood Community College, Cedar Rapids, Iowa (Hart, 1986; Hudspeth & Brey, 1986); (f) KIDS Knowledge Interactive Distribution System, Minnesota (Descy, 1991).

Positions relating to microwave systems  "A two-way, interactive microwave system is a very effective and viable alternative choice" (Nelson, Cvanca & Peters, 1989, p. 5). Short haul systems have decreased in cost, while digital systems have improved performance, creating an increase in microwave systems (U. S. Congress, 1989).
"Terrestrial microwave systems have long since reached their capacity" (Tomasi & Alisouskas, 1988, p. 304). Microwave is more costly on a per channel basis (Lanier, 1986). Despite the high cost of microwave terminal equipment and the need to build expensive towers to mount the aerials, microwave is often cheaper than the cost of negotiating easements and payment of rent for installing cable. In many cases, access makes anything other than microwave a practical impossibility (Brewster, 1986).

General costs for microwave systems  A microwave duplex system may cost $40,000-$65,000, plus towers, which range from $25,000-$75,000 each (Kitchen & Kitchen, 1988; U. S. Congress, 1989). Short haul systems may cost $35,000, plus towers, ranging
from $5,000-$50,000. Knowledge Interactive Distribution System (KIDS) dishes and equipment were $30,000-$40,000 (Descy, 1991).

Maintenance costs are three to five percent of the system cost per year (Kitchen & Kitchen, 1988; National School Board Association, 1989; U.S. Congress, 1989). These costs refer to those needed to keep the system operating once it has begun and include equipment service and repair and monthly maintenance fees. Microwave maintenance may result from adverse weather conditions. These systems also contain a large amount of electronics that can fail.

Compressed video technology

Compressed refers to digital video, audio, and data signals that are processed to reduce the amount of information required for transmission, reducing the bandwidth required. Compressed video is sent over fiber, satellite, microwave, and most often, high capacity digital service lines (T1). In compressed video, redundant information is removed. For example, in several frames the background does not change. This information is sent once, and in following frames, the background remains in memory. The system is used as easily and as readily as the telephone. Video compression is achieved by sacrificing some color, motion, or resolution information. Although there is some loss of quality, compressed video can be a viable alternative in many educational situations.

Equipment required for a compressed video system

Each system site must have: (a) codec; (b) transmission line; and (c) interface unit (see Figure 4). The codec converts the analog signal to digital format and compresses the signal with special algorithms. The transmission line is usually a T1 line (see below). The channel service unit (CSU) is the interface between the end user and the telephone T1 line. The CSU works in conjunction
with the data service unit (DSU) which translates and controls the signal for the T1. This unit functions similar to a modulator/demodulator.

T channels refer to a band of high speed, high capacity circuits devised to carry digital voice, audio, and data signals. These digital, full duplex transmission facilities (T1, T2, T3) are classified by the megabits per second (Mb/s) they transmit. A T1 facility transmits up to 1.544 Mb/s; the T3 facility transmits up to 45 Mb/s (equivalent of 28 T1 channels). Signals carried on T facilities are classified by the digital signal level or pulse code modulation line rate (DS1, DS2, DS3). A DS1 signal level has a transmission format in which 24 telephone voice channels can be multiplexed into one T1 channel. T1 facilities and DS1 signals are the technology most often used with compressed video systems. The DS1 signals have bandwidth capability for compressed video only; they do not have the necessary bandwidth for full motion video as the DS3. The T1 facilities are currently in place as regular copper telephone lines. With the purchase of codecs and installation of equipment, schools are ready to transmit interactive video systems. The T1 transmission lines can be leased from telephone companies or public utilities.

ISU distance education classroom study committee During fall semester, 1991, a compressed video system was installed between Iowa State University and the Des Moines School System's Central Campus building. The purpose of this system was to offer off-campus courses and to evaluate the effectiveness of compressed video. US West Communications made available, on a short-term loan, the equipment used in the system. Operating costs were recovered from the tuition generated from off-campus students.

Based upon the results of this experiment, a proposal was launched and funding provided to implement a distance education classroom using compressed video for the fall of
1992. A study committee was appointed to examine the transmission and classroom aspects. Appendices I-M exhibit data relevant to the Iowa State University compressed video classroom.

Committee discussions and vendor proposals centered around these points:

1. Standards. The Consultative Committee on International Telephony and Telegraphy (CCITT) set forth a family of standards, P x 64, that set video coding standards of compression and resolution quality. Vendors now utilize the H.261 standard that allows codecs from different vendors to communicate. There are additional facets of P x 64, which include standards for multipoint, encryption, and shared graphics handling, that are still under consideration. Some vendors go beyond the standards with proprietary algorithms.

Successful tests of interoperability have been completed among VideoTelecom Corporation (VTC), Compression Labs Incorporated (CLI), and PictureTel Corporation (PTC) codecs (Appendix M). Even though codecs from different vendors successfully communicate, the standard does not include support for camera control, voice activation, and keyboard sharing. The H.261 standard algorithms do not produce as high a quality as that of proprietary algorithms of individual vendors. A 384 kb/s may be acceptable from one vendor, but when run through another vendor's codec, the quality may be unacceptable. To attain the highest quality and best results, it is best to purchase and communicate with codecs from the same vendor.

2. Transmission rate. In the past, users of compressed video were limited to combining two 56 switched telephone lines to gain a 112 kb/s rate or using the full service T1 service. Recently multiple vendors have begun to provide fractional T's. This service makes it possible to realize the full cost saving of video compression. Fractional T's allow
more flexibility. With a transmission rate of 384 kb/s, the customer pays for the used portion, or allots the remaining T to other uses. Currently not all vendors have the fractional T1, but availability should increase. Although the price rate is not one-half the rate for a one-half T, over a year's time period, there can be significant dollar savings.

The quality of the video is determined by the transmission rate and motion handling. Codec engineers are continually increasing the processing power, or motion handling, so codecs can transmit more on less bandwidth with excellent results (B. Bruce, VideoTelecom, personal communication, June 4, 1992). The higher transmission rate also affects the quality of video. The wider bandwidth (full T1, 1.544 Mb/s) provides a noticeable difference when compared to the smaller bandwidth transmission rates (one-quarter T1, 384 kb/s). (On-site visit, State of Minnesota, Department of Administration, St. Paul, MN, June 12, 1992). VTC and PTC have a strong market with a transmission rate at 384 kb/s. CLI has the market with the high-end codec which transmits at 1.544 Mb/s.

3. Frame speed. Compressed video is available at 30 frames per second at 384 kb/s and 1.544 Mb/s. The P x 64 standard 30 frames per second is not the same 30 frames per second of full motion video. The P x 64 standard rates pixels per screen while the National Television Standards Committee (NTSC) analog motion does not have pixels. The P x 64 thirty frames per second means the picture is refreshed or updated every 30 seconds. Differences in picture quality can exist within this standard, for different vendor's codecs refresh different elements as color, gray scale, or motion. There are various ways to meet the specifications of the standard (M. McQuiston, US West, personal communication, June 23, 1991).
Advantages of a compressed video system

• The equipment is easy to install and use with little training required.
• Compressed video is readily installed with T1 lines already in place.
• Compressed video requires less bandwidth and therefore costs less for transmission.
• There is flexible adjustment of the data rates with two levels of picture resolution.
• Compressed video can have a price advantage over fiber or microwave in long distance installations or systems in hostile terrain.
• Compressed video interfaces with existing systems and is easily upgradable (Todd Communications, 1992).

Disadvantages of a compressed video system

• Systems require high start-up costs.
• Motion can become jerky.
• The color may be substandard and the picture may be less clear.
• There is dependence upon the lease-lines of the utility supplier.
• Compressed video systems can not transmit full motion video.

Successful users of compressed video systems

The following groups have reported successful compressed video systems: (a) California State University Campus, Bakersfield (Ward, 1990); (b) V.E.I.N. Video Education Interactive Network, Wyoming Center for Teaching and Learning at Laramie (Edwin, Owens & Rezabek, 1991); (c) Penn State (Phillips, 1987); (d) IVN Interactive Video Network, North Dakota (Tykwinski & Poulin, 1991); (e) University of Minnesota (Kolomeychuk & Peltz, 1991).

Positions relating to compressed video systems

Compressed video is perfectly acceptable for some learning situations. If a user wants to duplicate the traditional classroom setting as closely as possible, full motion video is needed (Currer, 1991). The transmission rate of compressed video image approaches broadcast quality, the most notable difference is that fast moving objects will sometimes blur (Tykwinski & Poulin, 1991). The increasing availability of DS3 due to extensive fiber installation has had an effect on the compressed video market. The future of video compression will be determined by one of two
factors: (a) the ability to provide inexpensive compression technologies or (b) the availability of low-cost bandwidth for transmission. If cost and supply of bandwidth is low and abundant, most of the market will stay with the full motion. Applications in higher education have utilized compressed systems with apparently no loss of learning or communication (Keller, Staab, & Stowe, 1989). However, "The point at which quality has climbed and costs have dropped sufficiently to allow widespread use in higher education is still a ways off" (p. 12).

Research regarding compressed video systems A study in Japan experimenting with compressed video supported the conclusion that compressed video had practical use for teaching at a distance in an interactive environment (Wakamatsu & Obi, 1990). A study conducted by the Applied Research Institute (cited in Keller, Staab & Stowe, 1989) found: (a) Compression technologies have come a long way since the early days, (b) signals have been compressed more and equipment costs have dropped, while picture quality has remained relatively good, (c) compression devices can now digitize and blend (multiplex) signals so information can be sent simultaneously, (d) the hardware and software are still expensive even though prices have decreased, (e) standards are emerging for compatibility among vendors, and (f) available T-1 lines make this transmission cost-effective.

Jurasek (1992) conducted an effectiveness study of Iowa State University classes taught using the compressed video technology. Students displayed positive attitudes toward instruction on the compressed video system. Students adjusted rapidly to the compressed video technique, and felt the convenience of having the remote site far outweighed any picture quality loss or technical problems.
General costs for a compressed video system  In North Dakota, the implementation costs for compressed video digital systems averaged $29,502 per school in comparison to analog fiber systems that averaged $60,706 per school (Hobbs, 1990). Compressed video systems range in cost from $20,000-$300,000 (Ostendorf, 1989a).

Developing a distance education system is a complex process. As discussed in this section, each transmission system has unique characteristics. There are multiple components and variable equipment pieces connected with each technology. Those adopting distance education must be prepared to evaluate each technology according to identified needs, financial constraints, and existing capabilities. Following is a discussion on the interactive classroom and production equipment.

The Interactive Television Classroom

Classrooms for ITV are of two types. The first type is a production studio, comparable to a television studio, which requires special lighting, special control room, and crew. The second type is the electronic classroom. In this classroom, there is no control room; the technology is operated by the instructor. This classroom is both a television studio and learning environment. Except for talking to the teacher or students through a monitor, this classroom is relatively traditional. The concept is to make the technology as transparent as possible, to appear as a classroom not a studio.

"For limited production needs, a modest investment in space and equipment can provide considerable return in terms of meeting the needs of remote learners" (Hudspeth & Brey, 1986, p 39). In the SHARE-ED system, individual school equipment and classroom renovation costs were $5,500 (Barker, 1989b). Classroom equipment costs of each site in the MSET system were $18,000.
Physical characteristics

Various examples of distance education classrooms were discussed in the literature. Following are characteristics that were described as important considerations in planning. The design and layout were similar in most of the systems.

Size The space can be a conventional school room, which typically is about 25 feet x 35 feet. Converted classrooms can be used as long as acoustical, lighting, and other needs are met (Hudspeth & Brey, 1986). Hughes (1988) stated that the room should be longer than wide, and, if a remote site, should be located near an indirect supervision potential, e.g., media center.

Soundproofing Soundproofing may be necessary to exclude exterior noise and to reduce classroom noise. Since sound can enter anywhere air can enter, all holes and gaps in or between walls, floors, and overhead structure should be filled and sealed. Doors should be of solid construction and equipped with floor sweeps and weather stripping (Price, 1991). Windows should be avoided if possible. Additionally, the walls, floor, and ceilings should be sound resistant and constructed of dense materials such as concrete, solid masonry, or double layers of gypsum board (Hudspeth & Brey, 1986; Price, 1991).

Interior noise is generated by ventilation systems, fluorescent lights, television monitors, furniture, and other equipment. Ventilation systems that lessen distraction should be selected. Ventilation systems should run constantly at a low pressure, if possible. Systems that cycle on and off are very distracting and may require users to make constant audio adjustments. To test a planned distance education room for external and internal sound disturbances, tape record the room when not in use. This tape will indicate outside noise disturbances and noise distractions from such things as ventilation and lights within the
room (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).

**Decor** Esthetic considerations of the classroom facility are fairly subjective. There are, however, particular items that do affect quality. Background color is particularly important for two-way video systems; there should be no complex patterns. All surface finishes should be non-glare. Reflective materials such as chrome, glass, and shiny plastics create distracting glare that can be reflected onto monitor screens.

**Lighting** Television is best viewed in normal light or a slightly dimmed room. Natural light from windows and skylights is usually too bright for television monitors and can cause glare on the screen. This can be controlled by draping or by facing the monitors away from windows. However, television cameras require light to capture images, so make sure room lighting is adequate. For most purposes, common fluorescent light fixtures provide adequate and economical lighting. In the typical classroom, no special lighting is needed (Ostendorf, 1989a).

**Classroom arrangement**

Two-way video classrooms have few possible arrangements. Participants must be seated in relation to cameras and microphones. This limits the configuration of the room and the size of groups. Students should be seated so they can see each other and not have to turn to face the camera. Monitors should be placed in the front and possibly rear of the room so participants and instructor can maintain continuous visual contact (Fink & Tsujimura, 1991).

It is best to avoid placing monitors in a corner; this can diminish the importance of the material being presented and can create awkward viewing angles (Price, 1991). A viewer
should not have to look up at an angle greater than 30 degrees (Price, 1991; Wood & Wylie, 1977). Looking upwards at a sharp angle for long periods can be tiring and uncomfortable. Monitors should be ceiling or wall mounted, four to six feet off the floor, if possible (Wood & Wylie, 1977). Remote site monitors should simulate the eye level of the instructor.

There should be comfortable seating for students and teacher (Minnesota State Dept. of Education, 1988). Individual comfort and appropriate style should be the highest priority. For extensive note taking or working with materials, each learner should be provided with a 20-24 inch deep table in front of his or her chair.

It is best to avoid a large class size. By keeping classes small, students will interact more readily and use the system more fully (Lanier, 1986). Optimum class size is 15 to 25 students (Barker, 1989b; Bowman, 1986).

**Teacher station**

An important element of the system is the teacher station. There are various forms--table, desk, lectern, or special built podium. The teacher station always faces student seating. Putting this station on a riser increases visibility (Minnesota State Dept. of Education, 1990).

The desirable method is for the teacher to have full control of preset cameras, lights, monitors, and various auxiliary equipment. With this method, there is no need for extra technical personnel. This promotes an instructional format like the traditional classroom; therefore, teachers do not need to completely change teaching strategies (Currer, 1991; Greenwood & McDevitt, 1987; Minnesota State Dept. of Education, 1990).
Equipment

There should be standardization of equipment and installation, so in case of breakdowns, spare parts or items are transferable. Identical equipment makes it possible to verbally instruct someone on how to adjust equipment at remote sites, and with identical equipment, either site can serve as the originating site (Minnesota State Dept. of Education, 1988; Randall & Valdez, 1988).

Microphones Sound quality is the most problematic aspect of distance education systems; it is the most often reported physical complaint (Bowman, 1986; Descy, 1991; Fink & Tsujimura, 1991; Hobbs, 1990; Price, 1991). Each component of the audio system should be of highest quality (Ostendorf, 1989b; Price, 1991).

Two problems occur in sound systems, feedback and echo. Feedback is caused when microphones pick up sound from the speakers, producing over amplification. A piercing squeal from the speaker results. Any time open microphones and open speakers are in the same room, feedback is a potential problem. This can be alleviated by separating the microphones and speakers. Directional or cardioid microphones should be chosen so excess noise in the room is not picked up. Feedback is also caused by turning the gain or amplitude of the microphones too high. This problem does not occur if adequate microphones and speakers are purchased (M. Darbyshire, Media Resources, personal communication, April 8, 1992).

Echoes in the room are caused by sound reflections off smooth surfaces as hard walls, floors, and ceilings. The shape of the room, the floor, ceiling, and walls all affect this reflection. Acoustics is the control of sound reflections in the room. A properly acoustic room will not have echoes. To reduce echoes, install acoustical ceiling tile and acoustical
wall covering. Carpet is the best and least expensive sound absorber to improve acoustics in
the room (Hughes, 1988; Minnesota State Dept. of Education, 1988; Price, 1991).

Television does not add to acoustical difficulties already existing in a room, but it does make
them more important. Acoustical problems in the class can seriously impair learning
(Smith, 1961).

**Cameras**

Most interactive classrooms have three cameras. One is focused on the
students, the second on the teacher, and the third is at the desk or above the instructor,
focused on graphic materials (Barker, 1989b; Bowman, 1986; Currer, 1991; Lanier,
1986; Minnesota State Dept. of Education, 1990; Nelson, Cvancara & Peters, 1989; Oaks,
1986). Using just one camera would allow no variation in the image, but less elaborate
productions could use only two cameras (Ostendorf, 1989b). Some classroom systems have
a fourth camera focused on students (Fink & Tsujimura, 1991).

Remote zoom and auto focus on cameras are recommended (Hughes, 1988; Minnesota
State Dept. of Education, 1988; Oaks, 1986). Remote tilting and panning can also be added
as extra features.

**Monitors**

Monitors allow the instructor and origination site students to view students
at the remote site. Monitors also allow the instructor to view what is being transmitted.
Monitors at the remote site show what is being transmitted, whether it be the instructor,
written material, or a shot of the origination site’s students.

Most systems use 21-25 inch monitors (Barber, 1989b; Minnesota State Dept. of
Education, 1988; Smith, 1961); others use large screen projections (Fink & Tsujimura,
1991; Greenwood & McDevitt, 1987). Some systems use a split screen to present the view
from two cameras. Hughes (1988) remarks that the split screen makes remote sites even
smaller and seemingly more remote. He suggests using additional 25 inch monitors.

**Visual presenter**  This device functions like an overhead projector. It is located at the teacher station to the right of the instructor. A color camera in the device projects photographs, charts, maps, and three dimensional objects. The camera has the ability to zoom in on a platform where materials are placed. This device has the same function as an overhead camera above the instructor.

**Telephone**  A telephone provides alternative communication in case of emergency or equipment failure. It also allows for student/teacher one-on-one, semiprivate/private conversations. A telephone allows the teacher a direct link to the remote site (Minnesota State Dept. of Education, 1988; Randall & Valdez, 1988).

**Facsimile machine**  A facsimile transmits printed copy from classroom to classroom in 30 seconds. It can be used to supply immediate feedback for tests and corrected assignments (Descy, 1991; Minnesota State Dept. of Education, 1988). A facsimile may not be necessary if there is a dependable delivery service, or a traveling teacher or administrator.

**Videocassette recorder (VCR)**  The VCR, obviously, is used to record class sessions. This recorded class has many uses. It is used by the student who has been absent. Special class sessions can be recorded for future use. Tapes provide a backup in case of technical difficulty. The tapes provide a record of distracting student behavior. The instructor may review the tape for self-critique (Minnesota State Dept. of Education, 1988; Randall & Valdez, 1988). The VCR is located at the teacher station and wired into the room control mechanism. A second VCR is added to the system to play videocassette tapes as class
presentations. This VCR can be located at the teacher station or on a separate shelf or cart that is easily accessible by the instructor.

**Auxiliary equipment**  In-class presentations may require the use of a videodisc player, a videocassette player, a tape recorder, or a record player. This equipment can be located in the room on a cart and plugged into the system as an auxiliary input. Films and slides may also be shown as an in-class presentation by projecting the film or slides onto a projection screen and focusing either the teacher, student, or visual presenter camera on the screen. If there are many slide and film presentations planned, slide/film to video converters should be purchased.

**Computers**  Use of computers as an auxiliary input requires special equipment. Computer outputs have different resolution capabilities and different scan rates than television monitors. Special equipment is needed to interface the two types of video. Output from high resolution computers must be converted down to the NTSC video standard. There are various options depending on the computer type. Best results are gained by purchasing multi-scan monitors or high quality video scan convertors, but these are expensive solutions. For occasional use of computers, a camera can be focused on the computer monitor. If continuous use of computers is necessary, the various options need to be explored, depending upon the particular computer: purchase internal computer cards, external scan convertors, or multiscan monitors. External scan convertors are priced according to quality and capability to convert the signal.

**Summary**

This chapter provided a review of the literature relating to distance education, particularly, the two-way interactive classroom. The main topics were theory of distance
education, the impact of distance education, distance education costs, the technology aspect of interactive television, and the interactive classroom.

Literature of distance education has four features: (a) Much of the literature exists in the form of occasional papers; (b) most distance education literature tends to be conceptual providing direction rather than theory; (c) distance education research tends to be descriptive presenting results of observational data, case studies or survey research; and (d) distance education literature is more international then national (Wagner, 1989).

Literature relating to a theory of distance education stated two views: one, distance education is a mode of traditional educational pedagogy; or two, distance education is a separate pedagogy. Most educators in the United States consider distance education as a resource to promote the learning process within the traditional educational pedagogy.

The literature revealed that distance education is gaining popularity in the United States and interactive systems are the most popular. There is evidence to support that interactive classes are effective and successful. Iowa schools are affected by the creation of the Iowa Communications Network. The Iowa oriented distance education literature revealed there is still much controversy concerning funding and hardware use. It may be years before some rural Iowa schools can take advantage of this resource.

Literature relating to distance education costs reported that start-up costs of the technologies of fiber, microwave, and compressed video are high, but these systems are still viable options. It is standard practice to amortize these high start-up costs over the lifetime of the system and divide by the number of students served to get a more realistic cost. Operating costs are also found to be significant expenses that are often underestimated.

The literature, relating to the transmission technologies of fiber, microwave, and
compressed video, reported that each technology in particular circumstances can be the
"best" and most cost-effective method. The choice of systems is not only affected by cost but
environmental factors, current infrastructures, needs, and benefits.

The literature presented various descriptions of interactive classrooms. The design and
layout of the classrooms were similar throughout. Basic equipment requirements were also
consistent. There was limited information in the areas of audio equipment and system
control aspects. No particular methods were prominent in the literature.

Based on the literature, it appeared there were few studies that specified detailed costs
for the three transmission methods. Information available regarding the specific
technologies was technical and not written in the context of distance education. It was
difficult to find complete, nontechnical information listing major cost variables affecting
each transmission system. A study detailing specific variables contributing to the total
costs of creating a distance education system would be helpful to distance educator planners.

This study determined the costs for creating an interactive television classroom used
for distance education. The start-up and general operating costs were determined for the
classroom and transmission hardware. This study also determined major cost variables for
each transmission technology and compared them. Decision makers can apply the cost
variables, equipment requirements, and cost comparisons to fit their specific situations and
needs. The next chapter will detail the methodology used to determine cost variables, collect
cost data, and compare this data.
Figure 1. Point-to-point digital fiber optics system
Figure 2. Point-to-point microwave system
Figure 3. Two hop microwave and passive repeater
Figure 4. Compressed video system
CHAPTER III. METHODOLOGY

This chapter explains the methodology used for this study. The chapter begins with descriptions of the sample, data collection, and procedures. It then describes the data analysis and significance of the study. The assumptions of the study complete the chapter.

This paper reports on a field study used to develop a cost analysis. This cost analysis depicted costs required to design, build, and install a distance education system using the transmission media of fiber, microwave, and compressed video. Cost analysis for this study was defined as follows: Perraton (1982) stated a cost analysis endeavors to discover all the costs involved in a particular activity. Adams, Hankins and Schroeder (1978) defined cost analysis as any manipulation of cost data that provides relevant information for those who make decisions. A common method is simply "a direct comparison method between or among the costs of specific decision alternatives, e.g., a make or buy decision" (p. 24). Kiesling (1979) differentiated between accounting cost studies and economic cost studies. Cost accounting is concerned with budgets and whether funds are being spent as planned. "All funds are traced and accounted for, whereas a major portion of good economic cost analysis is accomplished before the idea of money (in the form of prices) is introduced." The central concern of economic cost analysis is the use of physical resources.

Sample

The population sampled was authoritative individuals in the field of narrowcast technology. These people were recognized as authorities because of their experiences with the problem. Experts identified had experiences and possessed technical knowledge in the areas of microwave, fiber, and compressed video installations. Also identified were experts
who had experience in designing and installing interactive distance education systems. These experts were identified as those who would supply valid and reliable information about the research questions.

Data Collection

Data were collected using face-to-face, telephone, and on-site visit interviews, and written communications. The interview questions were designed to determine the cost considerations and total costs for establishing a distance education system. Interviews were open-ended to offer flexibility and opportunity to pursue additional information. Reliability was built into the interview process through the use of repeated questions, rephrasing questions, and follow up questions. Also, interview questions were asked of more than one source to check reliability. The cost data were calculated using geographic circumstances typical to Iowa.

Procedures

The first step was to gain general information from the literature, consultants, telecommunications specialists, governmental offices (federal and state), and vendors. Appendix D lists these sources.

Next, specific and relevant questions were identified. Questions were designed to illicit relevant and valid information to answer the research questions. The specific questions were designed to identify hardware components essential to transmit and receive audio and video signals between two sites (Appendix B).

Technical experts provided valid cost information. Technical experts identified had installation experience with the transmission systems. Also identified were vendors and
consultants who had installation experience with the distance education classroom equipment.

For the three transmission systems (fiber, microwave, and compressed video) six hypothetical pairs of sites were chosen. Vendors were identified to supply cost data. Total costs were supplied by the vendors for the fiber and microwave systems. Costs for the transmission of a compressed video system were identified using the bids for a system purchased by Iowa State University. Also vendors were identified and interviewed to supply lease information relating to compressed video and fiber for periods of 1 month, 36 months, and 60 months.

For the classroom equipment phase of this study, technical experts aided in the identification of designs, equipment items, and installation procedures. This process produced a final classroom design and equipment list. Vendor catalogs were used to obtain equipment prices. The final design was reviewed by staff at Media Resources, Iowa State University, who verified equipment costs and supplied installation charges for this equipment.

Data was systematically collected. Records were kept of interviews, on-site visits, and correspondence. In some interviews, questions were forwarded to the person interviewed beforehand. In other interviews, the question form included preformed answers to mark during the interview. In all interviews, notes were recorded.
Data Analysis

The data were collected by careful and critical examination. The data were presented in relation to the research questions. Tables and graphs were presented to show cost/media relationships and to summarize the cost data.

The data collected relating to the classroom were presented both as answers to the research questions and as a classroom design. The final classroom design included all hardware required to produce and receive television signals. Cost data was furnished in the form of an equipment list.

Significance of Study

Applications

The data furnished in this study provide practical answers to the question, How much does distance education cost? The study supplies cost data for transmission systems and classroom equipment. This study provides examples for educators to fit into existing situations. The data are representative for Iowa schools.

Assumptions of the Study

These following assumptions were made with regard to this study:

The transmission media

1. The terrain was flat with no major obstructions for all transmissions.
2. The elevations between sites were similar.
3. The connecting points were within the same telephone LATA and utilized the same carrier.
4. There was no need for right-of-way permits, e. g., from railroads or freeways.
5. For microwave transmissions, there was FCC license availability.

6. For lease options, infrastructures were available (T1 lines or DS3 level lines).

The classroom

1. The size of the room was 28 x 30 feet.

2. The room had adequate soundproofing and acoustics.

3. The room had adequate lighting.

4. The room had adequate power capabilities.

5. The room had a projection screen and blackboard/metal board.

6. There were various input equipment already available in the classroom, e. g., computer, film projector, slide projector, and record player.

7. A telephone was present in the classroom.

8. Tables and chairs were present.

The following chapter presents the data that resulted from this methodology. Results from interviews, on-site visits, and correspondence are compiled to present the classroom and transmission requirements and cost findings.
CHAPTER IV. RESULTS

The purpose of this chapter is to present findings and results. The results are summarized and categorized in two sections. The first section deals with transmission costs of fiber, microwave, and compressed video systems. The second section deals with the interactive classroom costs. A classroom design is presented. Concluding the chapter is a summary.

Transmission Costs

In setting up a distance education transmission system, specific elements define costs for each technology. These elements usually fall into three areas--feasibility and planning, system design, and purchase and installment. Appendix P lists these considerations for each transmission medium. Decisions on these variables affect system costs.

It is necessary to consult technical experts on these decisions. Using manufacturers as consultants has the disadvantage that vendors may present biased opinions and tend to promote their own product lines. Distance education consultants offer more objective counsel and are more likely to combine technologies to the customer's advantage.

Fiber systems

Fiber optic systems consist of cables that transmit light signals rather than electrical signals. This fiber is capable of transmitting full motion video. Purchasing and installing fiber systems is a complex process. Nearly 95 percent of the interactive television systems designed today are fiber optics in combination with coaxial cable (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992).

Fiber systems can be analog or digital. The fiber is identical; the termination
equipment is different. Digital fiber is best for quality. Analog fiber picks up noise over
distances; digital fiber does not (B. Norgaard, MWR, personal communication, June 9,
1992). H. Sarrazin of Tele-Systems stated an analog system is cost-effective under 30
miles, but an analog fiber system over 30 miles would be incredibly expensive. For an
analog fiber system, a repeater (booster) is needed every 30 miles at a cost of $15,000-
$18,000. A building protecting this repeater is also required, costing $1,500 (personal
communication, May 21, 1992).

Fiber systems demand a high degree of technical expertise, not only for the design and
planning, but skilled labor is also required for installation. Complex path studies and
easement attainment are required.

What does it cost to put into place a point-to-point, distance education fiber system?

The total cost of a fiber system depends on the fiber type, total system design, and
location. T. Crandall, General Services, stated fiber for state projects costs $12,000 per
mile, based on 10 miles (personal communication, June 4, 1992). H. Sarrazin, Tele­
Systems, concurred that fiber costs $10,000-$15,000 per mile (personal
communication, May 21, 1992), and W. Fackler, Spectra Associates, generalized costs of
fiber at $15,000-$20,000 per mile (personal communication, May 29, 1992). D.
Takkunen of Todd Communications estimated fiber costs at $20,000 per mile (personal
communication, April 27, 1992). These generalizations are strictly for labor and fiber, no
equipment, nor right-of-way expenses. In metropolitan areas as Des Moines and Cedar
Rapids, Iowa, requiring right-of-ways and increased labor, can increase installation rates
to as high as $70,000 per mile (T. Crandall).
MWR Telecom supplied budgetary cost data for a fiber system at $18,000-$22,000 per mile (Appendix E). T. Crandall, General Services, stated Iowa schools would likely pay somewhere between the state $12,000 per mile and the MWR $22,000 per mile (personal communication June 4, 1992).

**What are the major cost considerations?**

**Consultation** Consultation charges for fiber systems have a great variance. The costs vary depending upon detail, distance, and location. Services include: (a) feasibility studies, (b) route surveys, (c) coordinate specifications, (d) right-of-way checks, (e) and route designs with drawings. In a route design, the entire distance is mapped. In a city, the map is more detailed showing underground cables, gas lines, and electric cables. The more detail, the more expense. The longer the distance, the more detailed the map (B. Norgaard, MWR, personal communication, June 9, 1992). Also included in consultation fees are staking the route, supervising the construction, and scheduling of crews.

Consulting services average $5,000-$15,000 (D. Takkunen, Todd Communication, personal communication, April 27, 1992). At MWR consulting costs are charged at the engineering rate of $50.00 per hour (B. Norgaard, personal communication, June 9, 1992). In the MWR cost study (Appendix E), columns are marked indicating consulting costs of $3,000-$3,500 for rural areas and $7,500 for urban areas.

**Construction/materials** The MWR cost study identified construction and material costs (Appendix E). Labor construction costs are $1.55 per foot to $.97 per foot depending upon distance. Construction costs differ between rural and urban locations. Urban areas require more field work, engineer work, concrete work, and easement
attainment. The urban costs listed in Appendix E are suburban locations with various open areas, not downtown metropolitan areas. A downtown urban area requires additional concrete work costing $10 per foot or more (B. Norgaard, MWR, personal communication, June 9, 1992).

Material costs are listed as $9,672 for rural construction, and $15,712 for the urban construction (Appendix E). Material costs include fiber, manholes, warning tape, warning signs, and splices. In urban areas, duct costs are also added, and additional splicing and manhole costs are required.

**Easements**

If construction crosses roadways or railroads, an application is filed to obtain easement right-of-way. It may be as simple as getting permission, or it may be more involved. Most easements are obtained as public right-of-ways by formal application to the city, county or state entity. If the public easement is obtained, a license is needed to place the cable in this right-of-way. A lawyer fee is involved. Cities sometimes charge for easements in the range of a $1 per foot, per year. Other entities charge a percent of revenues for easement use. Even if money is not involved, time and effort is expanded securing these easements (D. Takkunen, Todd Communications, personal communication, April 27, 1992). When crossing private land, it is necessary to pay for easement rights to the private individual (B. Norgaard, MWR, personal communication, June 9, 1992).

Because Iowa has a limited number of right-of-ways, it is more likely an easement be granted to a utility than to a school system (J. Kingland & R. Pink, Telecommunications, Iowa State University, personal communication, April 6, 1992; B. Norgaard, MWR,
personal communication, June 9, 1992). It is often more difficult to gain easements from railroad entities (Norgaard).

**Terminal equipment** End point equipment varies in price according to speed of transmission and capacity. End equipment is usually one unit that functions as the codec, laser transmitter, optical receiver, and multiplexor/demultiplexor (MUX/DEMUX). MWR equipment runs from $25,000-$57,000, including installation. Equipment on the low end would transmit a DS1, the high end transmits DS3, plus includes a stronger laser for longer distances. Units in the $35,000 range will be used by the Des Moines School System for their installation (B. Norgaard, MWR, personal communication, June 9, 1992). Digital terminal equipment, connectors, and installation of this equipment can run as high as $70,000 for each site (T. Crandall, General Services, personal communication, June 4, 1992).

**Microwave systems**

Microwave signals are transmitted through the air on electromagnetic waves. Microwaves carry full motion video. The placement of towers, equipment configurations, federal regulations, and frequency specifications necessitate technical assistance and custom bids.

For a simple point-to-point system between two schools, microwave could be a good choice, especially for short distances. This system is easy to install, especially if transmitters are placed on buildings (Burt, Electronic Engineering; Fackler, Spectra Associates, personal communication).

Microwave signals can be analog or digital. Analog is less expensive since equipment is
not needed to create digital signals. Digital costs are decreasing, but Todd Communications continues to utilize analog with full motion (D. Takkunen, Todd Communications, personal communication, April 27, 1992). Electronic Engineering installs analog microwave to be compatible with previously constructed analog systems. When starting a new system, digital microwave is used because it provides higher quality. Analog is affected by weather and atmosphere conditions causing fading. This fade produces noise, creating a hiss on the line. Digital does not have noise. Digital systems cost the same except for adding a MUX and interface at each end (R. Burt, Electronic Engineering, personal communication, June 9, 1992).

**What does it cost to put into place a point-to-point, distance education microwave system?**

The average cost to construct a microwave tower with equipment per site is $100,000 (J. Kingland & R. Pink, Telecommunications, Iowa State University, personal communication, April 6, 1992). Electronic Engineering supplied cost figures for a short haul distance under 8 miles at $17,000 per site. One-hop systems over 8 miles can cost $150,000-$250,000 (Appendix F). The use of repeater towers adds expenses for additional electronics, path studies, installation costs, plus tower costs. Each repeater tower can add $90,000 in equipment costs and $20,000-$35,000 in tower construction costs.

**What are the major cost considerations?**

**Consultation Services included:** (a) path profile to check for obstructions (Appendix G); (b) frequency coordinates to find other frequencies that might interfere; (c)
path analysis to determine how much power is required (Appendix G); (d) completion of the FCC application (Appendix H); and (e) tower specifications to note things as ice and wind load. Consulting services cost $3,000-$4,000 (Tele-Systems); $2,000-$4,000 (Spectra Associates); and $3,000 with an additional $2,000 for tower specifications (Todd Communications). A one-hop path profile/coordination is $1,500 (D. Campbell, Alcatel Network Systems, personal communication, July 8, 1992).

**Tower construction** Besides distance, tower height is dependent upon obstructions, elevation above sea level, and earth curvature. To transmit 20 miles, the antenna must be at least 150-200 feet on both ends. The 200-foot tower is the average height in Iowa. Towers over farm land can be fairly short, but any trees, buildings, or grain elevators in the path will increase the height requirement (D. Campbell, Alcatel Network Systems, personal communication, July 8, 1992).

A 20-foot tower is usually the minimum height in Iowa. In order to clear trees, a 50-60-foot height is normally required. To place a dish on a building, the building must have height to clear trees and obstructions. Antenna extensions attach to a wall and go beyond the building roof. A 20-foot tower in Iowa is generally on a building or the side-mount type and would cost approximately $5,000 (D. Takkunen, Todd Communications, personal communication, April 27, 1992). An antenna on top of a two-story school building can send signals a short distance, one or two miles. A 12-foot tower placed on a 120-foot building boosts the tower elevation to 130 feet, capable of transmitting 10 miles (D. Campbell, Alcatel Network Systems, personal communication, July 8, 1992). Towers
placed on building tops need to allow for guy wire requirements (R. Burt, Electronic Engineering, personal communication).

A 100-foot tower costs: $20,000 (Todd Communications); $5,600 (Appendix F, Vendor A). A 200-foot tower costs $30,000 (Todd Communications); $20,000 (Electronic Engineering; Tele-Systems); $11,000 (Appendix F, Vendor A). A 300-foot tower costs $35,000 (Tele-Systems). Self-supporting towers need no guy wires. Construction costs are more, but less land is required. A 200-foot, self-supporting tower is $200,000 (R. Burt, Electronic Engineering, personal communication, June 9, 1992). A tower for the short haul distance under 8 miles (Appendix F) costs $2,000-$3,000. A heavier tower that attaches to the side of a building and extends up to 100 feet is $5,000 (R. Burt, Electronic Engineering, personal communication, June 19, 1992).

Land

Land is acquired for the actual construction site of the tower. Guy wires are attached at three places. A 200-foot tower requires a circumference around the base of 200 feet. Appropriate land must be acquired (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992). Two acres are required for the 200-foot tower plus the access road to the tower. It is better to lease land if possible. There is no tax benefit to purchasing land. By obtaining a long term, 99-year lease, the farmer can still farm or animal graze the land around the tower. A land lease runs from $500-$800 a year (R. Burt, Electronic Engineering, personal communication, June 9, 1992) to as high as $5,000-$6,000 per year (R. McCutcheon, US West Cellular, personal communication, June 19, 1992), depending upon the land location.
**Equipment**  Equipment is needed at both ends with two channels at each site—transmitters, receivers, antennas, hardware connections, and battery packs. This equipment averages $45,000 at each end for long haul and $11,000 for short haul. Appendix F exhibits equipment requirements and cost data from vendors. Larger antennas and transmitters are used to increase distance capabilities.

**Building**  It is necessary to construct a building to house the electronics at each tower site. Building construction is around $1,500 (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992).

**Connections to school**  The tower should be located within a mile of the school because signals distort over distance. If towers cannot be located near the school, short haul systems are required to get from tower to school (R. Burt, Electronic Engineering, personal communication, June 9, 1992). Coaxial cable used to connect the tower to the school is $5,000-$6,000 per mile. An amplifier is needed every 2,000 feet at $500 each. In the school, the cable is hooked to a translator channel box for television reception or to a VCR connection (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992).

**Installation and testing**  Before buying a microwave system, it is advantageous to place equipment on trucks and transmit from the point-to-point locations to verify there is no interference (J. Kingland & R. Pink, Telecommunications, Iowa State University, personal communication, April 6, 1992). Installation and testing costs are significant (Appendix F). R. Burt of Electronic Engineering stated installation costs are 10 percent of the purchase price (personal communication, June 9, 1992). D. Campbell, Alcatel, stated installation and testing would cost $16,000 per termination tower and $24,000 for
repeaters (personal communication, July 8, 1992); and Vendor A listed a cost of $43,330 for installation and testing a one hop system.

**FCC application** An application form 402 (Appendix H) is required. The application fee is $155 per hop. A hop is transmitter to transmitter. Multiple hops require more than one license. Noncommercial educational broadcasts are exempt from charges (CFR §1.1112 (c)). An accompanying letter would be necessary to explain fee exemption, and the FCC would need to approve the exemption (T. Dombrowsky, FCC Microwave Branch Office personal communication, May 21, 1992). The FCC required frequency coordinations must be completed by microwave technical experts. Electronic Engineering stated it costs up to $1,100 per path, to determine path coordinations (Appendix F). Alcatel charges $1,000 to fill out the FCC application and $1,500 for a path determination (D. Campbell, personal communication, July 8, 1992).

**Long haul systems** The maximum distance between towers is 30 miles. Any distance over 20-30 miles would require repeater towers to boost and retransmit signals. The farther the distance, the higher the tower required. The higher the tower, the more land required for the guy wires (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992). For longer distances, larger transmitters and antennas are required. Each repeater tower houses two sets of equipment, pointed each direction. Each repeater tower adds approximately $100,000 to the cost of the system plus additional installation and testing costs.

T. Crandall, General Services, stated that long haul, multi-hop microwave systems for Iowa schools are unnecessary. All schools are within short haul distance to ICN end points.
Even though schools are distanced further than 30 miles, schools can easily microwave to a 12-foot "stub" tower built at the ICN end point, travel through the ICN link points, hop off the ICN onto another 12-foot "stub" tower, and microwave to the second school. This method is less expensive than using complex repeater stations (personal communication, June 29, 1992).

**Compressed Video Systems**

Compressed refers to digital video, audio, and data signals that are processed to reduce the amount of information required for transmission. Compression reduces the bandwidth requirement. Compressed signals can be sent using any transmission method, but the most common carriers are T1 high capacity facilities. Compressed video systems do not transmit full motion video. Compressed video does, however, allow users to economically carry signals on smaller bandwidths. Compressed video is easily installed in schools by simply purchasing the terminal equipment and leasing the T1 facilities from telephone companies.

**What does it cost to put into place a point-to-point, distance education compressed video system?**

Equipment is needed to compress signals and change signals from analog to digital. Equipment and lease rates total $40,000-$50,000 per year for each site.

**What are the major cost considerations?**

There are not as many variables in the compressed video systems as the other technologies. Most of the cost is in the codec equipment at each termination point.
Consultation These services are included in the total cost with US West packages.

Design coordinators provide input into equipment needed for particular classrooms (P. Draper, US West, personal communication, June 22, 1992).

Equipment Transmission equipment consists of a codec, interface, and T1 line.

Codecs average $36,000 (Appendix J). A CSU/DSU interface to a T1 facility costs $1,700 (M. McQuiston, US West, personal communication, June 23, 1992). The T1 lease rates from US West are $5,200-$20,000 a year (Appendix A).

Installation Charges for installing codec equipment were $1,500 from the vendors supplying bids for the Iowa State classroom (Appendix K).

Upgrades Most vendors now have codecs that can be upgraded by updating the software. This is an essential item with technology changing so rapidly. The software can be upgraded easily if equipment is added to the system. These upgrades cost $8,000-$15,000 (ISU classroom bids). US West includes updates in the warranty and extended warranty (ISU classroom bids).

Is it usually better to lease or purchase?

In designing any system, the first step should be to determine existing infrastructures. Communicate with utility companies, telephone companies, and other major businesses in the area to find possible partnership ventures or leasing possibilities.

Fiber lease options Purchasing and installing fiber is an expensive venture. Schools may prefer not to be in business as telecommunication carriers. Leasing existing fiber is a more viable option. This high capacity digital video is not regulated, records are not kept; therefore, there is no one source for information. It is necessary to communicate with each
individual utility and carrier in the area to find lease possibilities (Iowa Public Utilities Division, personal communication, May 18, 1992).

Fiber capable of transmitting full motion video is available for lease from telephone companies. These DS3 facilities are normally available, but it is possible that in remote, rural areas, DS3 may not be available (P. Hassel, US West, personal communication, March 25, 1992). When leasing DS3 lines from US West, there is a one time connection charge of $1,466, not related to distance. Lease rates per mile vary considerably, the longer the distance, the less per mile charge. Appendix A lists a representation of DS3 US West charges. The year lease runs from $40,000-$90,000 for 3-75 miles.

DS3 codecs capable of transmitting 45 Mb/s full motion, and DS1 codecs capable of transmitting compressed video are different. The DS3 codecs are proprietary and not compatible with other vendors. The proprietary capabilities also vary from vendor to vendor. VideoTelecom codecs do not have the capability for remote camera control, pan/tilt/zoom, or graphics. There are no multipoint capabilities. Codec equipment that includes the digital interface for full motion, connectors, and additional capabilities for echo cancellation, lip sync, and microphone hook up costs $36,000 per site (M. McQuiston, US West, personal communication, June 23, 1992).

MWR leases DS3 "dark fiber", a term denoting fiber that is put in exclusively for the customer, to do with as the customer wishes. This dark fiber has unrestricted use. Phone companies do not utilize dark fiber systems. Telephone companies lease existing fiber and dictate how the customer uses it, possibly shared with another customer (B. Norgaard, MWR, personal communication, June 9, 1992).
Dark fiber systems are installed solely in areas where potential use is expected, as Iowa's larger cities. The Des Moines Schools will utilize a dark fiber system. The lease rates for dark fiber are generally less than leasing from telephone companies. Prices can vary from $150 per month to $2,500 per month with elements of distance, availability, and number of users on the line (B. Norgaard, MWR, personal communication, June 9, 1992).

Tele-Systems has negotiated many lease agreements for distance education networks involving several schools. Typical negotiated lease rates, per month, run from $28 per mile to $70 per mile. Leases were negotiated for 5 to 15 year terms, and schools purchased their own terminal equipment. Some leases included maintenance and others did not (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992).

**ICN lease options** Use of the ICN fiber network will cost $5.00 per hour, per link point. Distance will not be a factor in the rate charged; the cost will be entirely by number of link points. At this time there are no minimum usage charges or connection fees planned (L. Schatz, Narrowcast Telecommunications, personal communication, April 14, 1992 & June 19, 1992). Appendix C exhibits a map of the ICN showing possible link points.

**Microwave lease options** It is possible to lease space on existing broadcast towers, office buildings, hotels, grain elevators, water towers, FM towers, and high-rise apartment buildings. After defining the two points, the distance, and required elevation, drive between the points to view geographic limitations and available structures (G. Fairchild, Fairchild Communications, Inc., Boone, Iowa, personal communication, April 15, 1992).

Lease costs vary. Cost is not relative to distance from point to point, only that the
longer the distance, the higher on a tower the repeater must be. The top of a grain elevator can be rented from an Iowa farmer or farm cooperative for around $500-$600 a year. The lease rate is defined by the location of the tower. A general rule of thumb for lease rates in Iowa is $ .50-$1.00 per foot of height, per month. The top of a 500-foot tower would lease for $500 per month at the $1.00 rate. Sometimes the rates are on a sliding scale, the higher on the tower, the more expensive, e. g., rates at 100 foot, $ .50; rates at 200 foot, $ .75; and rates at 500 foot, $2.00. Premium location rates run $2.50-$3.00 per foot. Locations in metropolitan areas have higher rates than in smaller towns; lease rates in Des Moines, Iowa, would be higher than in Ames or Boone, Iowa (G. Fairchild, Fairchild Communications, Inc., Boone, Iowa, personal communication, April 15, 1992).

Those leasing a tower are still responsible for the purchase of transmitting equipment. This would cost approximately $45,000 for each end. If the leased structure is used as a repeater, it would contain two transmitters, two receivers, and two antennas. If the leased structure provides short hops and allows use of short haul equipment, the costs are cut significantly (R. Burt, Electronic Engineering, personal communication, June 19, 1992).

**Compressed video lease options**

When leasing T1 services, there is a one time connection charge of $1,386, not related to distance. Lease rates vary considerably. The longer the distance, the less per mile, per month. Year lease rates from US West are $5200-$20,000 for distances of 3-75 miles. Most schools apply for and receive TCC1 tariff rates (P. Hassel, US West, personal communications, May 26, 1992). Appendix A lists a representation of US West T1 charges. If schools are not in the same Local Access Transport Area (LATA), contacts must be made with two facilities, the local carrier and the
long distance carrier. It is basically the same procedure as specifying a long distance carrier on a personal telephone.

It is possible to lease terminal equipment (codecs). The list cost is multiplied by a cost factor to arrive at the monthly charge. A $36,000 codec leases for $1,136 per month, or $13,632 a year, based on a 36-month contract. Shorter contracts employ a higher cost factor. For a 12-month lease, the monthly charge is $2,798 or $33,576 per year (B. Bruce, VideoTelecom Corporation, personal communication, June 4, 1992).

How do the costs vary for distances of 3 miles; 10 miles; 20 miles; 30 miles; 50 miles; 75 miles?

The transmission methods of fiber and microwave are directly affected by distances. Fiber is affected the most dramatically. The costs per mile are very high. Each additional mile can add $12,000-$20,000 to the cost. Fiber can run well over $1 million for longer distances. Even shorter distances range from $100,000-$500,000. Leasing fiber from US West costs from $41,000-$90,000, a year, for a distance of 3-75 miles.

Microwave costs are also affected by distance. The longer the distance, the higher the tower, and the larger the antenna dish needed. A 6-foot dish is $1,500 compared to a 12-foot dish at $6,000 (D. Campbell, Alcatel Network Systems). Every increment of 20-30 miles requires a new repeater tower with two sets of electronics. Each repeater tower can add $90,000-$120,000 for equipment, $20,000-$35,000 for tower construction, and approximately $25,000 for installation and testing (Appendix F). Path studies for each additional hop would cost $1,000-$1,500 (R. Burt, Electronic Engineering; D. Campbell, Alcatel).
Compressed video is the least affected by distance. Most of the cost of the system is in the codec equipment at the end points. Compressed video systems are fairly constant in cost with less than $15,000 difference in year lease rates between 3 and 75 miles.

Table 1 compares lease costs for varying distances for full motion DS3 fiber and T1 facilities used for compressed video. The table lists the year lease fees and the cost of a two codecs, one at each school. Total costs for one year reflect total costs for the system that can be divided between the two schools. Figure 5 illustrates the data from Table 1 in graph form.

Table 2 compares the costs of developing digital fiber, digital microwave, and compressed video systems. Fiber costs were supplied from MWR Telecom (Appendix E). Microwave costs were supplied from various vendors (Appendix F). Compressed video lease costs were supplied by US West (Appendix A). Codec prices were obtained from bid responses for the Iowa State University compressed video classroom (Appendix J) and from interviews with vendors. Table 2 data are represented in graph form in Figure 6.

These cost data are only representative of costs. These data are not meant to represent the total system costs and can not be used to estimate a final cost for any given transmission system. Before considering any system, technical assistance and cost quotations that apply to specific needs should be obtained. These data do provide a reasonable basis for comparing variables within the systems in relation to costs.

What are the recurring and maintenance cost of the transmission equipment?

Transmission equipment is quite reliable and repairs are minimal. However, service and maintenance are important considerations for these costly systems. Technology does not
always work and environmental circumstances may necessitate costly repairs. Maintenance contracts should state how readily the vendor is expected to provide service. Additional payment may be required for high priority service. Local area service and 24-hour telephone service are beneficial vendor features.

**Fiber**  
Fiber equipment is reliable and needs few repairs. Replacement of a laser may cost $2,000 to $4,000, but replacement is not common. Another maintenance occurrence is location specifications. Anyone owning fiber may be requested to furnish locations for future installations. If this information is not readily available, locater services are hired. Locater services decrease the probability that fiber lines will be cut by future installations (B. Norgaard, MWR, personal communication, June 9, 1992). If fiber is accidentally cut, costs of repair are expensive and time-consuming. Maintenance contracts for end point equipment are 1.1 percent, per month, of the purchase price. This amount is $3,300-$7,600 per year (Norgaard).

**Microwave**  
Circumstances that require maintenance on microwave systems are wind damage, ice load, electrical storms, and electronic equipment failure (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992). Maintenance contracts vary, 1-2 percent of the original costs (Tele-Systems), 10 percent of the original costs (Todd Communications), or $25.00 per month (Electronic Engineering).

**Compressed video**  
Service for equipment is usually supplied free by telephone during business hours during the warranty period. After hours, service calls may cost $100 per hour, with a one hour minimum (Appendix K). Maintenance contracts range from
3-7 percent of the purchase cost (ISU classroom bids). A recurring expense, of course, is the lease cost per month of the T1 line.

What are the characteristics, advantages and disadvantages of the three transmission technologies?

**Fiber**  Fiber is superior as far as signal quality and bandwidth capacities. Fiber is unaffected by the environment and there is little maintenance. Fiber costs per channel capacity are cost-effective. The disadvantages of fiber are the capital cost expense and the complexity of installation.

**Microwave**  Microwave for short distances is easy to install and cost-effective. Short distances take advantage of inexpensive towers and special low cost transmitter equipment. W. Fackler of Spectra Associates, stated microwave is an aging technology, and the majority of frequencies in Iowa have been used, especially in metropolitan areas. Distance education systems require a great deal of channel capacity, and frequencies are limited (personal communication, May 29, 1992). R. Burt of Electronic Engineering reiterated that there is a problem in Iowa with frequency availability for long distances (lower frequencies). In the last five years, use of cellular phones, has increased using available frequencies. For short haul microwave (higher frequencies), there are more options available (R. Burt, Electronic Engineering Company, personal communication, June 9, 1992).

In certain areas of Iowa, microwave may not be feasible because of the terrain. Microwaves are affected by weather conditions. Some find FCC licensing and adherence to regulations restrictive.
Tele-Systems, in general, maintains that although a point-to-point microwave system for two sites is easy to construct, connecting less than three or four sites is not the most effective use of the microwave system based on time usage (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992).

Compressed video  Compressed video is easy to install and is relatively inexpensive compared to the other systems. For educational purposes, compressed video may technically not be the best system, but it is the easiest, and sometimes, least expensive to install; possibly, the only option available (H. Sarrazin, Tele-Systems, personal communication, May 21, 1992). Compressed video does not transmit full motion and at times, images appear jerky. However, research data supports that the quality is quite acceptable.

Interactive Classroom Costs

This section relates personal communications concerning the distance education interactive classroom. Technical experts were interviewed about classroom design, production equipment requirements, types, and specifications.

What does it cost to equip an interactive classroom?

The Narrowcast Advisory Committee and the Iowa Public Broadcasting Board approved a list of minimum equipment requirements for ICN phase I and II sites (Appendix N). The total equipment costs at one site are $28,360. The Narrowcast Advisory Committee and its Technical Advisory Committee are currently working with equipment requirements and specifications for a statewide bid that will allow schools districts to purchase classroom equipment at lower prices (L. Schatz, Narrowcast Telecommunications, personal communication, May 18, 1992).
B. Schoenenberger, FOCIS Des Moines schools, stated teaching sites cost $25,000 to equip, nonteaching sites $18,000 (personal communication, April, 14, 1992). Equipment for the design developed in this study cost $39,539 for the state-of-the-art classroom and $21,988 for a basic classroom (Appendix O).

Todd Communications’ classroom equipment prices range from $20,000 to $80,000. Prices vary according to equipment capabilities. Todd purchases from different vendors, such as, Panasonic, Sony, and JVC (D. Takkunen, Todd Communications, personal communication, April 27, 1992 & June 17, 1992).

**Videoconferencing packages** Vendors of compressed video systems have "turnkey" packages ready to install, complete with codec and classroom equipment. These packages are geared toward business teleconferencing rooms, but can be adapted for the distance education classroom. Most packages do not include all the necessary equipment, but additional items are offered for additional costs. Buying the package units does not save dollars over purchasing of individual items, but it does assure that all the equipment is compatible and it ensures obtaining correct cables and pin-out schemes. Buying the package unit saves time and effort in purchasing, and there is one source for installation and maintenance. These advantages will add 30-70 percent to equipment costs over individual purchase. Vendor general package price lists are exhibited in Appendix L.

Compression Labs Incorporated (CLI) equipment was chosen by Iowa State for a compressed video classroom. Minnesota has standardized on the CLI equipment. Most of the CIC schools (a regional network of Internet) also use CLI equipment (Pinkerton, 1992). Keller, Staab and Stowe (1989) ranked CLI highest in quality and technology. The total
package purchased by Iowa State included a codec, a camera with pan, tilt, zoom, a 25 inch monitor, audio mixer with echo canceller, microphones, speaker, and enclosure for each site. This package with the codec cost $55,000 per site plus installation of $3,500 for each site. The total cost for the two Iowa State classrooms with the CLI equipment and additional ordered video equipment was $145,000 (ISU Classroom Study Committee, personal communication). Various equipment lists and associated costs pertaining to the equipping of the Iowa State classroom are located in Appendix L.

For compressed video systems, it is necessary to include acoustic audio handling. In the compression process, audio is compressed and decompressed exaggerating and emphasizing any audio problems. An acoustic echo canceller, to handle this problem, is configured into some codecs or must be purchased as a separate unit. In order to play videocassette tapes on the compressed video system, the codec must accommodate non-time base corrected video. If this is not part of the codec configuration, a time base correction unit must be purchased separately (S. Charles, US West, personal communication, June 9, 1992).

**Classroom consulting** Todd Communications' classroom consultation is charged at a design engineering rate of $75 per hour. Time required depends on customer needs. Wiring designs and detailed lay-outs require more than just equipment lists. Average design consultations cost $5,000. Some of the consultation charges are applied to the cost of equipment bought and installed. Installation charges range around $5,000 for high end equipment to $2,500 for low end equipment (D. Takkunen, personal communication, April 27, 1992 and June 17, 1992).
Consultation charges from Media Resources at Iowa State University, are $250 for the initial visit and $250 a day plus expenses for additional visits. This service includes site visits and planning, design of the classroom, determination of the hardware requirements, and monitoring installation. Average time required is usually five days, costing around $1,250. Installation costs are $30 per hour. The average installation fees are $4,500-$5,000 (D. Rieck, Media Resources, Iowa State University, personal communication, May, 1992).

How much does it cost to remodel standard classrooms?

Most classrooms in Iowa are easily adapted for use as a distance education classroom with little remodeling required. The room is sufficient if there is adequate lighting for the cameras, no extensive glare problems, adequate wiring, and adequate space. Camera and monitor mounts are easy to install by maintenance personnel. Mounts can be installed in false ceilings by putting plywood over ceiling strips or by buying additional hardware (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).

Most rooms have adequate wiring for the distance education equipment. It is necessary to determine the power requirements for all equipment. The technician can then verify there are sufficient outlets and amperage levels. General rules to follow are: (a) Unless it is a special circuit, do not put more than five items to a line, and (b) always isolate a computer on a separate line from other equipment (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).
An acoustically treated room prevents many problems associated with audio systems. Acoustic treatment includes fiber ceiling tiles, carpet, drapes, or fabric covered panels. A room can be acoustically treated for $3-4,000 (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).

What are the recurring maintenance costs of the classroom equipment?

Most classroom production equipment is reliable and does not require repair, but replacement costs for broken microphones or cameras are possible. The more equipment, of course, the more that can go wrong. B. Schoenenberger, FOCIS, Des Moines schools, related that operating costs for a year were less than $2,000. This included facsimile paper, batteries, and miscellaneous incidentals. There was a charge of $500 to repair a camera, and various microphones needed repair (personal communication, April 14, 1992).

G. Strand, Kirkwood Community College, stated that push-to-talk microphones required numerous repair expenses (personal communication, April 14, 1992). Strand also stated that batteries for the wireless microphones were a significant cost.

Classroom Design

Input from classroom design experts resulted in a distance education state-of-the-art classroom design (Appendix O). The key to the design is the equipment list. Costs reflect current catalog list prices. School systems most often, by working with the local AEA, can expect a 30 percent discount from vendors.

The design in Appendix O is a state-of-the-art origination site classroom. To fit individual needs and budgets, items may be systematically eliminated from the design and
equipment list. The remote site should be identical to the origination site if both classes are to be used as origination sites. It is beneficial for the instructor to teach from the remote site on occasion (Hughes, 1988). The remote site should allow for students' presentations and possible guest speakers. If the remote site will never be used as a teaching site, the teacher station, teacher camera, and teacher monitors may be eliminated. Control units are available that allow both remote and local control from the origination site. A camera, monitor, and audio system are basic requirements. A document camera, facsimile machine, and VCR are additional items that, although not essential, add to ease of use and quality of the remote classroom. Following are descriptions of equipment, options, and advice from experts, all relating to the design produced as a result of this study.

**Equipment Descriptions**

The size of the classroom in the design (Appendix O) is 28 feet x 30 feet, which accommodates at least 24 students. A survey of schools determined there is no average size classroom. This size is only representative. Tables are 24 inch x 96 inch, each seating four students. Two monitors and two microphones are located on each table. The instructor desk can be placed upon a riser to improve visibility. Constructing a riser in an existing classroom presents problems with existing blackboards heights and safety regulations (D. Rieck, Media Resources, personal communication, June 8, 1992).

**Cameras** The CCD cameras (charged coupled device) use a "chip" in the pick-up device rather than a conventional tube. The chip is more durable and requires less light. Included in the camera list price are a pan/tilt controller, zoom lens, and AC adapters. The pan/tilt/zoom can be eliminated from the student cameras, but are necessary on the
instructor camera. A 2-chip camera is priced in the state-of-the-art classroom, as it offers higher quality with less light. Schoenenberger, FOCIS, recommends the 2-chip camera quality (personal communication, April 14, 1992). A 1-chip camera is acceptable for most applications and is priced in the basic classroom. The student camera is priced without the pan/tilt/zoom and the teacher camera has pan/tilt/zoom included in the price. Three-chip, studio quality cameras can be substituted but are more expensive.

The visual presenter (document camera) features a single chip, CCD color camera with manual focus and zoom control. An optional light unit that snaps into the base provides extra lighting. This lighting enhances video output and should be included. An overhead camera can be ceiling mounted as a substitution for the presenter. The visual presenter is easier to install and use. Schoenenberger, FOCIS, Des Moines schools, recommended overhead cameras rather than the visual presenter because of the presenter's limited display area and the ability to improve the camera quality (personal communication, April 14, 1992).

Monitors

Twenty-five inch color monitors are used at the origination and remote sites to display the program output. At the origination site, a monitor also displays the remote students. Three 7 inch color monitors are used at the teacher station to allow quick orientation by the instructor. One monitor displays the remote site students, one the video output, and one continually audits the document camera so the instructor can align materials before sending the signal from this output. These 7 inch monitors can be replaced with a rack mount black and white 4 inch set. The 13 inch color monitors on student tables allow for display of the program video. There are two students for each monitor. It is unnecessary to wire the audio on these monitors because of the room speakers; it may
interfere with the microphones. Reasons for including individual student monitors include:

(a) Larger projection screens lose resolution and have a degraded image, (b) vision is
affected by distance from the monitor; everyone is the same distance and has the same image,
(c) the closer the distance, the better the vision and legibility, and (d) if one monitor of the
system breaks down, not as much is lost as if the main monitor breaks down (J. Varnum,
Business & Engineering Extension, Iowa State University, personal communication, April 7,
1992). The large student monitors in front of the room can be eliminated with the
individual monitors. The individual monitors have been left out of the basic classroom.

Multiscan monitors automatically accept inputs from any video or personal computer
source. If there is a need to transmit computer data, this is an option, and all monitors are
multiscan. At the remote site, an additional monitor is added in a teacher's or principal's
office for supervisory purposes if no adult is in the class.

Brackets attach to the ceiling or wall to hold monitors and cameras in a permanent
position. These mounting brackets are easily installed. There are special mounts for false
ceilings available. Mounts must be adaptable to varying monitor and camera weights.
Mounts must be able to tilt and swivel. Monitors and cameras can be placed on carts rather
than ceiling or wall mounted. The height should be sufficient to clear students' heads.
Camera tripods may also be used. Tripods add versatility, but can be easily tipped over.

Audio systems Audio is one half of an audio/video system. In reality, people should
invest 50 percent of the system cost on audio equipment. Unfortunately, people do not buy
enough quality and quantity to obtain good results (M. Darbyshire, Media Resources, Iowa
State University, personal communication, April 8, 1992).
The classroom speakers in the design are not powered, equipped with amplifiers, but the speaker at the teacher station is powered. This allows the instructor to turn the volume up or down in regard to the teacher microphone. The cost reflects a shielded magnet which prevents interference from a CRT screen or video monitor. There should be adequate speakers in the classroom so gain controls are not operated at high level. Speakers should be spaced at least one or two feet from television monitors, because speakers can affect monitor performance. Five speakers are recommended for the distance education classroom design. Two are placed on each side of the room. The teacher is behind the wall speakers, so a fifth speaker is on the teacher desk. The speakers could also be distributed across the ceiling. Generally the more expensive the speakers, the better the quality (M. Darbyshire, Media Resources, personal communication, April 8, 1992). The use of monitor speakers does not produce satisfactory results. Most speakers are too small, and many monitors do not include speakers.

The ideal distance education classroom would have a microphone for each person. However, two people per microphone is adequate. The best microphones for the distance education classroom are cardioid. The cardioid picks up sound better from the front than the back. Cardioid microphones are used where ambient noise should be suppressed. Using directional microphones, might result in a loss of voice if a person turns their head to talk to a neighbor. Microphones should be located no farther that 18 inches from the person's mouth. Ceiling microphones are not adequate, for microphones pick up sound in a direct line and ceiling microphones only receive sound from a reflected angle (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).
Student microphones listed are low profile, wired, and automatic. The low profile require no installation but just set on the table. They require no action on the part of the student.

The teacher microphone is a wireless lapel. A battery operated radio transmitter and matching receiver are used. The receiver can be rack mounted at the teacher station. A lavalier, or around the neck type microphone, can be substituted. This is adequate if the instructor does not move about the room.

Push-to-talk microphones are not the best type. They require an action on the part of the student and are not as user friendly. The clicking of the button is also a distractive noise in the system. Frequent repairs result with this type of microphone because students are prone to handle them (G. Strand, Kirkwood Community College, on-site visit, personal communication, April 14, 1992).

The most economical wiring for the microphones in the design is to combine all the microphones in a row and to wire each row into the mixer. It is important to control the microphones by distance. Those in the back of the room may need different adjustment than those closer to the teacher station (M. Darbyshire, Media Resources, Iowa State University, personal communication, April 8, 1992).

The mixer combines several audio input channels together into a single channel to get the proper blend. If multiple microphones are used, it is necessary to acquire a mixer. The mixer priced is part of the Shure Automatic Microphone system. This system combines the microphones and mixer to act as one. Microphones act independently in the system when turning on or off and actuate only when addressed within an acceptance window. Sound
originating outside a microphone's acceptance window will not actuate that microphone.

There are various units available to enhance and control audio. It is possible to buy as separate units preamplifiers, audio amplifiers, echo cancellers, distribution amplifiers, mixers, and equalizers. It is difficult to determine which components are truly necessary. Some units combine the components. It is unnecessary to purchase distribution amplifiers if the monitors have loop-back capabilities (M. Darbyshire, Media Resources, personal communication, April 8, 1992). It is best to leave decisions on component requirements to a vendor or technician. The technician will be able to analyze and recommend correct components for specific room and system needs. It is not necessary to include units to produce sound quality required by recording studios.

**Media controller** Some mechanism is needed to switch output devices and to control camera functions. There are various control devices on the market. The basic classroom lists a routing switcher that allows the instructor to select and control multiple video outputs. A remote control manipulates cameras. The state-of-the-art classroom utilizes a room controller specially purchased with software custom designed. A room controller functions as a switcher, controls the local and remote sites, and controls camera functions. It can also have diagnostic functions. Some room controllers may be proprietary to specific equipment.

**Rack Mount** The rack mount shelving unit fits under or beside the desk. The price reflects a basic unit. Adapter kits need to be added to shelve individual units ($30-$150 each unit).
**Video distribution**  A video distribution amplifier is needed if multiple monitors are used. This unit divides and amplifies video signals. Some of the monitors in this design have loop back capabilities that provide this function. Other monitors do not and need to be connected to the distribution amplifier.

**Other equipment**  The light dimmer allows the instructor to dim or control lights from various locations on one main switch. The unit can be wired independently.

The video cassette recorder is used to record the class session. A second unit is needed to play tapes for class presentations. There are play only units available, but are more expensive than the recorder/player unit.

The facsimile unit provides an auxiliary means of communication. If there is a traveling teacher, administrator, or reliable overnight service available, a facsimile may not be needed.

The slide/film to video convertor units display slides/film in video format. The units look and operate similarly to a traditional slide/film projectors. If these units are not available, hire a commercial entity to convert slides/films to a videocassette tape. It is possible to project slides/films on a screen and focus camera on the screen. This is acceptable, but there is loss of picture quality.

The computer items listed interface high resolution computers with standard NTSC video television cameras and monitors. Listed are costs for multiscan monitors, internal interface boards and Genlock cards, and external scan converters. Less expensive scan converters are available.
The white porcelain/metal board display surface is heavy gauge aluminum. This price reflects the quality of board with proven reliability and durability installed on the Iowa State campus.

The acoustic treatment prices listed are from Planning and Facilities, Iowa State University. Wall coverings listed are fabric covered acoustical panels of pressed fiberglass. The drapes are described as room darkening, insulated, blackout fabric (P. Adams, personal communication).

The wood riser option quotes are from Munn Building Center, Ames, Iowa. The materials include 3/4" plywood tongue and groove underlayment, support, trim, end pieces, and nails. Labor costs can be saved if built by shop class or custodian.

This design (Appendix O) provides several trade-off options to fit various budgets and needs. Schools must determine what items are initially necessary and what can be added at a later date. It is important that classrooms be designed for today. Rapid technology changes make it difficult to project system capabilities of the future.

Summary

This chapter presented the findings and results of face-to-face, telephone, and on-site interviews with experts. The individuals identified had experience with designing and installing distance education classrooms and with fiber, microwave, and compressed video transmission systems.

Results were presented as they related to the research questions of this study. General findings substantiated that the transmission systems are complex and expensive. Fiber and microwave can not be installed without technical assistance. There are no "package" prices
for these systems. Generally, every step in the process has a price. Consulting, installation, testing, maintenance, upgrades, and service are all itemized costs. General findings concerning the classroom equipment substantiated that most classrooms in Iowa schools can be adapted for use as interactive distance education sites. Expensive remodeling is not required. State-of-the-art equipment is not necessary to obtain satisfactory results.

Other findings related to the transmission systems were:

• Fiber costs were more expensive and fiber systems more complex than the other media.

• Microwave for distances under 10 miles were cost-effective for two schools.

• The major cost variables found were: (a) system consulting and design, (b) materials, construction, and installation (c) terminal end point equipment (d) maintenance contracts for transmission systems.

• In most cases, it appeared best to lease rather than to purchase.

• Distance significantly affected the costs of fiber and microwave. Both became cost-prohibitive to connect two schools as distances increased.

• Compressed video costs were the least affected by distances. Most of the costs for this medium were for the terminal equipment.

• Most experts recommended using digital technology, which offers superior quality and will only continue to be used more in the future.

• Fiber could only be cost-effectively installed by schools short distances from each other.

• Urban fiber construction costs were greater than rural fiber construction costs.
• Terminal equipment costs were the same for fiber, compressed video, and leased fiber systems.

• For fiber systems, the labor costs and material costs were nearly the same for shorter distances. The labor costs decrease as distances increase.

• Microwave frequencies were not available in some Iowa cities.

• Leasing a building or tower for use as a repeater tower between two schools rather than constructing a tower decreased expenses.

• Leasing a repeater station required a large capital investment.

• There was variation in microwave repeater lease rates according to location.

• There was variation in land lease rates according to location for microwave towers.

• Towers should be built as close to schools as possible.

• Installation and testing microwave systems was expensive.

• Long haul microwave systems were not cost-effective unless a repeater structure was leased inexpensively, and dishes were be put on the buildings.

• One hop microwave costs (1 - 30 miles) increased as the distance increased--higher towers and more powerful equipment were needed.

• Microwave systems were the most susceptible to repair, because they were most affected by weather.

• Telephone companies charged more than utility companies for fiber leases.

• Metropolitan areas, generally, had access to less expensive fiber leases than rural areas.
• Cost per mile lease rates for T1 & DS3 were high for short distances.

• Lease rates for DS3 were 3-8 times the month lease rate of T1. When total system costs were figured, leased DS3 full motion fiber is 45 percent more than leased compressed video.

• Leasing codec terminal equipment was not cost-effective, especially for the short term lease.

Findings related to the distance education classroom were:

• Usually classes did not have to be remodeled to be distance education classrooms.

• Most systems' basic equipment costs were from $20,000-$25,000.

• Equipment was easily added or eliminated to fit budgets and needs.

• Packages of complete systems cost 30-70 percent more than purchase of individual items.

• Not all equipment in packages was compatible with components purchased individually.

• Maintenance is not a significant cost variable for classroom equipment.

• Computer usage required significant costs.

• There was variation in vendor's equipment packages in relation to capabilities, included options, and prices.
Table 1. Comparison of DS3\textsuperscript{a} and T1\textsuperscript{b} year lease rates and total year costs for varying distances

<table>
<thead>
<tr>
<th>Distance</th>
<th>Medium</th>
<th>Year Lease plus connection fee</th>
<th>Codec\textsuperscript{c} cost for two sites</th>
<th>Total Costs for 1 year for 2 sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 miles</td>
<td>DS3</td>
<td>$43,000</td>
<td>$72,000</td>
<td>$115,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$7,000</td>
<td>$72,000</td>
<td>$79,000</td>
</tr>
<tr>
<td>10 miles</td>
<td>DS3</td>
<td>$45,000</td>
<td>$72,000</td>
<td>$117,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$8,000</td>
<td>$72,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>20 miles</td>
<td>DS3</td>
<td>$49,000</td>
<td>$72,000</td>
<td>$121,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$10,000</td>
<td>$72,000</td>
<td>$82,000</td>
</tr>
<tr>
<td>30 miles</td>
<td>DS3</td>
<td>$58,000</td>
<td>$72,000</td>
<td>$130,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$14,000</td>
<td>$72,000</td>
<td>$86,000</td>
</tr>
<tr>
<td>50 miles</td>
<td>DS3</td>
<td>$65,000</td>
<td>$72,000</td>
<td>$137,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$17,000</td>
<td>$72,000</td>
<td>$89,000</td>
</tr>
<tr>
<td>75 miles</td>
<td>DS3</td>
<td>$92,000</td>
<td>$72,000</td>
<td>$164,000</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>$22,000</td>
<td>$72,000</td>
<td>$94,000</td>
</tr>
</tbody>
</table>

\textsuperscript{a} DS3 refers to a transmission medium that is capable of carrying full motion video.

\textsuperscript{b} T1 refers to a high capacity transmission medium that does not have bandwidth capabilities to carry full motion video, but it is commonly used to carry compressed video signals.

\textsuperscript{c} Codec refers to equipment that changes analog signals to digital signals, and in compressed video systems, it also compresses the signal.
Table 2. Comparison of digital fiber, digital microwave, and compressed video costs

<table>
<thead>
<tr>
<th>Distance</th>
<th>Transmission medium</th>
<th>Purchase(^a) costs</th>
<th>Codec(^b) for two sites</th>
<th>Lease(^c) for year</th>
<th>Total costs of 2 sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 miles</td>
<td>Fiber, purchased</td>
<td>66,000</td>
<td>70,000</td>
<td></td>
<td>136,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>43,000</td>
<td>115,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>35,000</td>
<td></td>
<td></td>
<td>35,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>7,000</td>
<td>79,000</td>
</tr>
<tr>
<td>10 miles</td>
<td>Fiber, purchased</td>
<td>212,000</td>
<td>70,000</td>
<td></td>
<td>282,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>45,000</td>
<td>117,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>41,000</td>
<td></td>
<td></td>
<td>41,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>8,000</td>
<td>80,000</td>
</tr>
<tr>
<td>20 miles</td>
<td>Fiber, purchased</td>
<td>415,000</td>
<td>70,000</td>
<td></td>
<td>485,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>49,000</td>
<td>121,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>166,000</td>
<td></td>
<td></td>
<td>166,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>10,000</td>
<td>82,000</td>
</tr>
<tr>
<td>30 miles</td>
<td>Fiber, purchased</td>
<td>615,000</td>
<td>70,000</td>
<td></td>
<td>685,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>58,000</td>
<td>130,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>213,000</td>
<td></td>
<td></td>
<td>213,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>14,000</td>
<td>86,000</td>
</tr>
<tr>
<td>50 miles</td>
<td>Fiber, purchased</td>
<td>993,000</td>
<td>70,000</td>
<td></td>
<td>1,063,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>65,000</td>
<td>137,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>357,000</td>
<td></td>
<td></td>
<td>357,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>17,000</td>
<td>89,000</td>
</tr>
<tr>
<td>75 miles</td>
<td>Fiber, purchased</td>
<td>1,431,000</td>
<td>70,000</td>
<td></td>
<td>1,501,000</td>
</tr>
<tr>
<td></td>
<td>Fiber, leased</td>
<td></td>
<td>72,000</td>
<td>92,000</td>
<td>164,000</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>493,000</td>
<td></td>
<td></td>
<td>493,000</td>
</tr>
<tr>
<td></td>
<td>Compressed</td>
<td></td>
<td>72,000</td>
<td>22,000</td>
<td>94,000</td>
</tr>
</tbody>
</table>

\(^a\) Purchase costs refer to all construction, material, and equipment (not termination) costs involved in building the system.

\(^b\) Codec refers to equipment that changes analog signals to digital signals, and in compressed video systems, it also compresses the signal.

\(^c\) This price reflects added costs for one time connection fee.
FIGURE 5. One year lease costs for DS3<sup>a</sup> and T1<sup>b</sup> (data from Table 1)

<sup>a</sup>DS3 refers to a transmission medium that is capable of carrying full motion video.

<sup>b</sup>T1 refers to a transmission medium that is commonly used to carry compressed video.
Figure 6. Fiber, microwave, and compressed video costs compared (data from Table 2)
CHAPTER V. SUMMARY, DISCUSSION, AND CONCLUSIONS

The purpose of this chapter is to provide a brief summary of the study, review Chapters I, II, and III, restate the nine research questions, discuss results reported in chapter IV, and state conclusions of these results. Suggestions for further study of interactive distance education technologies are also included in this chapter. The chapter ends with a summary.

Review of Chapter I, II, and III

Today the movement in distance education is to utilize live, two-way interactive instruction. Quality distance education is dependent on interaction and participation of learners. The goal of implementing an interactive system is to make distant education as close to the traditional classroom as possible.

The creation and future implementation of the Iowa Telecommunications Network (ICN) has created considerable interest among Iowa administrators in distance education. This interest is combined with questions regarding funding for schools utilizing the ICN, the future prospects of the ICN, and time schedules involving the completion of the ICN. Schools needing immediate solutions to problems are examining other methods for two-way interactive instruction. Several concerns are: How much will distance education cost? and What variables determine these costs?

Purpose of the study

This study determined the costs for creating an interactive, two-way distance education system using fiber, microwave, and compressed video. Transmission costs were compared
for various distances. The study also described costs for equipping and installing a distance education classroom.

Research questions

In order to accomplish the purpose of this study, the following research questions were explored:

(1) What does it cost to put into place a point-to-point, distance education system using: microwave, fiber, and compressed video?

(2) What are the major cost considerations for the three transmission methods?

(3) Is it usually better to lease or purchase?

(4) How do the costs vary for distances of: 3 miles; 10 miles; 20 miles; 30 miles; 50 miles; 75 miles?

(5) What does it cost to equip distance education interactive classrooms?

(6) How much does it cost to remodel standard classrooms?

(7) What are recurring and maintenance costs for the classroom equipment?

(8) What are the recurring and maintenance costs for the transmission equipment?

(9) What are the characteristics, advantages and disadvantages of the three transmission technologies?

Review of the literature

The literature provided an overview of the current research in distance education. The areas covered in the review were: (a) theory of distance education, (b) impact of distance education today, (c) distance education costs, (d) the technology aspect of interactive
television, and (e) interactive television classrooms. There is a large amount of literature on distance education. Most is in the form of papers or conference presentations and provides direction for action rather than establishes theoretical constructs. Distance education literature is far more international than national in its orientation.

Distance education is gaining popularity in the United States, and interactive systems are the most popular. Research indicates that interactive classrooms are effective and successful. Although interactive systems come close to duplicating the natural classroom, and can offer many advantages to schools, interactive systems are complex and expensive to install. High start-up costs are an inhibiting factor for many schools. Cost variables are difficult to identify and sources of reliable technical assistance are hard to find. There is a need for reliable technical expertise.

Research on the transmission technologies of fiber, microwave, and compressed video indicate that each method is effective and successful. The choice of systems is not only affected by high start-up costs, but by environmental factors, current infrastructure, needs, and benefits. Effective systems depend upon the quality and usefulness of the content delivered and received, not upon the choice of media.

The literature on distance education classrooms tend to be presented by users describing their specific classrooms. Literature indicates that classroom design is similar throughout. Audio and control systems are described the least.
Methodology

This study identified and compared cost variables for creating a distance education system using three transmission methods of microwave, fiber, and compressed video. Data were collected using face-to-face, telephone, on-site visit interviews, and written communications with technical experts. Experts were identified who had experience and possessed technical knowledge of the transmission systems.

Experts were also identified who had experience in designing and installing interactive distance education classrooms. These experts aided in the design of a state-of-the-art classroom, equipment requirements and costs, and installation charges for this equipment.

Discussion of Results

This study discussed costs for creating a distance education system. Identification of major cost variables will aid educators in projecting and decision making. The costs are generalizable for Iowa schools.

Each medium is unique. When selecting a medium, some compromises may be required; budget constraints or environmental factors may force trade-offs. Significant elements to consider are the content of material communicated, the quality of transmission desired, the cost, and the ease of use.

Fiber systems were more complex than the other media. Microwave and compressed video systems have elements that are comparable from system to system. Estimates of fiber costs, however, are more difficult. There are more cost variables to consider and these variables are not consistent from system to system.
Leasing fiber systems capable of full motion transmissions is a more viable option for schools. The US West monthly lease rates are 5-8 times greater for full motion fiber than those for T1 lines used for compressed video. When the total system costs for equipment and leasing are considered, fiber costs are 45 percent more than the compressed video equipment costs. It is necessary to measure additional costs against the desired end results and benefits. Usually lower lease rates can be negotiated with utility companies than with the telephone companies.

If full motion video is necessary, microwave systems are viable alternatives for schools in Iowa. Microwave systems are cost-effective and easy to install if the distance is less than 10 miles. Microwave is the least expensive option for short distances. Microwave systems over 30 miles are probably cost prohibitive for two schools. Leasing microwave towers can decrease costs for two-hop systems, but leasing still involves a large investment for two schools. Leasing is most cost-effective if the leased structures can provide short hop opportunities to implement the less expensive short haul equipment.

Microwave transmissions can be affected by weather conditions. Adverse weather can also inflict damage on microwave equipment. Microwave frequencies are not always available, and geographic topography may limit microwave feasibility.

Compressed video offers the quickest and easiest solution to creating an ITV network between two schools. A compressed video system can be installed without any construction, without any involved consultation process, or high installation fees. Most people say they prefer a full motion system, but research indicates that compressed video is effective and
satisfactory. The picture quality of the compressed video technology is constantly improving. Most viewers quickly forget small sacrifices of color, motion, or resolution. Users whose only alternative is via the telephone are tolerant of the quality attainable with a bandwidth of 112 kb/s to 384 kb/s. Successful users see information content taking precedence over superior video image.

Conclusions

If full motion video is essential for interactive distance education, microwave is the most viable solution for shorter distances. Even though microwave systems are affected by weather in Iowa, they still are an effective means to link two schools. Digital fiber is the best choice as far as quality and capacity, but high costs negate this advantage. Fiber is the most complex to install; complexity contributes to higher costs. These high costs make fiber too expensive to install between two school systems. If compressed video is deemed a satisfactory transmission method, it is the least expensive to install and is a viable solution no matter the distance. It is the only cost appropriate solution for longer distances. Both fiber and microwave systems are too cost-prohibitive at longer distances.

If possible, it is better to lease than purchase fiber. It is best to negotiate fiber leases from public utilities rather than telephone companies. It is not cost-effective to lease codec equipment to use with full motion or compressed video systems. Leasing structures for microwave repeaters can be cost-effective.

The standard classroom is easily adapted for use as a distance education classroom without significant remodeling costs. State-of-the-art equipment is not necessary to
provide satisfactory audio and video signals for transmission between two schools.

Maintenance or service contracts are probably not needed for classroom equipment. This equipment is reliable and does not require extensive repair costs. A minimal amount in the budget is sufficient for repairs. Transmission equipment, however, involves larger expenses. Damage to transmission equipment can result from environmental factors. Maintenance agreements stating reliable service are necessary.

Suggestions for Future Research

1. This study presented a cost comparison of start up costs. These start up costs could be applied by specific schools to find unit costs to determine cost-effectiveness of distance education in specific schools. These costs could be related to activities and programs to determine benefit costs in particular schools.

2. When phase I and phase II of the ICN are completed, 103 sites in Iowa will be utilizing full motion, two-way video. Previously, there have not been many studies looking at the effectiveness of distance education at kindergarten through grade 12. This group could be selected for studies.

3. Studies could analyze how learning styles and age groups relate the success of the ITV student.

4. Studies could follow students who previously used interactive technology to see if they are successful in subsequent courses.

5. Studies could determine the most suitable classroom arrangement and most suitable equipment to meet learning needs.
6. Studies could follow cost trends of the technologies to further determine feasibility and future costs.

7. Research could continue on alternate transmission methods of dial up services and multi channel commercial analog video methods just now becoming available.

8. Comparisons between compressed video effectiveness and full motion video effectiveness could be run side-by-side. These studies would indicate student's preference or attitudes toward each system.

Summary

Two-way, interactive television systems are complex and time-consuming to implement, construct, and coordinate. Once implemented, however, they are neither difficult nor complex to use. With knowledgeable advice and sufficient planning, schools can have successful distance education programs. If the purpose of choosing an interactive system is to reach intended audiences and provide instruction, all three media can attain that goal on a fairly equal status. The success of any telecommunicated delivery system, of course, depends upon the quality and usefulness of the content delivered and received, rather than upon the choice of equipment.

With the implementation of the ICN in 1993, Iowa schools will increasingly be aware of the opportunities offered by distance education. The ICN will provide Iowa schools with more than a means of transmitting conventional education to new sites. The ICN will provide opportunities to expand instruction and to use innovative learning and teaching styles.
Schools not a part of the ICN will need to seek ways to offer equal opportunities to their students.
REFERENCE LIST


Fogarty, T. A. (1992, June 18). Lawsuit threatened: Sioux City cuts fiber optic plans. The Des Moines Register, p. 7M.


Holmberg, B. (1988a). Is distance education a mode of education in its own right or is it a substitute for conventional education? In D. Sewart & J. Daniel (Eds.), Developing distance education (pp. 245-248). Papers submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)


Iowa Telephone Association. (1990, December 19). *Iowa telecommunications industry illustrative example for the Iowa Communications Network.* Presented at the final meeting of the Telecommunications Oversight Study Committee. Des Moines, IA: Authors.


Roos, J. (1991, October 14). DMACC says it can't afford optics system. The Des Moines Register, p. 6M.

Roos, J. (1991, December 7). Fiber-optic network's backbone should be finished, panel says. The Des Moines Register, p. 2M.


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I would like to express my appreciation to a number of people who helped me succeed in graduate school and complete this thesis. First, a special thanks goes to my major professor, Dr. Michael Simonson whose guidance, encouragement, and support through the past year has helped me accomplish my graduate work. He helped me keep things in perspective and focus on the significant elements. Also, I would like to thank the members of my committee, Dr. Ann Thompson and Dr. Sedahlia Crase for their time and contributions to my thesis.

A special thanks to Don Rieck and Matt Darbyshire at Media Resources, and John Kingland and Robert Pink at Telecommunications for all their time, assistance, support, and advice.

Many thanks goes out to my family for providing me support and understanding. I will not be able to repay all that I asked of them these past few months.

Thanks to Karla Wright for friendship, encouragement, and rhetoric assistance. She continually provided a model of true courage and strength.

Thanks to First in the Nation in Education (FINE) and Research Institute for Studies in Education (RISE) for financial support.

Most importantly, thanks to vendors, consultants, and experts who supplied information for this project. Educators will benefit from this cost information.
APPENDIX A. LETTER TO PAT HASSEL, US WEST COMMUNICATIONS
REPLY AND US WEST DS3 AND T1 CHARGES
515 26th St.
Ames, Iowa 50010
(515) 232-7832
March 25, 1992

Ms. Pat Hassel
U S West Communications
Business & Government Services
900 Keo 1st 4 South
Des Moines, Iowa 50309

Dear Ms. Hassel:

I am a graduate student at Iowa State University majoring in Education. I am presently pursuing a master of science degree in Curriculum and Instruction. My study, Distance Education Systems: A Cost Analysis, will determine the transmission costs of various technologies used in distance education. The study has been approved by my committee. I am working under the supervision of Dr. Michael Simonson. I believe he talked to you previously about my project and you helped him with some preliminary cost estimates. We need your help again.

We are trying to identify general transmission costs for our study. Could you help us identify the current prices for DS1 and DS3 service between several locations. We need the non-recurring and recurring costs for 1 month, for 36 months, and for 60 months.

The locations and distances are:

1. Ames High School to Ames Middle School, 3 miles
2. Webster City to Blairsburg, 9 miles
3. Guttenberg to McGregor, 17 miles
4. Alta to Spencer, 33 miles
5. Council Bluffs to Hamburg, 47 miles
6. Mapleton to Hull, 72 miles

You gave Dr. Simonson this information (last Fall) for T1 costs. We are trying to update that information, and also identify the costs for DS3 service.

We hope our research will provide educators valid data for decision making. We hope you will be able to provide us with the information we need. I will call you in a few days to see if our request is clear, or you can call Dr. Simonson. His phone number is 294-6840. Thanks.

Sincerely,

Signature redacted for privacy

/ Judy I. Jones
March 26, 1992

Ms. Judy Jones  
515 26th St  
Ames, Iowa 50010

Dear Ms. Jones:

Below I have listed the pricing for DS1 and DS3 service between the requested locations. These are priced from the FCC1 tariff. A surcharge applies at each customer designated premises, except at the premises at which the Private Line Transport Service is connected to Interstate service unless written certification is received from the customer certifying exemption status.

The non recurring charge for DS1 will always be $1,386.04.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance (Miles)</th>
<th>Monthly 36 Months</th>
<th>Monthly 60 Months</th>
<th>Monthly 60 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ames High School to Ames Middle School - 3 Miles</td>
<td>3</td>
<td>$437.35</td>
<td>$407.00</td>
<td>$374.00</td>
</tr>
<tr>
<td>Webster City to Blairsburg - 9 Miles</td>
<td>9</td>
<td>$557.35</td>
<td>$518.00</td>
<td>$476.00</td>
</tr>
<tr>
<td>Guttenberg to McGregor - 17 Miles</td>
<td>17</td>
<td>$717.35</td>
<td>$666.00</td>
<td>$612.00</td>
</tr>
<tr>
<td>Alta to Spencer - 33 Miles</td>
<td>33</td>
<td>$1,037.35</td>
<td>$962.00</td>
<td>$884.00</td>
</tr>
<tr>
<td>Council Bluffs to Hamburg - 47 Miles</td>
<td>47</td>
<td>$1,317.35</td>
<td>$1,221.00</td>
<td>$1,122.00</td>
</tr>
<tr>
<td>Mapleton to Hull - 72 Miles</td>
<td>72</td>
<td>$1,673.35</td>
<td>$1,550.30</td>
<td>$1,424.60</td>
</tr>
</tbody>
</table>
The non recurring charge for DS3 will always be $1,466.10.

<table>
<thead>
<tr>
<th>Route Description</th>
<th>Distance</th>
<th>Monthly 36 Months</th>
<th>Monthly 60 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ames High School to Ames Middle School - 3 Miles</td>
<td>3 Miles</td>
<td>$3,432.99</td>
<td>$3,089.68</td>
</tr>
<tr>
<td>Webster City to Blairsburg - 9 Miles</td>
<td>9 Miles</td>
<td>$3,664.43</td>
<td>$3,297.89</td>
</tr>
<tr>
<td>Guttenberg to McGregor - 17 Miles</td>
<td>17 Miles</td>
<td>$3,958.98</td>
<td>$3,562.93</td>
</tr>
<tr>
<td>Alta to Spencer - 33 Miles</td>
<td>33 Miles</td>
<td>$4,690.53</td>
<td>$4,221.40</td>
</tr>
<tr>
<td>Council Bluffs to Hamburg - 47 Miles</td>
<td>47 Miles</td>
<td>$5,264.25</td>
<td>$4,737.72</td>
</tr>
<tr>
<td>Mapleton to Hull - 72 Miles</td>
<td>72 Miles</td>
<td>$7,553.54</td>
<td>$6,798.55</td>
</tr>
</tbody>
</table>

If you have any questions or need additional pricing, please call me on 1 800 642-6571.

Sincerely,

rat Hassel
Service Specialist

cc: Linda Brown
APPENDIX B. LETTER TO JOHN KINGLAND, TELECOMMUNICATIONS
Date: March 30, 1992

To: John Kingland, Director
   Telecommunications
   371 Durham
   Iowa State University

From: Judy Jones
   Graduate student
   Curriculum and Instruction

Re: Interview April 6, 1992

Dear John:

As you know I am a graduate student here, at Iowa State, majoring in Education. I am presently pursuing a master of science degree in Curriculum and Instruction. I am working under the supervision of Dr. Michael Simonson. Dr. Simonson and I have mentioned my study, Distance Education Systems: A Cost Analysis, to you in the past. We have identified three transmission media for this study: fiber, microwave and compressed video. We need your professional expertise concerning these technologies.

We will be interviewing vendors concerning costs of installation and hardware. We need to be knowledgeable in order to request precise information to secure valid data for our study. The literature has provided considerable information relating to the technologies, but some technical aspects need clarification. We hope you can enlighten us in regard to these aspects during our interview scheduled for April 6, at 9:00 a.m.

Enclosed are the questions that we wish to cover during this interview. Most questions are related to microwave systems. We have found some answers in the literature, but want your help to see if this information is accurate. We hope you will be able to provide us with the information we need. We hope our research will provide educators valid data for decision making.

Thank you for the time you have allotted for this interview. We look forward to meeting with you on the 6th.

jij

cc/enc: M. Simonson
QUESTIONS REGARDING MICROWAVE AND FIBER SYSTEMS FOR JOHN KINGLAND
SCHEDULED INTERVIEW APRIL 6, 1992

MICROWAVE SYSTEMS

RE: FCC license

Where do you get the application?
What is the procedure to apply?
What is the cost of the license?
How long does it take to get the license after applying?
Are licenses readily available for cities in Iowa? For small towns in Iowa?

RE: Equipment for the system

What pieces of equipment are required for a microwave system?
Tower - Is there a minimum height? What is average height?
How are towers priced?
Do most schools need a tower or can they use a dish on the building?
Antenna - What types are used for school? Dish - Horn?
Antenna feed line - Cable?
Receiver/Demodulation - What types? Specifications?
Transmitter/Modulation - What types? Specifications?
Repeater station - Does this cost as much as original tower?
Do you need identical equipment of the original tower?
What is considered short haul or long haul in distance?
Is equipment different for long haul?
What supporting hardware is necessary?
What is a waveguide?
What is the capacity of one channel? Can channels be added later?
Is it better to use analog or digital?

RE: Consultants

Who are the consultants available? Are they vendors?
Who does the frequency study? Is this before the FCC application or part of the application process?
Who does the path feasibility?
Who designs the circuit and determines the exact point-to-point?
Who determines the easement and tower location?
Are there local zoning ordinances? How do you find out? Must you get zoning approval from the Zoning Board or City Council? Is this different from city to city?
RE: Maintenance

Are there maintenance packages available?
What kind of warranties are available?
What kind of maintenance is needed?
What would be considered operating costs?

RE: Lease options

Are there lease options available?
How does this work? Are there cables from existing tower? Is there a distance requirement?
How are the lease arrangements priced?

RE: Vendors

Who are the vendors that supply Iowa with microwave systems?

FIBER SYSTEMS (PURCHASED)

RE: Equipment for the system

What type of fiber is best?
What are advantages or disadvantages of LED vs. LD; PIN or APD? Which should be used in a school system?
What supporting hardware is necessary?
Is it better to use analog or digital?
What expenses must be considered in the total cost of purchasing a fiber system e.g. preliminary studies, actual construction, cable, hardware?

RE: Consultants or vendors

Who are the consultants or vendors available?
Do they do path studies, determine easement and right-of-way, and get zoning approval?

RE: Maintenance

What kind of warranties are available?
Is there any maintenance required?
Are there operating costs?
APPENDIX D. PERSONAL INTERVIEW SOURCES
PERSONAL INTERVIEW SOURCES

Penny Adams  
Planning and Facilities  
Iowa State University  
Ames IA 50011  
515-294-8213

Brady Bruce  
VideoTelecom Corporation  
303-355-6469

Richard Burt  
Electronic Engineering Company  
Motorola Communications  
5th & Burnett  
Ames IA 50010  
515-233-2337

Donald Campbell  
Alcatel Network Systems, Inc.  
1225 N. Alma Road  
P.O. Box 833802  
Richardson TX 75083  
214-996-6670

Sam Charles  
Engineering Consultant  
US West Communications  
9225 High Street  
Second Floor-North of Ten  
Des Moines IA 50309  
515-286-7721

Tony Crandall  
Iowa Dept. of General Services  
Communications  
Hoover Bldg  
Des Moines IA 50309  
515-281-3336

Matt Darbyshire  
Media Resources Center  
121 Pearson hall  
Iowa State University  
Ames IA 50011  
515-294-8022

Thomas Dombrowsky  
Federal Communications Commission  
Private Radio Bureau  
Microwave Branch  
1270 Fairfield Rd  
Gettysburg PA 17326  
717-337-1421

Pam Draper  
US West Communications  
900 Keo 1st 4 South  
Des Moines IA 50309

Erik Eriksen  
Iowa Department of Education  
Grimes Building  
E 14th & Grand  
Des Moines IA 50309  
515-281-3190

Warren Fackler  
Spectra Associates Inc.  
425 2 St. SE  
Cedar Rapids IA 52401  
319-366-1821

Gary Fairchild  
Fairchild Communications, Inc.  
709 10th St.  
Boone IA 50036  
515-432-8602
Pat Hassel  
US West Communications  
Business & Government Services  
900 Keo 1st 4 South  
Des Moines IA 50309

John Kingland  
Telecommunications  
371 Durham Center  
Iowa State University  
Ames IA 50011  
515-294-8555

Randy McCutchan  
US West Cellular  
1200 Keo Way  
Des Moines IA 50309  
515-283-1200

Mike McQuiston  
US West Communications  
900 Keo 1st 4 South  
Des Moines IA 50309  
515-241-3909

Brent Norgaard  
MWR Telecom  
201 SE First Street  
Des Moines IA 50309  
515-242-4378

Robert Pink  
Telecommunications  
371 Durham Center  
Iowa State University  
Ames IA 50011  
515-294-8558

Don Rieck  
Media Resources Center  
121 Pearson Hall  
Iowa State University  
Ames IA 50011  
515-294-8022

Hubertus Sarrazin  
Tele-Systems Associates, Inc.  
114 East Second Street  
Hastings MN 55033  
612-438-3510

Linda Schatz  
Narrowcast Telecommunications  
P.O. Box 6450  
6450 Corporate Drive  
Johnston IA 50131  
515-242-4102

Bill Schoenenberger  
Department of Information Management  
Des Moines School System  
1800 Grand Ave  
Des Moines IA 50307

Gary Strand  
Video Programming Specialist  
Kirkwood Community College  
6301 Kirkwood Blvd. SW  
Cedar Rapids IA 52406

Dan Takkunen  
Todd Communications  
6545 Cecilia circle  
Minneapolis MN 55439  
612-941-0556

James Varnum  
Video Production Specialist  
240 Engineering Annex  
Iowa State University  
Ames IA 50011  
515-294-1827
APPENDIX E. FIBER COST DATA FROM MWR TELECOM
## FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

### FIBER OPTIC CABLE INSTALLATION COSTS

<table>
<thead>
<tr>
<th>RURAL AREAS</th>
<th>CONSULTATION COSTS</th>
<th>TOTAL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONSTRUCTION</td>
<td>FIELD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COST/FT</td>
<td>COST/MI</td>
<td>TECHNICAL</td>
</tr>
<tr>
<td>3</td>
<td>$1.55</td>
<td>$8,184</td>
<td>$600</td>
</tr>
<tr>
<td>10</td>
<td>$1.40</td>
<td>$7,392</td>
<td>$600</td>
</tr>
<tr>
<td>20</td>
<td>$1.35</td>
<td>$7,128</td>
<td>$600</td>
</tr>
<tr>
<td>30</td>
<td>$1.30</td>
<td>$6,864</td>
<td>$600</td>
</tr>
<tr>
<td>50</td>
<td>$1.21</td>
<td>$6,389</td>
<td>$600</td>
</tr>
<tr>
<td>75</td>
<td>$1.09</td>
<td>$5,755</td>
<td>$600</td>
</tr>
<tr>
<td>100</td>
<td>$0.97</td>
<td>$5,122</td>
<td>$800</td>
</tr>
</tbody>
</table>

**CONSTRUCTION:** DIRECT BURY CABLE ALONG RURAL ROW BY PLOWING METHOD.

**FIELD WORK:** SURVEYING, SKETCH PLANS.

**DRAFTING:** CAD DRAWINGS OF PROPOSED INSTALLATION, AS-BUILT DRAWINGS.

**TECHNICAL:** SPLICE AND TEST FIBER CABLE.

**ENGINEERING:** ROUTE PLANNING, SUPERVISION OF CONSTRUCTION & TECHNICAL CREWS, SCHEDULING, SOME ROW ISSUES.

**OTHER:** ROW ACQUISITION, LEGAL, ADMINISTRATION

**MATERIALS:**
- CABLE: $1.00/FT (12-F, SINGLEMODE, ARMORED) $5,280
- MANHOLES: 3/MILE @ $700/EA $2,100
- WARNING TAPE: $0.05/FT $264
- WARNING SIGNS: 1/500' @ $50/EA $528
- SPlicing: 1 SPlice/MILE @ $1000 $1,000
- MISC. $500
- TOTAL $9,672

DATA SUPPLIED BY B. NORGARD OF MWR TELECOM

June 22, 1992
### FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

#### URBAN AREAS

<table>
<thead>
<tr>
<th>DISTANCE, MI</th>
<th>CONSTRUCTION</th>
<th>CONSTRUCTION</th>
<th>CONSTRUCTION</th>
<th>FIELD TECHNICAL</th>
<th>WORK DRAFTING</th>
<th>ENGINEERING</th>
<th>OTHER</th>
<th>MATERIALS</th>
<th>COST/MILE</th>
<th>ESTIMATED COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$4.00</td>
<td>$21,120</td>
<td>$1,500</td>
<td>$1,800</td>
<td>$2,500</td>
<td>$2,000</td>
<td>$15,712</td>
<td>$45,832</td>
<td>$45,832</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>$3.00</td>
<td>$15,840</td>
<td>$1,500</td>
<td>$1,800</td>
<td>$2,500</td>
<td>$2,000</td>
<td>$15,712</td>
<td>$40,552</td>
<td>$202,760</td>
<td></td>
</tr>
</tbody>
</table>

**CONSTRUCTION:**
- PLACE 2" PVC DUCT @ 36" DEPTH; PULL CABLE THROUGH DUCT.

**MATERIALS:**
- CABLE: $1.00/FT (12-F, SINGLEMODE, ARMORED)
- DUCT: $0.50/FT (3" PVC)
- MANHOLES: 5/MILE @ $700/EA
- WARNING TAPE: $0.05/FT
- WARNING SIGNS: 1/500' @ $50/EA
- SPLICING: 2 SPLICE/MILE @ $1000
- MISC.

**TOTAL:**

$15,712

---

#### END EQUIPMENT COSTS

<table>
<thead>
<tr>
<th>LOW</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>$20,000</td>
<td>$50,000</td>
</tr>
</tbody>
</table>

**EQUIPMENT COSTS:**
- $20,000

**INSTALLATION LABOR:**
- $5,000

**TOTAL ESTIMATED COSTS END:**
- $25,000

---

**RANGE OF LOW - HIGH COSTS ARE DETERMINED BY INDUSTRY SPECIFICATIONS FOR SPECIFIC APPLICATION.**

**EQUIPMENT COSTS INCLUDE THE FOLLOWING:**
- FIBER OPTIC MULTIPLEXER
- VIDEO CODEC EQUIPMENT
- RACKING HARDWARE
- FIBER TERMINATION HARDWARE
- CROSS CONNECT HARDWARE
- POWER SUPPLY SYSTEM
- MISCELLANEOUS CABLES

---

**MAINTENANCE**

**ESTIMATED COSTS FOR MAINTENANCE AGREEMENT:**
- $3300 - $7600/YEAR/END
  - (MAINTENANCE ON END EQUIPMENT)
APPENDIX F. MICROWAVE COST DATA FROM ELECTRONIC ENGINEERING COMPANY; IOWA DEPARTMENT OF GENERAL SERVICES; ALCATEL NETWORK SYSTEMS
### DIGITAL RADIO SYSTEM
#### BASIC SYSTEM DUPLEX (Non-Protected)

**SHORT HAUL 3 MILES**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit Price</th>
<th>Point A</th>
<th>Point B</th>
<th>Point C</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver w/ battery unit</td>
<td>$10,300</td>
<td>1</td>
<td>1</td>
<td></td>
<td>$20,600</td>
</tr>
<tr>
<td>Antenna (included)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable</td>
<td>600</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,200</td>
</tr>
<tr>
<td>Audio Subcarrier</td>
<td>930</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,860</td>
</tr>
<tr>
<td>Tower</td>
<td>3,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>Path Study</td>
<td>1,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>1,500</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td><strong>System Total</strong></td>
<td><strong>$34,660</strong></td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
</tbody>
</table>


**TERMS USED ON THE FOLLOWING PRICE LISTS ARE DEFINED BELOW:**

- Duplex refers to two-way communication.
- Audio subcarrier refers to equipment to put audio on video channel.
- Waveguide refers to antenna feed from antenna to transmitter.
- Dehydrator refers to unit that keeps the waveguide moisture free.
- Charger system refers to the battery power unit.
- High power (TWT) and the auto power control refers to a power amplifier unit.
- Non-Protected refers to equipment that does NOT supply automatic redundancy to cover system failures.
## DIGITAL RADIO SYSTEM

**BASIC SYSTEM DUPLEX (Non-Protected)**

**SINGLE HOP 10 MILES**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit Price</th>
<th>Point A</th>
<th>Point B</th>
<th>Point C</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver</td>
<td>$10,300</td>
<td>1</td>
<td>1</td>
<td></td>
<td>$20,600</td>
</tr>
<tr>
<td>Antenna 4 feet</td>
<td>1,500</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>Ant Cable</td>
<td>600</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,200</td>
</tr>
<tr>
<td>Tower</td>
<td>5,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>Path Study</td>
<td>1,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>2,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$40,800</strong></td>
</tr>
</tbody>
</table>

Data supplied from Electronic Engineering letter dated June 17, 1992, and personal communication with R. Burt. This system includes a heavier extension tower on the building roof that extends to at least 100 feet. The antenna size is increased over the 3 mile distance antenna adding an additional $1,500 to the cost.
# DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
## BASIC SYSTEM DUPLEX (Non-Protected)

**SINGLE HOP 20 MILES**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit</th>
<th>Price</th>
<th>Point</th>
<th>Point</th>
<th>Point</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver</td>
<td></td>
<td>$32,720</td>
<td>1</td>
<td>1</td>
<td></td>
<td>$65,440</td>
</tr>
<tr>
<td>Antenna 8 foot</td>
<td></td>
<td>3,200</td>
<td>1</td>
<td>1</td>
<td></td>
<td>6,400</td>
</tr>
<tr>
<td>Waveguide (per foot)</td>
<td></td>
<td>13</td>
<td>250</td>
<td>250</td>
<td></td>
<td>6,500</td>
</tr>
<tr>
<td>Ant/WG Hardware</td>
<td></td>
<td>2,500</td>
<td>1</td>
<td>1</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>Dehydrator</td>
<td></td>
<td>756</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,512</td>
</tr>
<tr>
<td>Charger System 12 Amps</td>
<td></td>
<td>2,095</td>
<td>1</td>
<td>1</td>
<td></td>
<td>4,190</td>
</tr>
<tr>
<td>Batteries 96 Amp Hour</td>
<td></td>
<td>937</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,874</td>
</tr>
<tr>
<td>Tower 200 foot</td>
<td></td>
<td>20,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>40,000</td>
</tr>
<tr>
<td>Path Study</td>
<td></td>
<td>1,500</td>
<td></td>
<td></td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td></td>
<td>16,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>32,000</td>
</tr>
</tbody>
</table>

$\text{System Total} = \text{Transmitter/Receiver} + \text{Antenna} + \text{Waveguide} + \text{Ant/WG Hardware} + \text{Dehydrator} + \text{Charger System} + \text{Batteries} + \text{Tower} + \text{Path Study} + \text{Installation/Test}$

$\text{System Total} = \$65,440 + \$6,400 + \$6,500 + \$5,000 + \$1,512 + \$4,190 + \$1,874 + \$40,000 + \$3,000 + \$32,000 = \$165,916$

Equipment data are from an Alcatel Network Systems cost study dated December 12, 1991, sent to Iowa Department of General Services and personal communication with D. Campbell, Alcatel Network Systems, July 8, 1992. The tower costs reflect cost data received from various vendors.
### DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
#### BASIC SYSTEM DUPLEX (Non-Protected)

#### 1 HOP  30 MILES

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit Price</th>
<th>Point A</th>
<th>Point B</th>
<th>Point C</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver</td>
<td>$32,720</td>
<td>1</td>
<td>1</td>
<td></td>
<td>$65,440</td>
</tr>
<tr>
<td>High Power (TWT)</td>
<td>4,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>Auto Power Control</td>
<td>1,550</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,100</td>
</tr>
<tr>
<td>Antenna 8 foot</td>
<td>3,200</td>
<td>1</td>
<td>1</td>
<td></td>
<td>6,400</td>
</tr>
<tr>
<td>Waveguide (per foot)</td>
<td>13</td>
<td>320</td>
<td>320</td>
<td></td>
<td>8,320</td>
</tr>
<tr>
<td>Ant/WG Hardware</td>
<td>2,554</td>
<td>1</td>
<td>1</td>
<td></td>
<td>5,108</td>
</tr>
<tr>
<td>Dehydrator</td>
<td>850</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,700</td>
</tr>
<tr>
<td>Charger System 25 Amps</td>
<td>3,700</td>
<td>1</td>
<td>1</td>
<td></td>
<td>7,400</td>
</tr>
<tr>
<td>Batteries 200 Amp Hour</td>
<td>1,500</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>Tower 300 foot</td>
<td>35,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>70,000</td>
</tr>
<tr>
<td>Path study</td>
<td>1,500</td>
<td></td>
<td></td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>16,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>32,000</td>
</tr>
</tbody>
</table>

$213,468

Equipment data are from an Alcatel Network Systems cost study dated December 12, 1991, sent to Iowa Department of General Services and personal communication with D. Campbell, Alcatel Network Systems, July 8, 1992. The tower costs reflect cost data received from various vendors. Distances over 25 miles require larger antenna, dehydrator, and battery unit, plus the TWT unit. Per data sent to Iowa Dept. of General Services, a TWT power amplifier can be eliminated if antenna is increased to 12 foot. Larger antennas require additional hardware and installation costs. A taller tower is also required.
# DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
## BASIC SYSTEM DUPLEX (Non-Protected)

**TWO HOP 50 MILES**
20 mile hop & 30 mile hop

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit</th>
<th>Price</th>
<th>Point A</th>
<th>Point B</th>
<th>Point C</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver</td>
<td></td>
<td>$32,720</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>$130,800</td>
</tr>
<tr>
<td>High Power (TWT)</td>
<td>1</td>
<td>4,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>Auto Power Control (APC)</td>
<td>1</td>
<td>1,550</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,100</td>
</tr>
<tr>
<td>Antenna 6 foot</td>
<td>1</td>
<td>1,529</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3,058</td>
</tr>
<tr>
<td>Antenna 8 foot</td>
<td>1</td>
<td>3,200</td>
<td>1</td>
<td>1</td>
<td></td>
<td>6,400</td>
</tr>
<tr>
<td>Waveguide (WG) per foot</td>
<td>1</td>
<td>13</td>
<td>320</td>
<td>640</td>
<td>320</td>
<td>16,000</td>
</tr>
<tr>
<td>Ant/WG Hardware</td>
<td>1</td>
<td>2,554</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>10,216</td>
</tr>
<tr>
<td>Dehydrator</td>
<td>1</td>
<td>756</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,512</td>
</tr>
<tr>
<td>Dehydrator</td>
<td>1</td>
<td>850</td>
<td>1</td>
<td></td>
<td></td>
<td>850</td>
</tr>
<tr>
<td>Charger System 12 Amps</td>
<td>1</td>
<td>2,095</td>
<td>1</td>
<td>1</td>
<td></td>
<td>4,190</td>
</tr>
<tr>
<td>Charger System 25 Amps</td>
<td>1</td>
<td>3,700</td>
<td>1</td>
<td></td>
<td></td>
<td>3,700</td>
</tr>
<tr>
<td>Batteries 96 Amp Hour</td>
<td>1</td>
<td>937</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1,874</td>
</tr>
<tr>
<td>Batteries 200 Amp Hour</td>
<td>1</td>
<td>1,500</td>
<td>1</td>
<td></td>
<td></td>
<td>1,500</td>
</tr>
<tr>
<td>Tower 300 foot</td>
<td>1</td>
<td>35,000</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>105,000</td>
</tr>
<tr>
<td>Path study</td>
<td>1</td>
<td>1,500</td>
<td></td>
<td></td>
<td></td>
<td>4,500</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>1</td>
<td>16,000</td>
<td>1</td>
<td>1</td>
<td></td>
<td>32,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>1</td>
<td>24,000</td>
<td>1</td>
<td></td>
<td></td>
<td>24,000</td>
</tr>
</tbody>
</table>

**Total** $356,700
Equipment data are from an Alcatel Network Systems cost study dated December 12, 1991, sent to Iowa Department of General Services and personal communication with D. Campbell, Alcatel Network Systems, July 8, 1992. The tower costs reflect cost data received from various vendors. Per data sent to Iowa Dept. of General Services, a TWT power amplifier can be eliminated if antenna is increased to 12 foot. Larger antennas require additional hardware and installation costs.

Equipment for the 20 mile hop and 30 mile hop are different because more powerful equipment is needed for the longer distance. When the distance is over 25 miles, larger antenna, dehydrator, and battery units are used.
### DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
#### BASIC SYSTEM DUPLEX (Non-Protected)

#### FOUR HOP 75 MILES
25 mile hops

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit Price</th>
<th>Point A</th>
<th>Point B</th>
<th>Point C</th>
<th>Point D</th>
<th>System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter/Receiver</td>
<td>$32,720</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>$196,320</td>
</tr>
<tr>
<td>High Power (TWT)</td>
<td>4,000</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>16,000</td>
</tr>
<tr>
<td>Auto Power Control</td>
<td>1,550</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>6,200</td>
</tr>
<tr>
<td>Antenna 6 foot</td>
<td>1,529</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>9,174</td>
</tr>
<tr>
<td>Waveguide (WG)per foot</td>
<td>13</td>
<td>280</td>
<td>560</td>
<td>560</td>
<td>280</td>
<td>21,840</td>
</tr>
<tr>
<td>Ant/WG Hardware</td>
<td>2,700</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>16,200</td>
</tr>
<tr>
<td>Dehydrator</td>
<td>850</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3,400</td>
</tr>
<tr>
<td>Charger System 12 Amps</td>
<td>2,095</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4,190</td>
</tr>
<tr>
<td>Charger System 25 Amps</td>
<td>3,700</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>7,400</td>
</tr>
<tr>
<td>Batteries 96 Amp Hour</td>
<td>937</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1,874</td>
</tr>
<tr>
<td>Batteries 200 Amp Hour</td>
<td>1,500</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>Tower 250 feet</td>
<td>30,000</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>120,000</td>
</tr>
<tr>
<td>Path Study</td>
<td>1,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7,500</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>16,000</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>32,000</td>
</tr>
<tr>
<td>Installation/Test</td>
<td>24,000</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>48,000</td>
</tr>
</tbody>
</table>

$493,098

Equipment data are from an Alcatel Network Systems cost study dated December 12, 1991, sent to Iowa Department of General Services and personal communication with D. Campbell, Alcatel Network Systems, July 8, 1992. The tower costs reflect cost data received from various vendors. When the distance is over 25 miles, a larger antenna, dehydrator, battery unit, and TWT unit are used. Per data sent to Iowa Dept. of General Services, a TWT power amplifier can be eliminated if antenna is increased to 12 foot. Larger antennas would require additional hardware and installation costs.
June 17, 1992

Iowa State University
Distance Education Initiative
Attn: Judy Jones

The following is some information regarding the pricing of microwave equipment used to transport the interactive video signals from the fiber optic network to outlying schools some distance from the point of presence of the fiber.

There are two separate utilizations of microwave equipment commonly used. The short haul (18 or 23 GHZ) typically is used on systems where the transmit and receive units are placed eight miles or less from each other. There are times when these frequencies are used up to ten miles however heavy rains can cause temporary fade out conditions. The long haul (2 or 6 GHZ) typically is used quite adequately at distances of 20 miles, sometimes a little more.

The greatest problem in both cases is to get a good antenna site because microwave requires a direct line of site transmission. The short haul can go from building to building for the short distances as long as the buildings have an unimpeded view. The long haul requires, in most cases, a tower or tall building, such as a grain elevator, to get a sufficient height above ground to get from point A to point B without being blocked by trees or man made objects and also to compensate for the curvature of the earth. In addition the structures need to be quite stable in order to eliminate twisting and turning in the wind.

The licensing of the radio paths gets rather involved in that each path of the route between origin and termination has to be coordinated by an FCC delegated coordinator, and then a license application is filed for each path. The license application fee to the FCC is $155.00 per path, however the coordination and application preparation can be as high as $1100.00 per path.

The microwave equipment must have the necessary bandwidth to carry video signals, and usually has the necessary subcarrier to superimpose the accompanying audio signal. The following will give you some idea of equipment costs:

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Haul Digital 1 Transmitter-Receiver</td>
<td>$10,300.00</td>
</tr>
<tr>
<td>2 Audio Subcarrier</td>
<td>$ 930.00</td>
</tr>
</tbody>
</table>
In long haul applications, the hops in between origin and termination, do not need the mux equipment, but need two transmitter-receiver units back to back to repeat the signal both directions.

Lease options are available for these kinds of systems and probably would be the best arrangement for schools with budget problems. There are any number of ways to handle these kinds of systems.

Maintenance can be gotten for microwave systems both on contract as well as time and material agreements. We have found that this type of equipment is extremely reliable and is not prone to outgos. The typical contract for a transmitter-receiver is $25.00 per month which covers emergency calls, time and material costs, and necessary adjustments to the system.

I'm sure there are many other questions that have gone unanswered, but if you would like to call me I would be most happy to try to assist you.

Best regards,
Electronic Engineering Co.

Richard A. Burt
General Manager

Tower for long haul $20,000
Tower for short haul $2,000-$3,000
Installation is 10% of purchase cost
The compressed Video Mux is for digital transmissions
This information was received from T. Crandall, Iowa Department of General Services. The data was supplied by a microwave vendor.

11.8 miles

<table>
<thead>
<tr>
<th>Item</th>
<th>Model Number</th>
<th>Description</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Unit Price</th>
<th>Total</th>
<th>Extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K17YLD1676B</td>
<td>Ultrastar 6-45M Non-Protected Terminal</td>
<td></td>
<td></td>
<td>$30,946.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P141</td>
<td>Narrowband Service Channel Module</td>
<td></td>
<td></td>
<td>$397.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>P136</td>
<td>Flexible Waveguide, NP or MHSB</td>
<td></td>
<td></td>
<td>$303.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>P334</td>
<td>7.0' Rack for (Electronic Van Shipmont)</td>
<td></td>
<td></td>
<td>($32.80)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DQ290HDG</td>
<td>200' Guyed Tower $56/FOOT</td>
<td></td>
<td></td>
<td>$10,900.00</td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>DQ160HDG</td>
<td>100' Guyed Tower $56/FOOT</td>
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<td>$6,000.00</td>
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</tr>
<tr>
<td>7</td>
<td>MDH601OA</td>
<td>6' Standard Antenna (ANDREWS)</td>
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<td></td>
<td>$1,678.00</td>
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<td></td>
</tr>
<tr>
<td>8</td>
<td>MDN6039A</td>
<td>Radarome 6' (RGD)</td>
<td></td>
<td></td>
<td>$560.00</td>
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<tr>
<td>9</td>
<td>MDH6575A</td>
<td>Elliptical Waveguide ( EW53)</td>
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<td>$50.00</td>
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<td>$650.00</td>
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<tr>
<td>10</td>
<td>MDN7281A</td>
<td>Waveguide Connectors ( CPR137G/ UG343BA)</td>
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<td>$445.00</td>
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<td></td>
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<tr>
<td>11</td>
<td>TDN6950A</td>
<td>Angle Adapters for Waveguide (10 per pkg.)</td>
<td>3 5</td>
<td></td>
<td>$60.00</td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>MDN6810A</td>
<td>Elliptical Hangers for Waveguide (10 per pkg.)</td>
<td>3 6</td>
<td></td>
<td>$38.00</td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td>MDN6746A</td>
<td>Wall Feed Thru</td>
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<td></td>
<td>$81.00</td>
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<td></td>
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<tr>
<td>14</td>
<td>MDN7240A</td>
<td>Waveguide Doot 4&quot;</td>
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<td></td>
<td>TOTAL:</td>
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<td></td>
<td></td>
<td>$39,343.20</td>
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</tr>
</tbody>
</table>

**Optional Batteries / Chargers**

<table>
<thead>
<tr>
<th>Item</th>
<th>Model Number</th>
<th>Description</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Unit Price</th>
<th>Total</th>
<th>Extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MDN7167A</td>
<td>48V 25 Amp Charger Package with Rack and LVLD</td>
<td></td>
<td></td>
<td>$2,850.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>MDN7224A</td>
<td>100 Ah 20 yr Sealed Batteries (Cloride)</td>
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<td></td>
<td>$867.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MDN7253A</td>
<td>Battery Rack</td>
<td></td>
<td></td>
<td>$125.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL:</td>
<td></td>
<td></td>
<td></td>
<td>$4,842.00</td>
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</tbody>
</table>

**Installation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Unit Price</th>
<th>Total</th>
<th>Extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Field Service</td>
<td></td>
<td></td>
<td>$5,760.00</td>
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<tr>
<td>2</td>
<td>Install, Optimize and test Radios</td>
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<td></td>
<td>$31,801.00</td>
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</tr>
</tbody>
</table>

**TOTAL: $141,348.20**
APPENDIX G. SAMPLES OF MICROWAVE PATH STUDIES AND PATH PROFILES
PATH ROUGHNESS IS 35 FEET FROM 0 TO 11.8 MILES

GROUND ELEVATION OF PROFILE
- CENTERLINE/EVEN FRENSNEL ZONE
- FRENSNEL ZONE
- DIVERSITY CL/ODD FRENSNEL
- TERRAIN OVER WATER
- OBSTRUCTION OFF PATH

PATH PROFILE
DATA FROM: USGS 3-SEC DATA
DRAWN BY:
K=4/3

ACTUAL MICROWAVE PATH PROFILE DONE FOR TWO IOWA SCHOOLS,
RECEIVED FROM T. CRANDALL, IOWA DEPT. OF GENERAL SERVICES
**PATH STUDY COMPLETED FOR IOWA DEPARTMENT OF GENERAL SERVICES FOR TWO SCHOOLS IN IOWA**

<table>
<thead>
<tr>
<th>Path Name</th>
<th>DMACC</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Name</td>
<td>93° 36' 47.0&quot; N</td>
<td>93° 25' 17.0&quot; N</td>
</tr>
<tr>
<td>Latitude</td>
<td>41° 42' 29.0&quot; W</td>
<td>41° 35' 35.0&quot; W</td>
</tr>
<tr>
<td>Ground Elevation (ft)</td>
<td>950</td>
<td>225</td>
</tr>
<tr>
<td>Structure Height (ft)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tower Height (ft)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Antenna CL. (ft)</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Azimuth</td>
<td>2.1°</td>
<td>182.3°</td>
</tr>
<tr>
<td>Tilt</td>
<td>0.11°</td>
<td>0.07°</td>
</tr>
<tr>
<td>Path Length (miles)</td>
<td>11.79</td>
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<td>Frequency (GHz)</td>
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<tr>
<td>Free Space Loss (dB)</td>
<td>134.53</td>
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<td>Atmospheric Absorption (dB)</td>
<td>0.23</td>
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<td>Alignment Factor (dB)</td>
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<tr>
<td>Path Loss (dB)</td>
<td>136.16</td>
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<tr>
<td><strong>Tx/Rx Antenna System</strong></td>
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<td></td>
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<tr>
<td>Antenna Diameter (ft)</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Antenna Polarization (V/H)</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Antenna Gain (dBi)</td>
<td>39.58</td>
<td>39.38</td>
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<tr>
<td>Radome Loss (dB)</td>
<td>0.00</td>
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<td>Line Loss (dB/100 ft)</td>
<td>1.36</td>
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<td>Line Length (ft)</td>
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<td>Total Line Loss (dB)</td>
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<tr>
<td>Ant. Jumper (dB)</td>
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<td>Common Antenna (dB)</td>
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<td>Antenna System Gain (dB)</td>
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<td><strong>Transmitter</strong></td>
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<td>Transmitter Power (dBm)</td>
<td>30.00</td>
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<tr>
<td>Tx Attenuator (dB)</td>
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<tr>
<td>ERIP (dBi)</td>
<td>68.30</td>
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<td>Max FCC ERP (dBi)</td>
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<td><strong>Receiver</strong></td>
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<td>Rx Carrier (dBm)**</td>
<td>-30.16</td>
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<td>Receiver Sensitivity (dBm)</td>
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<tr>
<td>Flat Fading Margin (dB)</td>
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<tr>
<td>Dispersive Fading Margin (dB)</td>
<td>41.00</td>
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<td>Composite Fading Margin (dB)</td>
<td>36.77</td>
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<td><strong>Diversity Receiver</strong></td>
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<tr>
<td>Div Antenna Spacing (ft)</td>
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<td></td>
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<tr>
<td>Div Antenna Gain (dB)</td>
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<td></td>
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<tr>
<td>Radome Loss (dB)</td>
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<td></td>
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<td>Total Line Loss at Div. Rx (dB)</td>
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<td>Rx Act. Jumper (dB)</td>
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<tr>
<td>Div Rx Carrier (dBm)</td>
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<td>Div Flat Fading Margin (dB)</td>
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<tr>
<td>Div Composite Fading Marg. (dB)</td>
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<tr>
<td>Div Improvement Factor</td>
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<tr>
<td><strong>Multipath Outage</strong></td>
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<tr>
<td>Coasual, Average, Dry (2, 1, 0.5)</td>
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<td>1</td>
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<tr>
<td>Roughness Factor (20 ft ≤ ΔH ≤ 140 ft)</td>
<td>70</td>
<td>70</td>
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<tr>
<td>Average Temperature (35°F ≤ T ≤ 75°F)</td>
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<tr>
<td>Terrain Factor (c) (4, 1, 0.25)</td>
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<tr>
<td>Climatic Factor (b)(0.5, .25, .125)</td>
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<td>0.25</td>
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<tr>
<td>Probability of Multipath Outage</td>
<td>9.31B.07</td>
<td>9.31B.07</td>
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<tr>
<td>Multipath Outage (sec/yr)</td>
<td>29.45</td>
<td>29.45</td>
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<tr>
<td>Rain Rate (.01 % of time) mm/hr</td>
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<tr>
<td>Probability of Rain Outage</td>
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<tr>
<td>Rain Outage (sec/yr)</td>
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<tr>
<td>Total Rain &amp; Multipath Outages</td>
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<tr>
<td>Outage (severely errored) time per year (sec)</td>
<td>29.45 sec</td>
<td>29.45 sec</td>
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<tr>
<td>Percentage Availability***</td>
<td>99.959907</td>
<td>99.959907</td>
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</table>

**Calculated Received Carrier Level is Based on Free Space Loss**

***Predicted Availability is Based on Statistical Analysis and Cannot be Guaranteed for any Specific Time Period***
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Garnavillo</th>
<th>Elkader</th>
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<tbody>
<tr>
<td><strong>Main Antenna Size</strong></td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td><strong>Main Antenna Gain</strong></td>
<td>dBi</td>
<td>dBi</td>
</tr>
<tr>
<td><strong>Main Centerline</strong></td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td><strong>Feeder Length</strong></td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td><strong>Feeder Loss Per 100 FT</strong></td>
<td>dB</td>
<td>dB</td>
</tr>
<tr>
<td><strong>Feeder Loss</strong></td>
<td>dB</td>
<td>dB</td>
</tr>
<tr>
<td><strong>Radome Loss</strong></td>
<td>dB</td>
<td>dB</td>
</tr>
<tr>
<td><strong>Circulator Loss</strong></td>
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<td>dB</td>
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<tr>
<td><strong>Other Transmit Losses</strong></td>
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<td><strong>Other Receive Losses</strong></td>
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<td>dB</td>
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<tr>
<td><strong>Calculated EIRP</strong></td>
<td>dBM</td>
<td>dBM</td>
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<tr>
<td><strong>Maximum Allowed EIRP</strong></td>
<td>dBM</td>
<td>dBM</td>
</tr>
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</table>

| **Radio Equipment Type** | MDR-4106U NS |
| **Frequency Band**       | MHz          |
| **Path Length**          | Miles        |
| **Mean Annual Temperature** | Deg F       |
| **Absolute Humidity**    | g/m³        |
| **Climate Factor**       |             |
| **Roughness Factor**     | Feet        |
| **Free Space Loss**      | dB          |
| **Absorption Loss**      | dB          |
| **Field Margin**         |             |
| **Dispersive Fade Margin** | dB        |
| **Transmit Power**       | dBm         |
| **APC Power Reduction**  | dB          |
| **Maximum Received Signal** | dBM    |
| **Receiver Threshold**   | dBm         |

| **Main Received Signal** | dBM       |
| **Thermal Fade Margin**  | dB        |
| **External Interference FM** | dB     |
| **Number of Exposures**  | dB        |
| **Total External Int FM** | dB        |
| **Flat Fade Margin**     | dB        |
| **Freq Div Improve Factor** | THERMAL |
| **Space Div Improve Factor** | THERMAL |
| **Multipath Outage Seconds** | THERMAL |
| **Freq Div Improve Factor** | DIGITAL |
| **Space Div Improve Factor** | DIGITAL |
| **Multipath Outage Seconds** | DIGITAL |

| **Total Multipath 2-Way** | seconds |
| **Upfade Outage 2-Way**   | seconds |
| **Path Availability 2-Way** | percent |
| **Outage Objective Year** | percent |

*ATTENUATED TO MEET FCC MAX EIRP*
APPENDIX H. FCC APPLICATION FORM 402 AND INSTRUCTIONS
UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
GETTYSBURG, PA 17326
APPLICATION FOR STATION AUTHORIZATION IN THE
PRIVATE OPERATIONAL FIXED MICROWAVE RADIO SERVICE
FOR COMMISSION USE ONLY

FILE NUMBER: SEND TO ASB: ☐ YES ☐ NO

FOR APPLICANT: Use FCC Form 402 Instructions dated December, 1989, or later for reference in completing form.

SECTION I IDENTIFICATION INFORMATION

1. NAME OF APPLICANT:
2. MAILING ADDRESS: (No., street, city, state, ZIP code)
   ☐ Check here if you are a current Part 94 licensee and your mailing address, Item 2, IS NOT the address on file.

3. CALL SIGN: (If application refers to an existing Part 94 station)
4. LICENSEE IDENTIFICATION NUMBER: (If previously assigned by the Commission)

5A. NAME OF PERSON TO CONTACT REGARDING APPLICATION:
5B. TELEPHONE NUMBER OF THE CONTACT:

6. TYPE OF APPLICANT:
   ☐ INDIVIDUAL ☐ ASSOCIATION ☐ CORPORATION ☐ GOVERNMENTAL ENTITY

7. CLASS OF STATION: ☐ (enter code)
8. ELIGIBILITY RULE SECTION:

9A. PURPOSE OF APPLICATION:
   ☐ NEW STATION ☐ MODIFICATION ☐ MODIFICATION WITH RENEWAL (SEE 9B & 9C)
   ☐ ASSIGNMENT OF AUTHORIZATION ☐ OTHER (SPECIFY)

9B. PATH ACTION OLD VALUE OF KEY ITEMS CHANGED
   A. ☐ ADD ☐ CHANGE ☐ DELETE 20 30 31 32
   B. ☐ ADD ☐ CHANGE ☐ DELETE 20 30 31 32
   C. ☐ ADD ☐ CHANGE ☐ DELETE 20 30 31 32
   D. ☐ ADD ☐ CHANGE ☐ DELETE 20 30 31 32
   E. ☐ ADD ☐ CHANGE ☐ DELETE 20 30 31 32

9C. DESCRIBE ANY OTHER CHANGES:

10. WILL THIS SYSTEM BE USED TO PROVIDE A COMMUNICATIONS PRIVATE CARRIER SERVICE TO OTHERS? ☐ YES ☐ NO

SECTION II ANTENNA INFORMATION

11. LOCATION OF TRANSMITTING ANTENNA STRUCTURE:
   A. NUMBER AND STREET: (or other specific indication)
   B. CITY:
   C. COUNTY:
   D. STATE:
   E. COORDINATES: (Degrees, Minutes, Seconds)
      LATITUDE: N LONGITUDE: W

12A. IS THE ANTENNA TO BE MOUNTED ON AN EXISTING ANTENNA STRUCTURE? IF YES, ANSWER ITEMS 12B, C, D, & E:
   ☐ YES ☐ NO
12B. WILL THE ANTENNA INCREASE THE HEIGHT OF THE EXISTING STRUCTURE?
      IF YES, BY HOW MANY FEET?
      .................................................................................... FT

12C. NAME OF CURRENT LICENSEE USING STRUCTURE:
   ASB:
   12D. CURRENT LICENSEE'S RADIO SERVICE:
   12E. CURRENT LICENSEE'S CALL SIGN:

13. FOR ANTENNA TOWERS (OR POLES) MOUNTED ON THE GROUND: ENTER THE OVERALL HEIGHT ABOVE GROUND OF THE ENTIRE ANTENNA (OR POLE) INCLUDING ALL ANTENNAS, DISHES, LIGHTNING RODS, OBSTRUCTION LIGHTING, ETC. MOUNTED ON IT ................................. FT
14. FOR ANTENNAS OR ANTENNA TOWERS (OR POLES) MOUNTED ON A SUPPORTING STRUCTURE SUCH AS A BUILDING, WATER TOWER, SMOKE STACK, ETC.
14A. WHAT IS THE OVERALL HEIGHT ABOVE GROUND OF THIS SUPPORTING STRUCTURE? INCLUDE IN THIS HEIGHT ANY ELEVATOR SHAFTS, PENTHOUSES, LIGHTNING RODS, LIGHTS, ETC. WHICH ARE NOT PART OF THE ANTENNA TOWER (OR POLE) .......................................................... FT
14B. HOW MANY FEET DOES THE ANTENNA TOWER (OR POLE) (INCLUDING ALL ANTENNAS, DISHES, LIGHTNING RODS, LIGHTS, ETC.) INCREASE THE HEIGHT OF THE SUPPORTING STRUCTURE IN ITEM 14A? IF THIS ANTENNA OR ANTENNA TOWER (OR POLE) DOES NOT INCREASE THE HEIGHT OF THE SUPPORTING STRUCTURE, ENTER ZERO (0) ........................................ FT
14C. WHAT IS THE OVERALL HEIGHT OF THIS SUPPORTING STRUCTURE PLUS THE ANTENNA TOWER (OR POLE)? ......................................................... FT
15. GIVE THE GROUND ELEVATION ABOVE MEAN SEA LEVEL AT THE ANTENNA SITE ......................................................... FT
16A. NAME OF NEAREST AIRCRAFT LANDING AREA:
16B. DIRECTION AND DISTANCE TO NEAREST RUNWAY:
17A. Has notice of construction been filed with the FAA on FAA Form 7460-1? If yes, answer items 17B, C, and D. □ YES □ NO

17B. NAME UNDER WHICH YOU FILED: [ ]
17C. FAA REGIONAL OFFICE: (City) [ ]
17D. DATE FILED: [ ]

18. Would a Commission grant of your application be an action which may have a significant environmental effect as defined by Section 1.1307 of the Commission’s Rules? See Instruction 18. If you answer yes, submit the statement as required by Sections 1.1308 and 1.1311. □ YES □ NO

19. If this is an existing station, enter the year it was first licensed: [ ]

**SECTION III—TECHNICAL INFORMATION**

<table>
<thead>
<tr>
<th>NAME OF ITEM</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tr>
<td>20. Frequency (MHz)</td>
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<td>21. Bandwidth (kHz) and Emission Type</td>
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<tr>
<td>22. Type of Message Service</td>
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<td>23. Initial Baseband Channel Loading</td>
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<td>24. 10 yr. Projected Baseband Channel Loading</td>
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**TRANSMITTER INFORMATION**

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<th>B</th>
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<tbody>
<tr>
<td>25. Transmitter Operating Frequency Tolerance (%)</td>
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<tr>
<td>26. Antenna Gain (dBi)</td>
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<tr>
<td>27. Effective Isotropic Radiated Power (dBm)</td>
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<td></td>
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<td>28. Beamwidth (Degrees)</td>
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<tr>
<td>29. Height to Center of Final Radiating Element (Ft)</td>
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<tr>
<td>30. Polarization</td>
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<tr>
<td>31. Azimuth to Receive Site or Passive Repeater (PR) No. 1 (Degrees)</td>
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**RECEIVE SITE INFORMATION**

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<tbody>
<tr>
<td>32. Receiving Station’s Call Sign</td>
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<td>33. Receiving Antenna Gain (dBi)</td>
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<tr>
<td>34. Median Received Signal Level at Input to the Receiver (dBm)</td>
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<tr>
<td>35. Latitude N (Degrees, Minutes, Seconds)</td>
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<tr>
<td>36. Longitude W (Degrees, Minutes, Seconds)</td>
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<tr>
<td>37. Ground Elevation AMSL (Ft)</td>
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<tr>
<td>38. Height to Center of Receiving Antenna (Ft)</td>
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**PASSIVE REPEATER NO. 1 INFORMATION (IF ANY)**

If you have two or more passive repeaters on the same transmission path, check this box and answer items 39-46 on an additional FCC Form 402 or a separate sheet of paper for the second and successive passive repeaters.

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<thead>
<tr>
<th>NAME OF ITEM</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tbody>
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<td>39. Latitude N (Degrees, Minutes, Seconds)</td>
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<tr>
<td>40. Longitude W (Degrees, Minutes, Seconds)</td>
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<tr>
<td>41. Ground Elevation AMSL (Ft)</td>
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<td>42. Overall Height of PR Structure Above Ground (Ft)</td>
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<tr>
<td>43. Dimensions (Ft x Ft) or Beamwidth (for dishes) (Degrees)</td>
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<tr>
<td>44. Height Above Ground to Center of PR (Ft)</td>
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<td></td>
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<td></td>
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<tr>
<td>45. Polarization</td>
<td></td>
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</tr>
<tr>
<td>46. Azimuth to Receive Site or Next PR (Degrees)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**SECTION IV—CERTIFICATION**

1. Applicant certifies that a copy of CFR 47, Part 94 has been retained for reference.
2. Applicant waives any claim to the use of any particular frequency regardless of prior use by licensee or otherwise.
3. Applicant will have unlimited access to the radio equipment and will control access and exclude unauthorized persons.
4. Neither applicant nor any member thereof is a foreign government or representative thereof.
5. Applicant will utilize type accepted radio equipment and antenna of correct specifications.
6. Applicant certifies that all statements made in this application and attachments are true and complete.

**WILLFUL FALSE STATEMENTS MADE ON THIS FORM OR ATTACHMENTS ARE PUNISHABLE BY FINE AND IMPRISONMENT U.S. CODE TITLE 18 SECTION 1001**

<table>
<thead>
<tr>
<th>TYPED NAME:</th>
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<tr>
<td>TITLE:</td>
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</tr>
</tbody>
</table>

**SIGNATURE** of individual, partner, official of a governmental entity, officer or authorized employee of a corporation, or officer who is also a member of the association.

**DATE:**

**NOTICE TO INDIVIDUALS REQUIRED BY PRIVACY ACT OF 1974 AND THE PAPERWORK REDUCTION ACT OF 1980**

Sections 301, 303, and 308 of the Communications Act of 1934, as amended, (licensing powers) authorize the FCC to request the information on this application. The purpose of the information is to determine your eligibility for a license. The information will be used by FCC staff to evaluate the application, to determine station location, to provide information for enforcement and rule-making proceedings and to maintain a current inventory of licensees. No license can be granted unless all information requested is provided. Your response is required to obtain this authorization.
APPLICATION FOR STATION AUTHORIZATION IN THE PRIVATE OPERATIONAL FIXED MICROWAVE RADIO SERVICE (PART 94)

Public burden for this collection of information is estimated to be six hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden to the Federal Communications Commission, Office of Managing Director, Washington, DC 20554, and to the Office of Management and Budget, Paperwork Reduction Project (3060-0064), Washington, DC 20503.

GENERAL INSTRUCTIONS

A. CORRECT FORM:
Use FCC Form 402 to apply for an operational fixed microwave (928 MHz and above) station authorization in the Private Operational Fixed Microwave Radio Service (Part 94). This includes applications for new licenses, modifications, modifications with renewal, assignment of licenses or reinstatements of expired authorizations. For more details, see Instruction for completing Item 9A of the application form.

NOTE: Please submit the original and one copy of the complete application package to assist in processing.

B. RENEWALS:
Applications for renewal (without modification) of license, for all fixed microwave stations, should be made on FCC Form 402R, which is prepared and mailed by the FCC to licensees automatically, several months prior to the expiration date of each license. If an FCC 402R is not received within 60 days prior to license expiration, file FCC 402, check the “Other” block in Item 9A and specify “renewal only, no 402R available”.

C. RULES:
Applicant should refer to the FCC Rules before preparing this application. To purchase FCC Rules, CFR 47 Part 80 to END, contact the Superintendent of Documents, Government Printing Office, Washington, DC 20402. You may call (202) 783-3238 for the correct price.

D. FEES:
Most applications for station authorization in the Private Operational Fixed Microwave Radio Service must be accompanied by a fee. See Private Radio Services Fee Filing Guide, or contact the FCC Consumer Assistance Branch, Gettysburg, PA 17326 at (717) 337-1212 for fee information. Checks must be made payable to FCC. DO NOT SEND CASH.

E. MAIL TO:
Each application for station authorization in the Private Operational Fixed Microwave Radio Service must be filed, with fee, at:

Federal Communications Commission
Microwave Service
P.O. Box 360850M
Pittsburgh, PA 15251-6850

Applications exempt from fees, requests for extension of time in which to construct a new station, and general correspondence should be submitted in letter form, and sent to:

Federal Communications Commission
Microwave Branch
Gettysburg, PA 17326
INSTRUCTIONS FOR COMPLETING EACH ITEM OF THE FORM 402

SECTION I — IDENTIFICATION INFORMATION

ITEM 1. Enter the full legal name of the applicant. If applicant is an individual doing business in his/her own name, enter first name, middle initial, and last name. If applicant is an individual doing business under a firm or company name (sole proprietorship), enter both the individual’s name and the firm or company name. “Doing business as” may be abbreviated as “dba”.

Example: John H. Collins
dba Circle Construction Company

If applicant is a partnership doing business under a firm or company name, enter the full name of each partner having an interest in the business, and the firm or company name.

Example: John H. Collins & Richard Lee Doe
dba Circle Construction Company

If the application is to be submitted under the name of an unincorporated association, enter the name of the association.

If the application is to be submitted under the name of a corporation or governmental entity, enter the full legal name of the entity.

ITEM 2. Enter applicant’s United States mailing address. Indicate Post Office Box and Rural Route numbers where appropriate. Be sure to include ZIP Code. Since the address will be used to return the authorization, include the name of any person, office or division of the organization to whom it should be directed.

If the mailing address associated with this station has changed since the last application for this station, indicate the change by checking the box.

ITEM 3. If this application refers to a microwave station already licensed by the Commission (even if the authorization has expired) or if this is an application to relocate a presently licensed microwave station, or to change, delete, or add a path at a presently licensed microwave station, enter the call sign of the microwave station.

ITEM 4. If applicant has been assigned a Licensee Identification Number by the FCC on the last authorization for this station, enter the nine digit number. If the last authorization does not have a Licensee I.D. number, or this is the first time applying for a license, leave this item blank.

ITEM 5A. Enter the name of the person who is knowledgeable and may be contacted for clarification of the technical and administrative details of the application.

ITEM 5B. Enter this person’s telephone number, include the area code and extension number.

ITEM 6. Indicate the type of applicant filing the application. Refer to the instruction for Item 1 for more details.

ITEM 7. Enter the appropriate code corresponding to the class of station (see Rule Section 94.3 for definitions) as follows:

<table>
<thead>
<tr>
<th>CLASS OF STATION</th>
<th>CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Fixed</td>
<td>FX0</td>
</tr>
<tr>
<td>Control</td>
<td>FX1</td>
</tr>
<tr>
<td>Fixed Relay</td>
<td>FX2</td>
</tr>
<tr>
<td>Operational fixed at temp</td>
<td>FX5</td>
</tr>
<tr>
<td>Mobile</td>
<td>M0</td>
</tr>
</tbody>
</table>

ITEM 8. Enter the Rule Section number from Part 80, 87, or 90 that establishes the applicant’s eligibility to hold a radio license. For example, if the applicant is applying under the Railroad Radio Service, the Rule Section number is 90.91. DO NOT enter Rule Section 94.5 as the eligibility rule section. On an attachment, provide a statement which clearly indicates the applicant’s qualifications of eligibility for the specified radio service.

ITEMS 9A - 9B. Indicate the purpose of the application as follows:

NEW STATION — Check this box and proceed to Item 10 if this is an application for a microwave station not presently licensed.

If this is an application to relocate a presently licensed microwave station, or to change, delete, or add a path at a presently licensed microwave station, do not check this box, refer to the instruction for Modification.

MODIFICATION — Check this box if this is an application to change the terms of a license, e.g., to relocate a presently licensed microwave station or to change, delete, or add a path at a presently licensed microwave station. See Rule Section
94.45 for a list of those changes which require the filing of an application for modification of a license.

For Section II: Complete Items 11, 18 and only those items that are to be changed. If the change relates to the station location or the antenna structure (Items 11-17D), then all items in this Section must be completed.

For Section III: Enter information only for those paths that are to be changed, deleted, or added; do not fill in a column in Section III for a path that is not to be changed. If changing a path, complete Items 20, 30, 31, and 32 and only those items that are to be changed in a column for the path in Section III and mark Item 9B appropriately; if changing any of Items 20, 30, 31, and 32, also enter in Item 9B the old value of each of these items to be changed. If deleting a path, complete only Items 20, 30, 31, and 32 in a column for the path in Section III and mark Item 9B appropriately. If adding a new path at the station, complete a new column for the path in Section III and mark Item 9B appropriately.

MODIFICATION WITH RENEWAL — Check this box if this is an application to change the terms of a license concurrent with renewal.

For Section II: Complete Items 11, 18 and only those items that are to be changed. If the change relates to the station location or the antenna structure (Items 11-17D), then all items in this Section must be completed.

For Section III: Enter information only for those paths that are to be changed, deleted, or added; do not fill in a column in Section III for a path that is not to be changed. If changing a path, complete Items 20, 30, 31, and 32 and only those items that are to be changed in a column for the path in Section III and mark Item 9B appropriately; if changing any of Items 20, 30, 31, and 32, also enter in Item 9B the old value of each of these items to be changed. If deleting a path, complete only Items 20, 30, 31, and 32 in a column for the path in Section III and mark Item 9B appropriately. If adding a new path at the station, complete a new column for the path in Section III and mark Item 9B appropriately.

ITEM 9C. Describe all changes being made to the station which were not covered in Item 9B. If necessary, an attachment may be used.

ITEM 10. If applicant is providing a communications service as an entrepreneur, check the “yes” box.

SECTION II—ANTENNA INFORMATION

ITEMS 11A-11E. Enter the requested information about the transmitting antenna location. If the location of the antenna does not have a street address, describe the location in such a way that it can be located readily. For example, if the station is on a mountain, give the name of the mountain; for antennas at rural locations, indicate the route numbers of the nearest highway intersection and the distance and direction from the nearest town.

Example: 1.3 mi N.N.W. of Erie, Pa.

Enter the names of the county and state in which the transmitting antenna structure is actually located. However, enter the name of the city that is closest to the structure even if the city is not in the same county and/or state as the structure.

Enter the geographical coordinates in degrees, minutes and seconds, rounded to the nearest second, for the antenna location. The latitude and
longitude should be accurate to plus or minus one second for the antenna location. These coordinates are an important part of the location description. Do not estimate what they might be. Consult a qualified surveyor, if necessary. You MUST use coordinates based on North American Datum (NAD) 27.

ITEMS 12A-12E. Indicate in Item 12A whether the antenna(s) for this station will be mounted on an existing antenna tower (or pole). If not, do not complete Items 12B through 12E; if so, then complete Items 12B through 12E. Enter the name of a licensee using the same tower you propose to use, the name of the radio service in which he is licensed, and his station's Call Sign.

ITEM 13. If your antenna will be mounted on a tower (or pole) which is mounted on the ground, enter the overall height (feet) above ground of this tower (or pole), including as part of this tower any antennas, lights, lightning rods, etc. If you answer Item 13, DO NOT answer Item 14.

If your antenna or antenna tower (or pole) is mounted on a supporting structure such as a building, water tower, smoke stack, etc., answer Items 14A, B, and C and DO NOT answer Item 13.

ITEM 14A. Answer this Item if your antenna or antenna tower (or pole) will be mounted on a supporting structure such as a building, water tower, smoke stack, etc. Enter the overall height (feet) of only the supporting structure. Include in this height anything which is a part of the supporting structure such as an elevator shaft or penthouse for a building. Lightning rods should also be included in this height.

ITEM 14B. Enter the height (feet) that the antenna or antenna tower (or pole) (including all antennas, dishes, lightning rods, lights, etc.) will extend above the height of the supporting structure in Item 14A. If your antenna or antenna tower (or pole) will not extend above the height of the supporting structure in Item 14A, enter zero (0).

ITEM 14C. Enter the overall height (feet) above ground of the supporting structure plus the antenna or antenna tower (or pole).

\[ \text{Item 14A} + \text{Item 14B} = \text{Item 14C} \]

ITEM 15. Enter the ground elevation above mean sea level (feet) at the transmitting antenna site.

ITEMS 16A-16B. Enter in Item 16A the name of the nearest airport or aircraft landing area. Enter in Item 16B the direction (N., N.E., etc.) and the distance in miles from the antenna site to the nearest runway of the nearest airport or aircraft landing area.

ITEMS 17A-17D. Indicate whether notice of construction has been filed with the Federal Aviation Administration. Refer to Part 17 of the Commission's Rules for requirements and procedures for notification. If the FAA has been notified on Form 7460-1, enter the name of the organization it was filed under in Item 17B, the city of the FAA Regional Office where it was filed in Item 17C and the date when it was filed in Item 17D.

ITEM 18. Check yes if a Commission grant of the proposed communication facility would be an action which may have significant environmental effect. Such actions include: (a) a new antenna or structure (including any appurtenances or lighting) located in a residential area, or a change to such a structure, which results in FAA imposition of a requirement or option, for high intensity white hazard lighting; (b) facilities which are to be located in an officially designated wilderness area, wildlife preserve, or floodplain; (c) facilities which will affect sites significant in American History; (d) construction which involves extensive changes in surface features. Further details may be found in Sections 1.1306 and 1.1307 of the Commission's Rules.

If the answer to Item 18 is yes, submit the required Environmental Assessment (EA) along with the application. The EA includes: a) a description of the facilities (including height and special design features, access roads and power lines), a description of the site, the surrounding area and its uses, and a discussion of environmental and other considerations which led to its selection; b) the zoning classification of the site (if any) and communication with or proceedings before zoning, planning environmental, or other local, State or Federal Authorities on matters relating to environmental effect; c) a statement as to whether construction of the facilities has been a source of controversy on environmental grounds in the local community; d) a discussion of the nature and extent of any unavoidable adverse environmental effects perceived by the applicant and (where adverse effects are present) a discussion of any efforts made to minimize such effects and of any alternative routes, sites or facilities which have
been or might reasonably be considered. Further details may be found in Sections 1.1308 and 1.1311 of the Commission's Rules.

ITEM 19. If this is an application for an existing station, enter the year the station was first licensed. If this is an application for a new station, enter the year when the station operation will begin.

SECTION III—TECHNICAL INFORMATION

Read the instructions for Items 9A-9B and the following instructions carefully before completing Items 20-46. Each column, A through E, pertains to a single transmission path, emanating out from this station, whose frequency is entered in Item 20 of that column. It is suggested that you enter the frequencies first and work down.

We have provided columns for only five transmission paths on the FCC Form 402. If you have additional transmission paths emanating out from this station, use additional FCC Forms 402. Fill in only Item 9A “Other” and Section III on these additional forms, relabelling the columns as F, G, H, I, J, and so on as needed, and submit them attached to the first form. Be sure to cross reference the appropriate form which shows the first five paths.

ITEM 20. Enter the frequency (MHz) of the transmitter for this transmission path. Start a new column for each different frequency or transmission path. If two or more frequencies are to be used on the same path, or if the same frequency is to be used on two or more paths, start a new column for each.

ITEM 21. Enter the full emission designator of the transmitter, composed of its necessary bandwidth in kHz and its emission type, e.g., 25F9, 800F9, 10000A9Y, 5750A5, 25000A9, etc. See Rule Sections 2.201 and 2.202 for more detailed information. The new ITU emission designators put into use in 1985 for certain of the Commission’s radio services are not to be used on any Private Operational Fixed Microwave Radio Service applications until further notice is given.

ITEM 22. Enter the type of message service to be applied to the baseband of the transmitter: enter ANA for analog, DIG for digital, VID for video, or HYB for hybrid.

For digital message service, attach an exhibit describing voice and digital channel loading, data reduction or packing schemes, digital multiplex hierarchy, aggregate bit transmission rates (bps), etc.

For video message service, enter “1” in Items 23 and 24. If a non-standard bandwidth is being requested, attach an exhibit describing the video system, and additional information being carried, and justification for the requested bandwidth.

ITEM 23. For a new path, enter the number of 4 kHz equivalent analog voice channels contemplated to be put into service on the transmitter baseband within one year from the grant of this application. For a path being changed, enter the number of such channels in use at the time of application.

ITEM 24. Enter the number of 4 kHz equivalent analog voice channels contemplated to be put into service on the transmitter baseband in the next ten years.

TRANSMITTER INFORMATION

ITEM 25. Enter the frequency tolerance (percent) of the transmitter under normal operation.

ITEM 26. Enter the gain, over an isotropic radiator, (dBi, rounded to one decimal place) of the transmitting antenna.

ITEM 27. Enter the effective isotropic radiated power (EIRP) (dBm, rounded to one decimal place) radiated off the transmitting antenna. For a periscope antenna system, this is the anticipated EIRP radiated off its reflector.

ITEM 28. Enter the beamwidth (degrees, rounded to one decimal place) of the transmitting antenna, the angular distance between the half power points of its major lobe in the horizontal plane. For a periscope antenna system, also attach an exhibit showing the dimensions of the reflector (feet) and how the antenna system complies with the requirements of Rule Section 94.75(b). See also Rule Section 94.75(d).

ITEM 29. Enter the height above ground (feet) to the center of the final radiating element. For a parabolic dish antenna, this is the height to the center of the dish. For a periscope antenna system, this is the height to the center of the reflector. In all cases, this height should not exceed that which was entered in Item 13 or 14C.
**ITEM 30.** Enter the polarization of the transmitting antenna. Use V for vertical or H for horizontal. For other polarizations, refer to Rule Section 94.75(c). For a periscope antenna system, this is the expected polarization of the signal radiated off the reflector.

**ITEM 31.** Enter the azimuth, clockwise from True North, (degrees, rounded to one decimal place) from this station to the receive site or to the first passive repeater, if any, on this transmission path.

**RECEIVE SITE INFORMATION**

**ITEM 32.** Enter the call sign of the station at the far end of this transmission path, the station which will receive the transmissions of this transmission path on the frequency entered in Item 20. For a receive-only station, or a new station, leave this item blank.

**ITEM 33.** Enter the gain, over an isotropic radiator, (dBi, rounded to one decimal place) of the receiving antenna.

**ITEM 34.** Enter the median received signal level (dBm, rounded to one decimal place) at the input to the receiver.

**ITEMS 35-36.** Enter the latitude and longitude (degrees, minutes, seconds, rounded to the nearest second) of the receive site.

**ITEM 37.** Enter the ground elevation above mean sea level (feet) of the receive site.

**ITEM 38.** Enter the height above ground (feet) to the center of the receiving antenna. For a parabolic dish antenna, this is the height to the center of the dish. For a periscope antenna system, this is the height to the center of its reflector. If you use space diversity, this is the height to the center of the higher antenna.

**PASSIVE REPEATER NO. 1 INFORMATION**

Each transmission path may have one or more passive repeaters. If you do not have passive repeaters on a path, enter “NA” in Item 39. If you have one passive repeater on this transmission path, answer Items 39-46.

If you have two or more passive repeaters on this transmission path, check the box provided and use additional FCC Forms 402 or a separate sheet of paper. Reference these additional forms or sheets as PR 2, PR 3, and so on. answer only Items 39-46 on each, and submit them attached to the first FCC Form 402 with the appropriate cross references, should they become separated.

**ITEMS 39-40.** Enter the latitude and longitude (degrees, minutes, seconds, rounded to the nearest second) of this passive repeater.

**ITEM 41.** Enter the ground elevation above mean sea level (feet) of the site of this passive repeater.

**ITEM 42.** Enter the overall height above ground (feet) of the structure on which this passive repeater is to be mounted. Include any supporting structure, such as a building, water tower, smoke stack, etc., and any antenna tower (or pole), including any lightning rods, VHF antennas, lights, beacons, etc.

**ITEM 43.** For a reflector passive repeater, enter the dimensions (feet x feet) of the reflector. For back-to-back parabolic dish antennas used as a passive repeater, enter the bandwidth (degrees, rounded to one decimal place) of the receiving and emanating dish, the angular distance between the half-power points of its main lobe in the horizontal plane.

**ITEM 44.** Enter the height above ground to the center of the reflector or back-to-back dishes.

**ITEM 45.** Enter the expected polarization of the signal radiated off the reflector or back-to-back dishes. Use V for vertical or H for horizontal. For other polarizations, refer to Rule Section 94.75(c).

**ITEM 46.** Enter the azimuth, clockwise from True North, (degrees, rounded to one decimal place) from this passive repeater to the receive site or to the next passive repeater, if any, on this transmission path.
NOTICE TO INDIVIDUALS REQUIRED TO FILE PRIVACY ACT OF 1974 AND PAPERWORK REDUCTION ACT OF 1980

Sections 301, 303, and 308 of the Communications Act of 1934, as amended, (licensing powers) authorize the FCC to request the information on this application. The purpose of the information is to determine your eligibility for a license. The information will be used by FCC staff to evaluate the application, to determine station location, to provide information for enforcement and rulemaking proceedings and to maintain a current inventory of licensees. No license can be granted unless all information requested is provided. Your response is required to obtain this authorization.

TO PREVENT UNNECESSARY DELAYS IN PROCESSING YOUR APPLICATION, COMPLY WITH THE FOLLOWING:

1. EXCEPT AS PROVIDED IN RULE SECTION 94.63(E), EACH APPLICATION FOR A NEW OR MODIFIED STATION AUTHORIZATION MUST BE ACCOMPANIED BY A CERTIFICATION OF INTERFERENCE ANALYSIS OR COORDINATION PURSUANT TO THE APPLICABLE RULE SECTIONS IN PART 94. ANY TECHNICAL PATH DATA SHEETS SUBMITTED WITH THE REQUIRED CERTIFICATION MUST BE CONSISTENT IN DETAIL WITH THE TECHNICAL INFORMATION PROVIDED ON THE FCC FORMS 402.

2. ATTACH A FUNCTIONAL SYSTEM DIAGRAM AND DETAILED DESCRIPTION OF THE MANNER IN WHICH INTERRELATED STATIONS WILL OPERATE REQUIRED PURSUANT TO RULE SECTION 94.31(B).

3. ATTACH AND CROSS REFERENCE ALL SUPPLEMENTAL EXHIBITS REQUIRED BY THE RULES OR AS REQUESTED IN THESE INSTRUCTIONS, PURSUANT TO RULE SECTION 94.31(F).

4. READ THE CERTIFICATION CAREFULLY BEFORE YOU SIGN AND DATE THE APPLICATION. APPLICATION MUST BE PERSONALLY SIGNED AND DATED PURSUANT TO RULE 94.29.

5. BE SURE ALL NECESSARY ATTACHMENTS ARE INCLUDED, AND MAIL TO:

FEDERAL COMMUNICATIONS COMMISSION
MICROWAVE SERVICE
P. O. BOX 360850M
PITTSBURGH, PA 15251-6850

COMMISSION FIELD ENGINEERING OFFICES

Mailing addresses for Commission Field Engineering Offices are listed below. Street addresses can be found in local directories under "United States Government". All communications with Field Offices should be addressed to the Engineer in Charge.

Alaska, Anchorage 99502
Arizona, Phoenix 85024
California, Livermore 94551-0311
California, Cerritos 90701
California, San Diego 92111-2216
California, San Francisco 94111
Colorado, Denver 80228
Florida, Vero Beach 32961-1730
Florida, Miami 33166
Florida, Tampa 33607-2356
Georgia, Atlanta 30309
Georgia, Powder Springs 30073
Hawaii, Waipahu 96797
Illinois, Park Ridge 60068
Louisiana, New Orleans 70123
Maine, Belfast 04915
Maryland, Baltimore 21201
Maryland, Columbia 21045
Massachusetts, Quincy 02169
Michigan, Allegan 49010
Michigan, Farmington Hills 48331
Minnesota, St. Paul 55101
Missouri, Kansas City 64133
Nebraska, Grand Island 68802
New York, Buffalo 14202
New York, New York 10014
Oregon, Portland 97204
Pennsylvania, Langhorne 19047
Puerto Rico, Hato Rey 00918
Texas, Dallas 75243
Texas, Houston 77008
Texas, Kingsville 78363-0632
Virginia, Virginia Beach 23455-3725
Washington, Custer 98240
Washington, Bellevue 98006
APPENDIX I. RFP SPECIFICATIONS FOR THE IOWA STATE UNIVERSITY DISTANCE EDUCATION CLASSROOM COMPRESSED VIDEO CODER/DECODER
3.0 Overview

3.0.1 Today, Iowa State University has classrooms utilizing video cameras, monitors, microphones, speakers, video recorders and document cameras. ISU desires to purchase CODEC units and CSU/DSU that will provide interconnection of distant classrooms.

3.1 Scope

3.1.1 The following specifications define the minimum performance characteristics for a compressed video coder/decoder (CODEC), video switcher and audio mixer meeting the CCITT, px64 international standard (formerly referred to as H.261).

3.2 Technical Requirements - Minimum

3.2.1 Transmission Facilities

Digital Dedicated.

Dial-up (SW/56) with at least two circuits.

3.2.2 Transmission Rate

Px64, 56 kbps to 2.04 Mbps.

3.2.3 Transmission Mode

Digital.

3.2.4 Supported Video Format

NTSC.

3.2.5 Supported Motion Resolution

FCIF 352 x 288 pixels.

3.2.6 Maximum Frame Rate Supported

30 fps.

3.2.7 Transform Coding

Discrete cosine Px64 (H.261).

3.2.8 A CSU/DSU unit is required. The proposed unit must be compatible with the proposed CODEC.
3.3 Technical Requirements - Optional  Please provide as optional items (not required), the following capabilities/functions, showing a unit cost for each option.

3.3.1 Transmission Rate  45 Mbps.

3.3.2 Supported Video Format  PAL and SECAM.

3.3.3 Supported Motion Resolution  QCIF 176 x 144 pixels.

3.4 Physical Requirements  Please provide the following information on the proposed equipment: physical dimensions, weight, power requirements, minimum/maximum operating temperature, and mounting requirements.

3.5 Any new software upgrades that are announced prior to complete installation and acceptance of the proposed equipment must be provided to ISU at no charge.

3.6 Please provide additional technical details where appropriate.

3.7 Please submit your prices as shown in Section 5.10, Form of Proposal. ISU is interested in a quantity of two for this project.

3.8 Service  Provide costs for the following service options and list any other service options available.

1) Immediate telephone response for technical questions.
   a. During normal business hours
   b. All hours and all days

2) Next business day response with technician on site.

3) Spare parts and/or a replacement unit must be on-site within 24-hours of determination of a problem.

4) Is there a recommended spare parts kit? Please elaborate and identify costs.

5) Other service options.
3.9 **Warranty** A one year warranty is required. Please identify response times, etc. (see paragraph 3.8). Is an extended warranty plan available? If so, identify the time periods available and the relative costs.

3.10 **Installation** Identify when the proposed equipment could be installed and by whom (See paragraph 3.19). The price should include setup at ISU in a test environment to simulate a possible Ames to remote site connection. Installation of the CODEC must be scheduled with ISU Media Resources personnel to allow connection of ISU-owned distance education equipment.

3.11 **Training** Your price should include at least 4 hours of training for up to six people at ISU. A room will be provided for this training.

3.12 **Upgrades** Please explain your firmware and software upgrade policy and the respective costs.

3.13 **Video/Audio/Data Inputs/Outputs** Please identify how many of each type.

3.14 **Proprietary Features** Please describe the following capabilities/features and show their respective costs. Available funding will dictate, which (if any) optional features ISU will be able to purchase.

- Far end control.
- Local control.
- Camera position presets.
- Video graphics.
- Other proprietary/optional features.

3.15 Finalists may be requested to set up a demonstration of the proposed equipment with one end located at ISU.

3.16 The Iowa Board of Regent's universities and the State Department of General Services desire compatibility and interoperability among compressed video equipment used in the state. Please identify whether the following state agencies could purchase at the same prices offered in your proposal to ISU. Please identify how long your prices will remain firm and if educational discounts are available.

- The University of Iowa
- The University of Iowa Hospitals and Clinics
3.17 Additional Questions

3.17.1 Network Management. What diagnostics and alarming does your system offer for both the local and far ends?

3.17.2 Can the equipment be rack mounted in a standard 19" rack?

3.17.3 Is the proposed equipment listed on a GSA schedule? If so, would ISU be eligible to purchase at those prices?

3.17.4 Has the system been successfully tested at the Px64 (H.261) standard?

3.17.5 Please explain how the following equipment/functions are integrated: CODEC, video switching, audio mixing, terminal adapters, audio/video integration.

3.17.6 Audio Please state the minimum/maximum frequency response. Describe the characteristics of your audio system. Does the proposed equipment meet or exceed CCITT specifications G.722 and G.711 (as adopted 12/90)? Please explain. Does the proposed equipment offer enhanced audio? Echo canceling? Please explain.

3.17.7 Explain in detail the proposed equipment’s video switching and audio mixing capability.

3.17.8 Does the proposed system support FAX communication?

3.17.9 Describe your multi-point control unit capabilities for the proposed CODEC units and the respective costs.

3.17.10 The following standards have not all been approved for inclusion in the Px64 standard. Please identify if the proposed equipment meets the standards (as adopted 12/90).

- H.221 Communications framing
- H.230 Control and indication signal
• H.242 Call set up and disconnect

• H.320 Requirements for narrow bandwidth system (interoperability)

3.18 Delivery and Installation ISU intends to use this equipment for fall classes. The total system should be delivered by August 1, 1992, to allow time for installation and testing. Please identify if you could deliver any earlier.

3.19 Acceptance Test/Payment Schedule ISU will pay for seventy-five percent (75%) of the cost of the CODECs upon completion of the initial acceptance test. This test is described in paragraph 3.10. The remaining twenty-five percent (25%) will be paid after final acceptance of the proposed equipment. Final acceptance will consist of installation at the actual remote site (not yet determined) and successful completion of a thirty (30) consecutive day operational and testing period by ISU personnel. The start date of this test will be mutually agreed upon by the vendor and ISU. Any failure of the CODEC system and software within the 30-day testing period will cause the clock to be reset to zero, and the test to be repeated.

As ISU-owned equipment will be part of this installation, if a failure was caused by ISU-owned equipment, the clock will stop until the equipment is repaired, will not be reset to zero, but will begin again at the number of days reached prior to the failure. The warranty period will not start until completion of the final acceptance test.
APPENDIX J. COMPRESSED VIDEO CODEC BID RESPONSES FOR THE IOWA STATE CLASSROOM
**IOWA STATE UNIVERSITY VIDEO CONFERENCING SYSTEM**

**EQUIPMENT PRICING**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>QTY.</th>
<th>DISCOUNT PRICE</th>
<th>EXTENDED PRICE</th>
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<td><strong>MANDATORY REQUIREMENTS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>VisuaLink 5000 Model 20 Codec (full duplex)</td>
<td>2</td>
<td>$32,560</td>
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</tr>
<tr>
<td>Px64 Compatibility</td>
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<tr>
<td>56Kbps - 2.048Mbps capability</td>
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<tr>
<td>3 compression algorithms</td>
<td>(CIF, QCIF, NEC High Res.)</td>
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<tr>
<td>PIP</td>
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<tr>
<td>3 data ports</td>
<td>(2-RS232, 1-RS449)</td>
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<tr>
<td>4x3 Video Switcher</td>
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</tr>
<tr>
<td>Choice of Line Interface</td>
<td>T1 or Dual RS-449 or Dual V.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice of Audio Compression</td>
<td>Standard 48/56Kb Audio Compression</td>
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<td></td>
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<tr>
<td>G.711 (3.4KHz) - A-Law, u-Law</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>G.722 (7 KHz) - SB ADPCM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or</td>
<td>NEC's Proprietary MPC 16Kb including</td>
<td></td>
<td></td>
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<tr>
<td>G.711 (3.4KHz) - A-Law, u-Law</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>and ADPCM</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>AEC-400 Acoustic Echo Canceller</td>
<td>2</td>
<td>$4,608</td>
<td>$9,216</td>
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<tr>
<td>CSU/DSU</td>
<td>2</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>NEC can provide a compatible CSU/DSU to interface to the VisuaLink 5000. There are a wide variety of CSU/DSU's available based on transmission speed and other factors. Once Iowa State University determines it's network requirements, NEC will provide the proper CSU/DSU to meet both NEC's and the University's specifications.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**TOTAL COST FOR REQUIRED EQUIPMENT ====>** $37,168 $74,336

**CODEC BID RESPONSE FROM NEC FOR CODEC EQUIPMENT FOR AN IOWA STATE UNIVERSITY DISTANCE EDUCATION CLASSROOM**

**MAY 27, 1992**
US WEST is pleased and proud to propose the following equipment to meet the needs of Iowa State University for compressed video distance learning:

**PROPOSED**

**MEDIAMAX BASIC PLATFORM**

- Basic MediaMax platform
  - CCITT Standards H.261/H.221
  - TrueTalk Audio System (3.3Khz)
  - Multipoint interoperable
  - User Control tablet with overlay
  - Built-in FAX port
  - RS232 data port
  - 30 Frames/second Kit (software and hardware that permits MediaMax to operate up to 30 fps @ 384 Kbps)

The price of this equipment as mentioned in sections V is $37,892/codec
### Installation and Maintenance Pricing

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>QTY</th>
<th>Discount Price</th>
<th>Extended Price</th>
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<tbody>
<tr>
<td>Installation</td>
<td>2</td>
<td>$1,500</td>
<td>$3,000</td>
</tr>
<tr>
<td>Per site to include the Ames facility and one other facility used for the test environment.</td>
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<td></td>
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</tbody>
</table>

**Maintenance - As per Item 3.8 in the RFP**

1. Telephone Service
   - During normal business hours
   - All hours and all days

   - Discount Price: $0
   - Extended Price: $100/hour

2. Next business day with technician on-site

   - Discount Price: $800/manday + expenses

3. Spare parts and/or replacement on site within 24 hours of problem determination
   - Discount Price: 3% / annum
   - Note: Percentage above will be applied to the total cost of the equipment purchased. For example, based on the Mandatory Equipment provided in this response, the annual costs would be:

     $74,336 \times 3\% = $2,230
3.9 Warranty. A one year warranty is required. Please identify response times, etc. (see paragraph 3.8). Is an extended warranty plan available? If so, identify the time periods available and the relative costs.

The Standard Warranty Service Plan represents Norstan’s full service support offering. In the event of a major system failure, Norstan’s Technical Assistance Center will attempt to determine and correct the problem remotely. If these attempts prove ineffective, Norstan will dispatch a Technician per the on-site support response times indicated below.

Rembrandt II and Gallery Systems will receive this warranty support for a period of one (1) year from the cutover date.

COVERAGE HOURS: 8:00 A.M. - 5:00 P.M. MONDAY-FRIDAY

HOLIDAYS: EXCLUDED

RESPONSE TIMES:
(Immediate Technical Assistance)
MAJOR - 30 MINUTES MAXIMUM
MINOR - 4 HOURS MAXIMUM

RESPONSE TIMES:
(On-Site Support)
Within Norstan’s Local Support Zones
Major - 4 Hours
Outside Norstan’s Local Support Zones
Major - 24 Hours

FEATURES:
Corrective Maintenance (On-Site)
Replacement Components
Technical Assistance Center
Telesupport
Remote Diagnostic Capability
Defined Response Parameters
Software Maintenance Updates
24 Hour X 7 Day 800 Service Center

* Norstan’s Local Support Zones are identified in the Maintenance Plan Feature Guide.

3.10 Installation. Identify when the proposed equipment could be installed and by whom (See paragraph 3.19). The price should include setup at ISU in a test environment to simulate a possible Ames to remote site connection. Installation of the CODEC must be scheduled with ISU Media Resources personnel to allow connection of ISU-owned distance education equipment.

$1000 trip charge + $500 codec or rollabout room ordered
$3,500/rollabout.

WARRANTY AND INSTALLATION INFORMATION SUPPLIED BY NORSTAN FOR COMPRESSEION LABS EQUIPMENT IN RESPONSE TO A BID FOR CODEC EQUIPMENT FOR THE IOWA STATE UNIVERSITY COMPRESSED VIDEO CLASSROOM
APPENDIX L. IOWA STATE UNIVERSITY PRELIMINARY EQUIPMENT SPECIFICATIONS AND COST ESTIMATES; BID RESPONSES FOR THE COMPRESSED VIDEO CLASSROOM; VENDOR PRICE LISTS FOR VIDEOCONFERENCING CLASSROOM EQUIPMENT PACKAGES
## DISTANCE EDUCATION PROJECT

### PRELIMINARY EQUIPMENT SPECIFICATIONS AND COST ESTIMATES

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MAKE</th>
<th>MODEL</th>
<th>QTY</th>
<th>UNIT</th>
<th>SUB</th>
</tr>
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<tbody>
<tr>
<td>I. ORIGINATION SITE INSTRUCTOR CONSOLE</td>
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</tr>
<tr>
<td>PROG. SPEAKER</td>
<td>ANCHOR</td>
<td>AN-1000X</td>
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<td>COMPUTER</td>
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<td>W/NU-VISTA BD</td>
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<td>VISUAL PRESENTER</td>
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<td>EV-308/LU-308</td>
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<td>TRV-35G</td>
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<td>VHS PLAYER</td>
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<td>500.00</td>
<td>500.00</td>
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<tr>
<td>VHS RECORDER</td>
<td>PANASONIC</td>
<td>AG-1730</td>
<td>1</td>
<td>500.00</td>
<td>500.00</td>
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<tr>
<td>REMOTE SITE MONITOR</td>
<td>PANASONIC</td>
<td>PVM-8220 IN DUAL CONFIG</td>
<td>1</td>
<td>1200.00</td>
<td>1200.00</td>
</tr>
<tr>
<td>LAVALIERE MIC</td>
<td>SHURE</td>
<td>AMS 28</td>
<td>1</td>
<td>200.00</td>
<td>200.00</td>
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<tr>
<td>BACKUP WIRED MIC</td>
<td>SHURE</td>
<td>AMS 24</td>
<td>1</td>
<td>225.00</td>
<td>225.00</td>
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<tr>
<td>PREVIEW/PROGRAM MONITOR</td>
<td>SONY</td>
<td>PVM-8220 IN DUAL CONFIG</td>
<td>1</td>
<td>1200.00</td>
<td>1200.00</td>
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<tr>
<td>FURNITURE/RACKS</td>
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<td>1</td>
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<tr>
<td>FAX MACHINE</td>
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<td></td>
<td>1</td>
<td>800.00</td>
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</table>

| II. ORIGINATION SITE DISTRIBUTION EQUIPMENT |              |                        |     |      |      |
| CODEC & CONTROLLER           |              |                        | 1   | 35000.00 | 35000.00 |
| AUDIO/VIDEO DIST.AMP         | ESE          |                        | 1   | 400.00  | 400.00  |
| AUDIO/VIDEO SWITCHER         | EXTRON OR TECH |                    | 1   | 1500.00 | 1500.00 |
| REM.CONT. CAMERAS            | PANASONIC    | WV-D5100               | 2   | 2800.00 | 5600.00 |
| AUDIO MIXER/ALC SYSTEM       | SHURE        | AMS 4000               | 1   | 1800.00 | 1800.00 |

| III. ORIGINATION SITE STUDENT STATIONS |              |                        |     |      |      |
| SPEAKERS FOR SONY MON        | ANCHOR       | AN-1001                | 6   | 200.00  | 1200.00 |
| FURNITURE                    | LUXOR        | ATW-56                 | 3   | 300.00  | 900.00  |
| MICROPHONES                  | SHURE        | AMS 22                 | 8   | 200.00  | 1600.00 |
| VIEWING MONITORS             | SONY         | PVM-2530               | 3   | 1500.00 | 4500.00 |
| FURNITURE                    | TABLES       |                        | 8   | 200.00  | 1600.00 |

| IV. REMOTE SITE DISTRIBUTION EQUIPMENT |              |                        |     |      |      |
| CODEC & CONTROLLER           |              |                        | 1   | 35000.00 | 35000.00 |
| AUDIO/VIDEO DIST.AMP         | ESE          |                        | 1   | 400.00  | 400.00  |
| AUDIO/VIDEO SWITCHER         | EXTRON OR TECH |                    | 1   | 1500.00 | 1500.00 |
| REM.CONT. CAMERAS            | PANASONIC    | WV-D5100               | 2   | 2800.00 | 5600.00 |
| AUDIO MIXER/ALC SYSTEM       | SHURE        | AMS 4000               | 1   | 1800.00 | 1800.00 |
| FURNITURE/RACKS              | WINSTED      |                        | 1   | 1000.00 | 1000.00 |

**PRELIMINARY EQUIPMENT REQUIREMENTS FOR THE IOWA STATE UNIVERSITY COMPRESSED VIDEO CLASSROOM**
**DATA PRESENTED TO THE CLASSROOM STUDY COMMITTEE**
**V. REMOTE SITE MONITOR CONSOLE**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MAKE</th>
<th>MODEL</th>
<th>QTY</th>
<th>UNIT</th>
<th>SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fax Machine</td>
<td>?</td>
<td>EV-308/LU-308</td>
<td>1</td>
<td>800.00</td>
<td>800.00</td>
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<tr>
<td>Visual Presenter</td>
<td>ELMO</td>
<td>AG-1730</td>
<td>1</td>
<td>2500.00</td>
<td>2500.00</td>
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<tr>
<td>VHS Recorder</td>
<td>PANASONIC</td>
<td>AMS 28</td>
<td>1</td>
<td>500.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Backup Wired Mic</td>
<td>SHURE</td>
<td>PVM-8220 IN DUAL CONFIG</td>
<td>1</td>
<td>200.00</td>
<td>200.00</td>
</tr>
<tr>
<td>Preview/Program Monitor</td>
<td>SONY</td>
<td>PVM-8220 IN DUAL CONFIG</td>
<td>1</td>
<td>1200.00</td>
<td>1200.00</td>
</tr>
<tr>
<td>Remote Site Monitor</td>
<td>SONY</td>
<td>PVM-8220 IN DUAL CONFIG</td>
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<td>1000.00</td>
<td>1000.00</td>
</tr>
<tr>
<td>Furniture/Racks</td>
<td>WINSTED</td>
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</table>

**VI. REMOTE SITE STUDENT STATIONS**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MAKE</th>
<th>MODEL</th>
<th>QTY</th>
<th>UNIT</th>
<th>SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furniture</td>
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<td>AN-1001</td>
<td>8</td>
<td>200.00</td>
<td>1600.00</td>
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<tr>
<td>Speakers for Sony Mon</td>
<td>ANCHOR</td>
<td>AN-1001</td>
<td>4</td>
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<td>Video Carts</td>
<td>LUXOR</td>
<td>ATW-56</td>
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<td>Microphones</td>
<td>SHURE</td>
<td>AMS 22</td>
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<td>200.00</td>
<td>1600.00</td>
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<td>Viewing Monitors</td>
<td>SONY</td>
<td>PVM-2530</td>
<td>2</td>
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</table>

**EQUIPMENT TOTAL**

$130225.00

**VII. INSTALLATION COSTS**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MAKE</th>
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<th>QTY</th>
<th>UNIT</th>
<th>SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabling/Conduit</td>
<td>BELDEN &amp; PANDUIT</td>
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<td>2000.00</td>
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<tr>
<td>Labor</td>
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**VIII. LINE LEASING**

**IX. SYSTEM MAINTENANCE/SUPERVISION SUPPORT**

MOVING AND SETUP COSTS ($250/DAY)

TOTALS

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>INSTALLATION</th>
<th>LINE LEASING</th>
<th>SYSTEM MAINTENANCE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

$130225.00

**TOTALS**

$130225.00

**ANNUAL ONGOING COSTS**
<table>
<thead>
<tr>
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<th>Description</th>
<th>Quantity</th>
<th>Price</th>
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</thead>
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<td>V8603</td>
<td>24.5&quot; RACK CABINET</td>
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<td>V8606</td>
<td>35&quot; RACK CABINET</td>
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<td>857822</td>
<td>1/2&quot; PLATE CASTORS</td>
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<td>E4892</td>
<td>2&quot; CASTORS FOR E4942</td>
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<td>E4970</td>
<td>MOVABLE ROLL-UP MONITOR BRIDGE</td>
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<td>85142</td>
<td>5&quot; BLANK PANEL</td>
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<td>Sony MB-507</td>
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<td>Panasonic WV-PSO3</td>
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<td>ANCHOR SB-730 SWIVEL MOUNT</td>
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<td>BRETFORD CR-8501-GM TRAP. TABLE</td>
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<td>ELMO EV-308, VISUAL PRESENTER</td>
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<td>ELMO LU-308 LIGHT BAR FOR EV-308</td>
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<td>TOTAL Equipment</td>
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<tr>
<td>MAC II ci</td>
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<tr>
<td>Extended Keyboard</td>
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<tr>
<td>Orange Micro Sys PC -386 board</td>
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<tr>
<td>NTSC Genlock Card</td>
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BID RESPONSES FOR DISTANCE EDUCATION CLASSROOM EQUIPMENT, JUNE 1992
The prices listed herein are not discounted. Ordering offices must apply discount of 18%.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK125</td>
<td>MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, one 25&quot; monitor, PIP, and Benchmark 125 enclosure</td>
<td>$67,000</td>
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<tr>
<td>BK220</td>
<td>MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 20&quot; monitors, and Benchmark 220 enclosure</td>
<td>$68,000</td>
</tr>
<tr>
<td>BK225</td>
<td>MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 25&quot; monitors, and Benchmark 225 enclosure</td>
<td>$72,000</td>
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<tr>
<td>BK235</td>
<td>MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 35&quot; monitors, and Benchmark 235 enclosure</td>
<td>$85,000</td>
</tr>
<tr>
<td>MM-FD1</td>
<td>MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, and two 13&quot; monitors in a ready-to-ship hardened enclosure</td>
<td>$75,000</td>
</tr>
</tbody>
</table>

Information supplied as part of the bid response for the Iowa State compressed video classroom

BK 125 SYSTEM

Codec = $37,892
Equipment = $29,108

List price for equipment from Appendix J

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>$2,270</td>
</tr>
<tr>
<td>Elmo</td>
<td>$3,100</td>
</tr>
<tr>
<td>Microphones</td>
<td>$420</td>
</tr>
<tr>
<td>Speaker</td>
<td>$163</td>
</tr>
<tr>
<td>Monitor</td>
<td>$1,590</td>
</tr>
<tr>
<td>Pen Pal</td>
<td>$7,000</td>
</tr>
<tr>
<td>Enclosure</td>
<td>$2,000 (Brackets $677)</td>
</tr>
</tbody>
</table>

Total $16,543 = 43% less by individual purchase

ALL COMPONENTS HAVE A ONE YEAR WARRANTY.
GALLERY VIDEOCONFERENCE SYSTEM

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallery 125</td>
<td>Roll-about videoconference room system includes front camera with pan/tilt/zoom/focus capability; one 25-inch NTSC color monitor; control system with table-top control panel; complete audio system with Voicecrafter™ digital echo cancellation and two microphones, and modem for remote diagnostics.</td>
<td>$25,000</td>
</tr>
</tbody>
</table>

Codec = $36,195
Equipment = $25,000

List price for equipment from Appendix J
Camera $2,270
Microphones $420
Speaker $163
Monitor $1,590
Control $2,000
Enclosure $2,000 (Brackets $677)
Mixer $2,800
Echo cancel $1,640

Total $12,883 = 48% less by individual purchase

| Gallery 235 | Roll-about videoconference room system includes front camera with pan/tilt/zoom/focus capability; two 35-inch NTSC color monitors; control system with table-top control panel; complete audio system with Voicecrafter™ digital echo cancellation and two microphones; NTSC document camera with stand, and modem for remote diagnostics. | $41,500 |

Information supplied as part of the bid response for the Iowa State compressed video classroom
APPENDIX M. VIDEOCONFERENCING INTEROPERABILITY TEST SUCCESS
NEWS RELEASE

Contacts:  Tracy Beaufort  Ron Taylor  Alison Raffalovich
Compression Labs  PictureTel Corp.  VideoTelecom Corp.
408/922-4610  508/977-8567  512/834-3720

U.S. Videoconferencing Vendors Announce Interoperability Test Success

CLI, PictureTel and VideoTelecom Offer Users Full Px64 Standards

AUSTIN, Texas; PEABODY, Mass; SAN JOSE, Calif. February 26, 1992—Compression Labs, Incorporated, PictureTel Corporation and VideoTelecom Corporation today announced that their respective videoconferencing systems have successfully interoperated using the CCITT videoconferencing standard, commonly called px64. The three vendors account for more than 70 percent of the world’s installed videoconferencing systems. Once installed in a system, the standard allows each vendor’s customers to access any other vendor’s system that uses the px64 algorithm.

The tests were carried out independently during the past several months among the three vendors at 112 kilobits per second (Kbps) and 384 Kbps. All three vendors expect to have a significant installed base of px64 customers by the end of the year. Additional facets of px64 such as the standards for multipoint, encryption and graphics handling are currently under consideration by the CCITT standards committee.

This press release was included with bid information for the Iowa State University compressed video classroom.
APPENDIX N. NARROWCAST ADVISORY COMMITTEE MINIMUM EQUIPMENT STANDARDS FOR THE ICN
### CLASSROOM EQUIPMENT

**SYSTEM TWO**

#### CAMERA EQUIPMENT:
CCD 1 chip Cameras with head, ac, lens, tripod head adaptor, and controller.  
12,066

#### VIDEO EQUIPMENT:
Monitor, mounting brackets, video switcher, synchronizing generator, video amplifier, and associated equipment.  
6,689

#### AUDIO EQUIPMENT:
Distribution amplifiers, preamplifiers, power amplifiers, speakers, talk back system, microphones, and associated equipment.  
4,298

#### OTHER ASSOCIATED REQUIREMENTS:
Podium, cables, connectors, and classroom control unit.  
6,800

<table>
<thead>
<tr>
<th>Anticipated Discount of 5%</th>
<th>1,493</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td><strong>$28,360</strong></td>
</tr>
</tbody>
</table>

Minimum equipment list for Iowa Communications Network phase I and II classrooms from the Narrowcast Advisory Committee and the Iowa Public Broadcasting Board.
## CLASSROOM EQUIPMENT
**SYSTEM TWO**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>UNIT</th>
<th>EXTENDED COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAMERA EQUIPMENT:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3- CCD 1 Chip Camera</td>
<td></td>
<td>$11,466</td>
</tr>
<tr>
<td>With Head, AC, Lens, Tripod Head Adaptor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Controller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1- Copy Stand Camera Mount Power Pole</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>2- Camera Wall Mounts</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td><strong>VIDEO EQUIPMENT:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3- 27&quot; Color Monitor</td>
<td>1,040</td>
<td>3,120</td>
</tr>
<tr>
<td>3- TV Mounting Brackets or TV Stands</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>1- 8&quot; Color Monitor</td>
<td>449</td>
<td>449</td>
</tr>
<tr>
<td>1- Rack Mount for 8&quot; Color Monitor</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>1- 10X1 Active Video Switcher (Remote Controllable)</td>
<td>995</td>
<td>995</td>
</tr>
<tr>
<td>1- Synchronizing Generator</td>
<td>1,005</td>
<td>1,005</td>
</tr>
<tr>
<td>1- Video Amplifier</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td><strong>AUDIO EQUIPMENT:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2- Audio Distribution Amplifier</td>
<td>360</td>
<td>720</td>
</tr>
<tr>
<td>1- Mixer Preamplifier Input</td>
<td>398</td>
<td>398</td>
</tr>
<tr>
<td>7- Modules for Mixer Preamplifier</td>
<td></td>
<td>436</td>
</tr>
<tr>
<td>1- Mixer Power Amplifier</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>4- Speaker Assemblies</td>
<td>43</td>
<td>172</td>
</tr>
<tr>
<td>1- Audio Talk Back System -</td>
<td>1,066</td>
<td>1,066</td>
</tr>
<tr>
<td>includes Rack Mount</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10- Student Desk Microphones  98  980
1- Teacher's Lavalier Microphone  306  306

OTHER ASSOCIATED REQUIREMENTS:
Podium With Copy Stand  1,500  1,500
Cables/Connectors  300  300
Classroom Control Unit  5,000

Anticipated Discount of 5%  1,493

Total  $28,360

OPTIONS:
Additional cost for upgrade to wireless microphone for teacher instead of lavalier microphone.  1,144
Video-Switcher remote panel  200
White porcelain board  500
Installation  4,000
Camera pan and tilt capability
Graphics monitor
Preview monitor for podium
APPENDIX O. STATE-OF-THE-ART DISTANCE EDUCATION CLASSROOM DESIGN; STATE-OF-THE-ART EQUIPMENT LIST; BASIC CLASSROOM DISTANCE EDUCATION CLASSROOM EQUIPMENT LIST
### State-of-the-Art
### Distance Education Classroom Equipment List
### Origination Site

<table>
<thead>
<tr>
<th>Cameras</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Student camera (Panasonic WV-F70)</td>
<td>1</td>
<td>4295</td>
<td>4295</td>
</tr>
<tr>
<td>B Student camera</td>
<td>1</td>
<td>4295</td>
<td>4295</td>
</tr>
<tr>
<td>C Teacher camera</td>
<td>1</td>
<td>4295</td>
<td>4295</td>
</tr>
<tr>
<td>Mounting brackets camera (Pan WV131P)</td>
<td>3</td>
<td>52</td>
<td>156</td>
</tr>
<tr>
<td>D Visual presenter (Elmo EV-308)</td>
<td>1</td>
<td>3100</td>
<td>3100</td>
</tr>
<tr>
<td>Mounting brackets monitor (ceiling)</td>
<td>6</td>
<td>221</td>
<td>1326</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitors</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>E Monitor, outgoing 25&quot;(Sony PVM2530)</td>
<td>2</td>
<td>1590</td>
<td>3180</td>
</tr>
<tr>
<td>F Monitor, remote site 25&quot;</td>
<td>2</td>
<td>1590</td>
<td>3180</td>
</tr>
<tr>
<td>G Teacher monitor, remote site 25&quot;</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>H Teacher monitor, outgoing 25&quot;</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>I Monitor, individual student 12&quot; (NEC PM1271A)</td>
<td>12</td>
<td>525</td>
<td>6300</td>
</tr>
<tr>
<td>J Monitor, teacher 7&quot; (Panasonic BT-S701N)</td>
<td>3</td>
<td>600</td>
<td>1800</td>
</tr>
<tr>
<td>Mounting brackets monitor (ceiling) (Bretford Mfg TVM1)</td>
<td>6</td>
<td>221</td>
<td>1326</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Audio</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Speakers (Anchor AN1001)</td>
<td>4</td>
<td>163</td>
<td>652</td>
</tr>
<tr>
<td>K2 Teacher speaker (Anchor An1000X)</td>
<td>1</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>L Microphone, student (Shure AMS22)</td>
<td>12</td>
<td>210</td>
<td>2520</td>
</tr>
<tr>
<td>M Microphone, teacher/wireless (Telex FMR-25TD)</td>
<td>1</td>
<td>600</td>
<td>600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teacher station</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Audio/Video control (Crestron)</td>
<td>1</td>
<td>6000</td>
<td>6000</td>
</tr>
<tr>
<td>O Teacher control unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rack mount shelving (Winstead)</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Audio mixer (Shure AMS8000)</td>
<td>1</td>
<td>2800</td>
<td>2800</td>
</tr>
<tr>
<td>Video distribution (Panasonic WJ300B)</td>
<td>2</td>
<td>290</td>
<td>580</td>
</tr>
<tr>
<td>Power strip (Winstead 98700)</td>
<td>1</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Light/dimmer control (AMXM320)</td>
<td>1</td>
<td>675</td>
<td>675</td>
</tr>
<tr>
<td>P VCR play/record (Panasonic AG1250)</td>
<td>2</td>
<td>350</td>
<td>700</td>
</tr>
<tr>
<td>Q Facsimile (HP200)</td>
<td>1</td>
<td>1200</td>
<td>1200</td>
</tr>
</tbody>
</table>

**EQUIPMENT TOTAL** $52199
-30% $36539

Supplies, cabling, wiring, connectors

**TOTAL** $39539
Options for substitution or enhancement

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 chip camera (Panasonic WV-F250)</td>
<td>1</td>
<td>7800</td>
<td></td>
</tr>
<tr>
<td>Tripod for camera (ITE-T30)</td>
<td>1</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>Large screen monitor 35&quot; (Sony PVM5310)</td>
<td>1</td>
<td>2625</td>
<td></td>
</tr>
<tr>
<td>Multiscan monitors 13&quot; (Sony GVM-1300)</td>
<td>1</td>
<td>1495</td>
<td></td>
</tr>
<tr>
<td>20&quot; (Sony GVM-2000)</td>
<td>1</td>
<td>2300</td>
<td></td>
</tr>
<tr>
<td>35&quot; (Mitsubishi AM-3501R)</td>
<td>1</td>
<td>6900</td>
<td></td>
</tr>
<tr>
<td>b&amp;w teacher display monitors 4&quot; (PVM 411)</td>
<td>1</td>
<td>1540</td>
<td></td>
</tr>
<tr>
<td>Metal cart for monitor (Winstead R3353)</td>
<td>1</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>Lavalier microphone (Shure AMS28)</td>
<td>1</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Room control panel (PenPal USWest)</td>
<td>1</td>
<td>7000</td>
<td></td>
</tr>
<tr>
<td>Slide to video converter (Elmo TRV-35G)</td>
<td>1</td>
<td>3215</td>
<td></td>
</tr>
<tr>
<td>Film to video converter (Elmo TRV-16G)</td>
<td>1</td>
<td>4290</td>
<td></td>
</tr>
<tr>
<td>Echo canceller (Shure)</td>
<td>1</td>
<td>1640</td>
<td></td>
</tr>
<tr>
<td>Time Base corrector (NOVA 700)</td>
<td>1</td>
<td>2290</td>
<td></td>
</tr>
<tr>
<td>Computer interface (Micro 386 board)</td>
<td>1</td>
<td>2200</td>
<td></td>
</tr>
<tr>
<td>NTSC Genlock card</td>
<td>1</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Video Scan Converter PS 2</td>
<td>1</td>
<td>12995</td>
<td></td>
</tr>
<tr>
<td>Video Scan Converter MAC</td>
<td>1</td>
<td>9995</td>
<td></td>
</tr>
<tr>
<td>Table 96&quot; x 24&quot; Barron</td>
<td>1</td>
<td>606</td>
<td></td>
</tr>
<tr>
<td>Table 18&quot; x 60&quot; Barron</td>
<td>1</td>
<td>483</td>
<td></td>
</tr>
<tr>
<td>Table 60&quot; x 24&quot; Barron</td>
<td>1</td>
<td>518</td>
<td></td>
</tr>
<tr>
<td>Porcelain board/metal board 72 x 48 $6.20 sq.ft.</td>
<td></td>
<td></td>
<td>149</td>
</tr>
</tbody>
</table>

Acoustic treatment

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpet</td>
<td>14.00 - 16.00 sq. yd</td>
</tr>
<tr>
<td>Wall panels</td>
<td>5.60 sq. ft</td>
</tr>
<tr>
<td>Drapes</td>
<td>6.25 sq. ft</td>
</tr>
</tbody>
</table>

Riser

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials 8' x 16'</td>
<td>160</td>
</tr>
<tr>
<td>Materials 8' x 24'</td>
<td>240</td>
</tr>
<tr>
<td>Labor</td>
<td>100</td>
</tr>
</tbody>
</table>

Consultation: $1,250-$5,000

Installation: $2,500-$5,000

Total Cost: $39,539
## Basic Classroom

**Distance Education Classroom Equipment List**

**Origination Site**

<table>
<thead>
<tr>
<th><strong>Cameras</strong></th>
<th><strong>Quantity</strong></th>
<th><strong>Cost/Unit</strong></th>
<th><strong>Total Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A Student camera w/o pan, tilt, zoom</td>
<td>1</td>
<td>1720</td>
<td>1720</td>
</tr>
<tr>
<td>C Teacher camera (Panasonic WVD5100)</td>
<td>1</td>
<td>2930</td>
<td>2930</td>
</tr>
<tr>
<td>Mounting brackets camera (Pan WV131P)</td>
<td>2</td>
<td>52</td>
<td>104</td>
</tr>
<tr>
<td>Teacher camera control</td>
<td>1</td>
<td>1495</td>
<td>1495</td>
</tr>
<tr>
<td>D Visual presenter (Elmo EV-308)</td>
<td>1</td>
<td>3100</td>
<td>3100</td>
</tr>
<tr>
<td>lightbar (Elmo-LU308)</td>
<td>1</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Monitors</strong></th>
<th><strong>Quantity</strong></th>
<th><strong>Cost/Unit</strong></th>
<th><strong>Total Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>E Monitor, outgoing 25&quot; (Sony PVM2530)</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>F Monitor, remote site 25&quot;</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>G Teacher monitor, Remote site 25&quot;</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>H Teacher monitor, Outgoing 25&quot;</td>
<td>1</td>
<td>1590</td>
<td>1590</td>
</tr>
<tr>
<td>Mounting brackets monitor (ceiling) (Bretford Mf TVM1)</td>
<td>4</td>
<td>221</td>
<td>884</td>
</tr>
<tr>
<td>J Monitor, teacher 7&quot; (Panasonic BT-S701N)</td>
<td>3</td>
<td>600</td>
<td>1800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Audio</strong></th>
<th><strong>Quantity</strong></th>
<th><strong>Cost/Unit</strong></th>
<th><strong>Total Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>K Speakers (Anchor AN1001)</td>
<td>4</td>
<td>163</td>
<td>652</td>
</tr>
<tr>
<td>K2 Teacher speaker (Anchor AN1000X)</td>
<td>1</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Brackets (Anchor SB730)</td>
<td>4</td>
<td>43</td>
<td>172</td>
</tr>
<tr>
<td>L Microphone, student (AMS22)</td>
<td>12</td>
<td>210</td>
<td>2520</td>
</tr>
<tr>
<td>M Microphone, teacher/lavalier (Shure AMS28)</td>
<td>1</td>
<td>235</td>
<td>235</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Teacher station</strong></th>
<th><strong>Quantity</strong></th>
<th><strong>Cost/Unit</strong></th>
<th><strong>Total Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>N Audio/Video control (Extron Model 8)</td>
<td>1</td>
<td>1495</td>
<td>1495</td>
</tr>
<tr>
<td>O Teacher control unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rack mount shelf (Winstead)</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Video dist.(Panasonic WJ300B)</td>
<td>1</td>
<td>290</td>
<td>290</td>
</tr>
<tr>
<td>Audio mixer (Shure AMS8000)</td>
<td>1</td>
<td>2800</td>
<td>2800</td>
</tr>
<tr>
<td>Power strip (Winstead 98700)</td>
<td>1</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>P VCR play/record (Panasonic AG1250)</td>
<td>2</td>
<td>350</td>
<td>700</td>
</tr>
<tr>
<td>Q Facsimile (HP200)</td>
<td>1</td>
<td>1200</td>
<td>1200</td>
</tr>
</tbody>
</table>

**EQUIPMENT TOTAL** $28555

- 30% $19988

**Supplies, cabling, wiring, connectors** $2,000 $21988
APPENDIX P. CONSIDERATIONS FOR SETTING UP A TRANSMISSION SYSTEM FOR A DISTANCE EDUCATION CLASSROOM
CONSIDERATIONS FOR SETTING UP A DISTANCE EDUCATION SYSTEM

Fiber System

1. Feasibility study. This is a planning stage. Specific options to consider are:
   • Service needs
   • Consider economic and technical aspects
   • Check on the possibility of procuring easements from the railway or state, city or county
   • Contact individuals currently utilizing fiber systems
   • Contact individual telephone companies, utility companies, cable companies, and large businesses for leasing potential
   • Research all possible partnerships and funding sources
   • Consider growth requirements

2. System design. This includes determining specifications, routing distances, and estimating costs. Specific decisions and concerns include:
   • Type of system - analog or digital
   • Transmission distance
   • Type of fiber - single mode or multimode, step index or graded index
   • Type of optical equipment - LED or ILD; PIN or APD
   • Modulation type and code format; wavelength
   • Determine path coordinates
   • Detail map of route
   • Secure easements for roadways and railroads
   • If leasing, negotiate contract with conditions on rates, maintenance, service priority, and time periods

3. Purchase and install. This phase involves actually putting the fiber into the ground, tying the system together with terminal equipment, and testing the system. Specific concerns are:
   • Determine method of installation
   • Stake the route
   • Decide on splices or connectors
   • Install the fiber
   • Install terminal equipment - cost and technical support
   • Initial check out of the system to see if it works
   • Maintenance agreement/fees
   • Warranty
   • Maintenance support
   • Compatibility of end point equipment with classroom equipment

Microwave System
1. Feasibility study. This is the planning stage. Following are options to consider:
   • Service needs
   • Consider economical and technical aspects
   • Explore funding and financial planning
   • Contact individuals currently utilizing microwave systems
   • Determine if frequencies are available or leasing facilities are possible
   • Determine if the land topography and distance make microwave feasible
   • Consider growth requirements
   • Availability of suitable sites for repeater stations

2. System design. This includes determining specifications, locating points, and estimating costs. Specific decisions and concerns include:
   • Type of system - analog or digital
   • Determine the distance and number of repeaters needed
   • Selection of sites - must be line-of-sight with no obstructions as trees, or buildings
   • Drive the route and visually check out lease possibilities and obstructions
   • Initiate a frequency band study to find other frequencies that might interfere
   • Set frequency
   • Path profile to determine tower height and check for obstructions - use topographical map to determine elevations and plot points
   • Determine tower specifications, e.g., wind load and ice load
   • Path calculations to determine equipment parameters/configurations to meet performance requirements, such as antenna size, transmitter power output, receiver noise figure, required bandwidth
   • Path survey to provide information vital to installation; review above calculations and specifications
   • If leasing, negotiate contract with rates, maintenance, service priority, and time periods

3. Purchase and install. This phase involves the actual construction of the tower, installing transmission and terminal equipment, and testing equipment. Specific decisions and concerns include:
   • Acquire land-lease or buy
   • Availability of power and access road
   • Get FAA clearance
   • File FCC application which includes an interference analysis and system design
   • FCC tower construction application if over 200 feet
   • Construct the tower - consider time schedule
   • Install the transmission equipment; build protective building
   • Beam alignment, equipment lineup, checkout
   • Connections from tower to school
   • Hook up cable in classroom
Compressed video system

1. Feasibility study. This is the planning stage. Following are options to consider:
   - Service needs
   - Consider the economic and technical aspects
   - Explore all possibilities for leasing the cable
   - Plan cost sharing between two sites
   - Decide if compressed video has the quality needed for the determined educational use
   - Contact individuals currently utilizing compressed video systems

2. System design. This includes determining equipment specifications, estimating costs, and negotiating contracts. The following are specific decisions and concerns:
   - Transmission equipment (codec) - purchase or lease
   - Transmission rate - 112 kb/s, 384 kb/s, 1.544 Mb/s
   - Dial up or dedicated line
   - P x 64 standards for interoperability or proprietary standards
   - Full or fractional T lease

3. Purchase and install.
   - Lease T1 lines - negotiate rates, maintenance, service priority, time periods
   - Install equipment - time schedule, costs
   - Technical support for installation of equipment
   - Purchase own classroom equipment or purchase vendor video package
   - Compatibility of all equipment in system
   - Upgrade capabilities
   - Technical hardware and software service support
   - Warranty on equipment
   - Maintenance agreement/fees