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ABSTRACT

The costs of three types of transmission technology in distance education are compared, and the costs for equipping and installing a distance education classroom are estimated. Two of the technologies--fiber optics and microwave--deliver two-way, full motion video and two-way audio. The third technology, compressed video, also delivers two-way audio and two-way video, but uses a computer device to compress the signal. Data about costs were collected through interviews with suppliers, users, and technical experts. If full motion video is essential, microwave is the most viable solution for shorter distances. Digital fiber is the best choice as far as quality and capacity are concerned, but high costs tend to negate advantages. Fiber is the most complex to install, and consequently very expensive. If compressed video is satisfactory for the situation, it is the least expensive alternative to install and remains cost-appropriate for longer distances. The standard classroom can be easily adapted for distance education without significant remodeling. A distance education classroom can be equipped for less than 30,000 dollars. Two-way interactive television is expensive to design and install, but neither complex nor difficult to use. Five appendixes provide considerations for distance education systems, specific cost estimates, and classroom design and equipment plans. (Contains 74 references.) (SLD)

Title:

Distance Education: A Cost Analysis

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DISTANCE EDUCATION: A COST ANALYSIS

by
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INTRODUCTION

The concept of distance education is enlarging the definitions of how students learn, where they learn, and who teaches them (U. S. Congress, 1989). In the past, distance education was of greatest importance to adults. Recently, there have been increasing numbers of distance education opportunities offered to high school students, and even elementary schools have taken advantage of enrichment activities offered to children from distant sites.

Distance education has become increasingly sophisticated since the first educational radio programs. Barker (1989a) 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 telecommunication systems that permitted live, interactive audio and/or video exchanges.

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, and
- quasi-permanent absence of group learning.

Keegan also includes the following characteristics as ones that are often part of distance education systems:

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

Distance education systems that use two-way interactive telecommunications have the following features. The instructor is at an origination site and students are at a remote site; students may be present at the origination site as well. Instruction is influenced by an educational organization--the school. Sites are connected point-to-point with fiber, microwave, or twisted pair copper media, often referred to as compressed video. This allows two-way interactive video, data, and/or audio communication and permits live interaction between instructor and students, with instruction directed to one or more students.

In this study, the term "compressed video" refers to video signals that have been digitized and significantly compressed so they can be transmitted using traditional transmission media, including twisted pair copper wire. The terms fiber and microwave refer to the media for transmitting video and data signals, and compressed video refers to a technique for modifying a video signal. Although they are not directly related, the three terms (fiber, microwave, and compressed video) are used in the study because they are commonly cited in distance education literature.

We would like to acknowledge the Office of Telecommunications and the Media Resources Center at Iowa State University for their review of the technical information in this monograph.

The trend in distance education in the United States is to provide distant learners with 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 situations as close to traditional instruction as possible.

Today, the technical capabilities exist for schools to provide distance education opportunities to students. While advances in technology make it possible for school districts to improve their curricula and learning experiences, the use of technology also creates new problems. Technology is expensive and complicated, and some question the propriety of using telecommunications to offer courses to students located at remote sites.

Administrators, school boards, and policy-makers often ask about how much distance education costs. Since distance education systems require significant cost commitments, those responsible for making large capital investments must have reliable data available to them to help them in the decision making process.

First, this study compares the costs of three types of transmission technology. Two of the technologies deliver two-way, full motion video and two-way audio: (a) fiber optics and (b) microwave. The third technology, compressed video, also delivers two-way audio and two-way video, but uses a computer device to "compress" the signal.

Second, this study describes costs for equipping and installing a distance education classroom. Lists of equipment and prices are supplied.

The following research questions guided the preparation of this report.

(1) What are the characteristics, advantages, and disadvantages of the three transmission technologies?
(2) What does it cost to put into place a point-to-point, distance education system using fiber, microwave, and compressed video?
(3) What are the major cost considerations for the three transmission methods?
(4) How do the costs vary for distances of 3 miles, 10 miles, 20 miles, 30 miles, 50 miles, and 75 miles?
(5) What are the recurring and maintenance costs for the transmission equipment?
(6) Is it usually better to lease or purchase?
(7) What does it cost to equip an interactive distance education classroom?
(8) What are the recurring and maintenance costs for the classroom equipment?

Distance education is a viable way to enrich and improve the quality of the curriculum. Technology can link teachers and learners from all educational levels--elementary, high school, and college, as well as business and community --and bring a wide variety of expertise and information to the classroom. Costs can be justified by an increase in educational opportunities (Giltrow, 1989).

REVIEW OF LITERATURE

This review of the literature summarizes research related to distance education and key variables of this study. The information in this section is organized in the following categories: (a) a brief description of theories of distance education; (b) the impact of distance education today; (c) the economics of distance education; (d) distance education and technology; (e) transmission systems; and (f) the interactive distance education classroom.

Distance Education

There are two views on the concept of distance education - distinctive and parallel.

Distinctive form. Many consider distance education to be a distinctive educational form based on individualized study. Many autonomous universities teach only to students at a distance and believe that distance education is a distinct form of education (Moore, 1988; Peters, 1988).

Considerable effort has been spent trying to formalize a theory specific to distance education. Keegan (1988) grouped the theories as follows: (a) *theories of autonomy and independence*; (Wedemeyer, 1981; Moore, 1988); (b) *theory of industrialization*; (Peters, 1988); and (c) *theories of interaction and communication*; (Holmberg, 1977, 1981, 1988a, 1988b; Baath, 1980; Sewart, 1988). Keegan (1980, 1986) analyzed the theories presented by Moore, Peters, and Holmberg to create the descriptive definition of distance education summarized above. It is the definition used most widely today.

Parallel form. A second perspective considers distance education as parallel to traditional education. Garrison (1989) asserts that distance education is not unique. The techniques appropriate for traditional education systems and distance education systems are the same. Many educators in the United States subscribe to 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).

Distance Education Today

Applications of distance education have increased dramatically during the last five years. Fewer than ten states were promoting distance education in 1987, while 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 is primarily due to increases in educational requirements that have coincided with the expanding capabilities and services of the telecommunications industry (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 funding.

Jefferson and Moore (1990) predict that all rural schools will have distance education service by 1995. 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).

The success of interactive distance education classes is well documented. Studies have supported the following conclusions:

- Students involved in distance education classes have reported positive feelings about their experiences (Barker, 1989b; Catchpole, 1988; Kitchen & Kitchen, 1988; Nelson, 1985; Nelson, Cvancara & Peters, 1989; Pirrong & Lathen, 1990; U. S. Congress, 1989).
- After teaching in an interactive distance education system, faculty have had positive responses about the experience (Barker, 1989b; Bowman, 1986; Hobbs, 1990; Kitchen, 1987; Randall & Valdez, 1988; U. S. Congress, 1989).
- Student achievement in interactive distance education classes has been as good or better as that of students learning from traditional teaching methods (Batey & Cowell, 1986; Hobbs, 1990; Kabat & Friedel, 1990; Minnesota State Department of Education, 1990; Pirrong & Lathen, 1990; Randall & Valdez, 1988; U.S. Congress, 1989).

The Economics of Distance Education

Economic implications of using distance education methods can be generalized as follows: (a) significant costs are incurred irrespective of student numbers, (b) transmission and production costs are high for systems, (c) conventional, non-distance education system costs are recurring costs and vary according to the number of students; distance system costs can be regarded as fixed costs and amortized over the life of a 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).

One of the most significant factors when planning a distance education system is the cost. A large portion of the expenses are start-up costs, which in effect, can be the equivalent of five years worth of teacher costs. To some, paying these costs before enrollment revenues are collected is unsettling (Giltrow, 1989), and is only acceptable if costs can be amortized over a long period of time (Perraton, 1982). Factors that affect costs of establishing a system are (a) type of technology, (b) distance and topography, (c) existing and available technology, (d) possible partnerships, (e) engineering requirements, (f) remodeling needs, 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 amount of money required to establish a system is often seriously underestimated (Rumble, 1986b). Obviously, personnel and curriculum costs to train instructors and revise materials are considerable, too.

In general, three factors influence the economics of distance education: choice of media, size or type of program, and number of students (Batey & Cowell, 1986; Rumble, 1982). Although 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 numbers of students. Markowitz (1990) maintains that distance education programs are predominantly self-sufficient.

Evidence also is available to support the conclusion that distance education is effective when effectiveness is measured by achievement, by attitudes of students and teachers, and by cost-effectiveness. Generally, the evidence has indicated that distance education "works."

Distance Education and Technology

Telecommunications is defined as communicating over a distance. Rapid advances in technology, deregulations of these technologies, and decreases in costs have made telecommunications attractive to schools.

Telecommunications 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 for communication are usually radio waves through the air, electronic impulses over transmission lines, or light through fiber made of glass or plastic silicon. 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 transmitted to an orbiting 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, often referred to as point-to-point or narrowcasting, is directed to a specific audience.

Two-way interactive television (ITV) and distance education. The term ITV originally referred to instructional television, but today has become synonymous with interactive 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. ITV has been shown to be comparable to the traditional method of instruction, both in terms of teacher and student acceptance and in achievement (Hughes, 1988). The Office of Technology Assessment reported that television-based interactive instruction is the distance education format that most closely resembles the traditional classroom; this has been the format of choice for many U.S. 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).

Transmission Systems

Since it is possible to discuss distance education systems from a number of perspectives, this monograph examines the costs for establishing a system by studying three forms of technology that are often used to characterize particular systems: fiber-based systems, microwave systems, and compressed video systems that use existing transmission networks. As was stated earlier, the three are not directly comparable. However, when distance educators discuss systems, they often categorize them in this manner.

Fiber Optic Systems

Fiber optics is one of the newest two-way, interactive technologies. The fiber, 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 travels in straight lines, but optical fibers guide light around corners. The number of fibers is unlimited, creating virtually an unlimited capacity. Optical cables are capable of transmitting far more information than coaxial cables of 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.

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 (ADP). Generally speaking, the ADP is used for systems greater than 100 km (62 miles) and PINs are preferred for shorter distances. The repeater is a signal amplifi-cation 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. Since a codec is needed only for digital transmission, 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 band vidth of fiber allows audio, video, and data to be combined on one line, resulting in a lower cost per channel.
- Fiber permits full motion video transmissions.
- 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 maximum signal security with little 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 time consuming and costly.
- Light sources have limited lifetimes and associated system reliability problems.
- Expansion is expensive if no fiber exists.
- Right-of-way costs for placing cables in the ground can be costly.

Successful users of fiber systems. The following groups have reported on successful use of 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).

Opinions about 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 expandability (Minnesota State Department of Education, 1990). Fiber lends itself well to two-way, interactive television because of its large 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 telephone applications (Szentesi, 1991). Currer (1991) reported that digital fiber gives the user the most benefit for the money spent. Barker (1989b) believes that fiber offers the best audio transmission quality, while Lanier (1986) suggests that fiber is superior to microwave, ITFS, and coaxial because of its higher image quality.

General costs for fiber systems. The Office of Technology Assessment reported that the equipment needed to connect one site to a fiber network would cost approximately $40,000. Fiber for a 134 mile network would cost approximately $8,955 per mile. The receiving site would need $40,000 worth of equipment, also (U. S. Congress, 1989, p. 174).

Maintenance costs average one percent of system cost per year (National School Board Associ-ation, 1989). Other vendors feel that up to 13% of the cost of a system should be reserved for maintenance. Fiber systems require little maintenance; however, if the fiber is accidentally cut, repairs are very expensive and time consuming.

Microwave Systems

Microwave signals are transmitted electromagnetically through the air. Microwave is similar to standard broadcasting, except microwave systems use much higher frequencies and are point-to-point. Each tower in a microwave relay system picks up the signal sent to it, amplifies the signal, 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 video 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 where 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 but less than 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 regulatory agency approval or right-of-way clearance (Ostendorf, 1989a).

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/multi-plexor, and (f) power unit.

Advantages of a microwave system.

- Microwave permits the transmission of full motion video.
- There is control over who receives the signal.
- Audio and video signals are of excellent quality.
- Numerous data and audio signals can be transmitted along with video channels.
- A properly designed system can have 99% 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.
- Atmospheric disturbances can cause fading of signals.
- Equipment can fail and power outages can occur.
- Adding channels to a system is not easy.
- Thirty miles is the maximum distance between towers.
- An FCC license is required.
- A limited number of frequencies are available.
- Towers are almost always needed.
- Terrain extremes can increase equipment and tower costs.
- Special building permits may be needed.

Successful users of microwave systems. The following groups have reported on their successful microwave systems: (a) WHETS--The Washington Higher Education Telecommunication System, Washington State University (Nelson, Cvancara & 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).

General costs for microwave systems. The estimated costs for a duplex microwave system include $40,000-$65,000, plus towers, which range from $25,000-$75,000 each. Short haul systems may cost $35,000, plus towers, which range from $5,000-$50,000.

Maintenance costs average three to five percent of the system cost per year (Kitchen & Kitchen, 1988; National School Board Association, 1989; U.S. Congress, 1989). These costs include equipment service and repair and monthly maintenance fees.

Compressed Video Systems

Compressed video is a name routinely, and somewhat incorrectly, used to refer to digital video, audio, and data signals that are processed to reduce the amount of information in order to minimize the bandwidth required. It is important to note that compressed video refers to a technique for reducing the amount of information transmitted between two sites. A "compressed" signal can be carried by fiber or microwave, but since it has been compressed, traditional, inexpensive, and readily available copper wires can also be used. In other words, the installation of a compressed video system is often simplified because existing communications carriers can be used.

Compressed video is sent over fiber, satellite, microwave, and most often, high capacity digital service lines. In compressed video transmissions, redundant information is removed. For example, if the background does not change for several seconds, this information is sent only once and remains in memory. Video compression is achieved by sacrificing small amounts of color, motion, or resolution information. Although there is some loss of quality, compressed video is considered a viable alternative for many educational situations.

Equipment required for a compressed video system. Each system site must have (a) codec; (b) transmission line; and (c) interface unit. The codec converts the analog signal to digital format and compresses the signal. The channel service unit (CSU) is the interface between the end user and the telephone line. The CSU works in conjunction with the data service unit (DSU), which translates and controls the signal. This unit functions similarly to a modem (modulator/demodulator).

T channels refer to a band of high speed, high capacity circuits devised to carry digital voice, audio, and data signals. T1 facilities and DS1 signals are the technology most often used for compressed video systems. DS1 signals have bandwidth capability for compressed video only; they do not have the necessary bandwidth for full motion video as does DS3. T1 facilities are often regular copper telephone lines. DS1 transmission lines can be leased from telephone companies.

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 of 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) video signal 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. Different vendors' codecs refresh different elements such as color, gray scale, or motion.

Advantages of a compressed video system.

- The equipment is easy to install and use and little training is required.
- Compressed video requires less bandwidth and therefore it costs less to transmit.
- 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 have high start-up costs.
- Motion can become jerky.
- Color may be substandard and picture quality may be poor.
- There is dependence upon the lease-lines of the utility supplier.
- Compressed video systems do not transmit NTSC, full motion video.

Successful users of compressed video systems. The following groups have reported successful use of 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).

Research relating to compressed video systems. The Applied Research Institute (cited in Keller, Staab & Stowe, 1989) found that (a) compression technologies have improved, (b) at the same time that signals have been further compressed and equipment costs have dropped, picture quality has remained relatively good, (c) compression devices can now digitize and blend (multiplex) signals so different kinds of 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) use of existing transmission lines make compressed video cost-effective.

A study conducted in Japan reported that compressed video had practical use for teaching at a distance in an interactive environment (Wakamatsu & Obi, 1990). Jurasek (1992) conducted a study of the effectiveness of Iowa State University classes taught using compressed video technology. Students displayed positive attitudes toward instruction. They adjusted rapidly to the compressed video technique and felt the convenience of learning remotely far outweighed the effects of any picture quality loss or technical problems.

General costs for a compressed video system. Compressed video systems range in cost from $20,000-$300,000 (Ostendorf, 1989a). A typical point-to-point system would cost approximately $100,000. For example, 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).

Distance Education Classrooms

Classrooms for ITV are usually one of two types. The first type is a production studio, comparable to a television studio. Production studios require special lighting, a control room, and a crew. The second type of distance education facility is the electronic classroom. In this classroom, there is no control room; the technology is operated by the instructor. The classroom is both a television studio and a learning environment. The concept is to make the technology as transparent as possible and to make the teaching site appear to be a classroom, not a studio.

Characteristics

Various examples of distance education classrooms are discussed in the literature. The following are characteristics that are described as important considerations for planning for the installation of a distance education classroom.

Size. The classroom can be a conventional school room, which typically is about 25 feet x 35 feet. Converted classrooms can be used as long as acoustic, lighting, and other needs are met (Hudspeth & Brey, 1986). Hughes (1988) stated that a distance education classroom should be longer than it is wide.

Soundproofing. Soundproofing may be necessary to exclude exterior noise and to reduce classroom noise. Since sound can enter any-where air can enter, all holes and gaps in or between walls, floors, and overhead structures should be filled and sealed. Doors should be of solid construction and equipped with floor sweeps and weather stripping (Price, 1991). Windows should be double pane, if possible. Walls, floors, 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 should be 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. One way to test a potential distance education room for external and internal sound disturbances is to tape record the room when it is not in use. This tape will indicate outside noise disturbances and distractions from such things as ventilation and lights within the room.

Decor. Esthetic considerations for the classroom 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. 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 in a slightly dimmed room. Natural light from windows and skylights is usually too bright for television monitors and can cause glare on screens. This can be controlled by draping or facing the monitors away from windows. However, television cameras require light to capture images and usually normal 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, thus limiting 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 instructors 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 Department of Education, 1988). Individual comfort and appropriate style should be the highest priority. For extensive note taking or working with materials, learners should be provided with 20-24 inch wide tables.

Optimum class size is 15 to 25 students (Barker, 1989b; Bowman, 1986). By keeping classes small, students will interact more readily and use the system more fully (Lanier, 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 Depart-ment of Education, 1990).

It is desirable for the teacher to have full control of cameras, lights, monitors, and various auxiliary equipment. If the instructor controls equipment, 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 Department of Education, 1990).

Equipment. There should be standardization of equipment and installation, so in case of breakdowns, spare parts or items are interchangeable. 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 origination site (Minnesota State Depart-ment of Education, 1988; Randall & Valdez, 1988).

- Microphones. Sound quality is the most problematic aspect of distance education systems; it is the most often reported technical 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). Directional or cardioid microphones are best.

  Two problems commonly occur in sound systems, feedback and echo. Feedback is caused when microphones pick up sound from the speakers, producing overamplification and a piercing squeal from the speaker. 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.

  Echoes in the room are caused by sound reflections off smooth surfaces such as hard walls, floors, and ceilings. The shape of the room, the floor, ceiling, and walls all affect reflection. An acoustically treated room will not have echoes. To reduce echoes, acoustical ceiling tile and wall covering should be considered. Carpet is the best and least expensive sound absorber to improve acoustics in distance education classrooms (Hughes, 1988; Minnesota State Department of Education, 1988; Price, 1991). Television does not add to acousti-cal difficulties already existing in a room, but it does make them more acute. Acoustical problems in the class can negatively impact on learning (Smith, 1961).

- Cameras. Most interactive classrooms have three cameras. One is pointed at the students, the second at 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 Department of Education, 1990; Nelson, Cvancara & Peters, 1989; Oaks, 1986). Some classroom systems have a fourth camera pointed at students (Fink & Tsujimura, 1991).

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

- Monitors. Monitors let the instructor and origination site students view students at the remote site. Monitors also let the instructor view what is being transmitted. Monitors at the remote site show what is being transmitted from the origination site.

  Most systems use 21-25 inch monitors (Barker, 1989b; Minnesota State Department of Education, 1988; Smith, 1961). Others use large screen projectors (Fink & Tsujimura, 1991; Greenwood & McDevitt, 1987). Some systems use a split screen to present the view from two cameras. Hughes (1988) reported that the split screen makes remote sites even smaller and seemingly more remote. He suggested using an additional 25 inch monitor rather than splitting the screen.

- Visual presenter. This device functions like an overhead projector. It is located at the teacher station, normally 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 the platform where materials are placed and functions similarly to the overhead camera.

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

- Facsimile machine. A facsimile transmits printed copy from classroom to classroom quickly. It can be used to supply immediate feedback for tests and corrected assignments (Descy, 1991; Minnesota State Department 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 is used to record class sessions. This recording can be used by the student who has been absent, as a backup in case of technical difficulty, to provide a record of distracting student behavior, or so that the instructor can review for self-critique (Minnesota State Department of Education, 1988; Randall & Valdez, 1988). Special class sessions can be recorded for use in the future, also.

- Auxiliary equipment. In-class presenta-tions may require the use of a videodisk 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 equip-ment. Computer monitors 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, or multiscan monitors must be used.

METHODOLOGY

This cost analysis identified costs required to design, build, and install a distance education system using fiber, microwave, and compressed video. Cost analysis was defined by Perraton (1982) as the process used 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).

Data Collection

Data were collected using face-to-face, telephone, and written interviews. Questions were designed to determine the 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 by the use of repeated questions, rephrased questions, and follow-up questions. Also, interview questions were asked of more than one source.

Procedures

The first activity of this project was to obtain general information from the literature, consultants, telecommunications specialists, governmental offices (federal and state), and vendors. Next, specific questions were prepared. These questions were designed to identify hardware components essential to transmit and receive audio and video signals between two sites.

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

Six hypothetical pairs of sites of varying distances from one another were chosen. Vendors were identified to provide estimates about costs about transmission media.

For the classroom equipment phase of this study, technical experts aided in the identification of designs, equipment items, and installation procedures. This process resulted in a classroom design and equipment list. Vendor catalogs and vendor quotations were used to obtain equipment prices.

RESULTS

Costs are summarized and categorized in two sections. The first section deals with the costs of fiber, microwave, and compressed video systems. The second section deals with the interactive distance education classroom costs.

Costs of Fiber, Microwave, and Compressed Video Systems

When 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 installation.

Fiber Systems

Fiber optic systems consist of cables that transmit light signals rather than electrical signals. Purchasing and installing fiber systems is a complex process. Nearly 95 percent of the interactive television systems designed today use fiber optics in combination with coaxial cables.

Fiber systems can be analog or digital. While the fiber is identical, the termination equip-ment is different. Digital fiber provides higher quality at a distance. Analog is more appropriate for short distances. Analog fiber picks up noise over distances; digital fiber does not. An analog system is cost-effective for distances under 30 miles, but the costs for an analog fiber system over 30 miles may be prohibitive since a repeater (booster) is needed every 30 miles (at a cost of $15,000-$18,000). A building protecting each repeater is also required (at a cost of $1,500).

<u>What does it cost to put into place a point-to-point fiber system?</u> The total cost of a fiber system depends on the fiber type, total system design, and location. T. Crandall, General Services, indicated that fiber for state of Iowa projects cost approximately $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 communi-cation, May 29, 1992). D. Takkunen, Todd Communications, estimated fiber costs at $20,000 per mile (personal communication, April 27, 1992). All of these estimates were strictly for labor and fiber; end point equipment and right-of-way expenses

have not been included in the totals above. In metropolitan areas where there are right-of-way expenses and higher costs for labor, installation rates may be as high as $70,000 per mile.

One vendor supplied budgetary cost data for fiber systems at approximately $18,000-$22,000 per mile (Appendix). T. Crandall, General Services, stated Iowa schools would likely pay somewhere between $12,000 and the $22,000 per mile (personal communication June 4, 1992).

What are the major cost considerations?

- Consultation. Charges for consultants vary greatly, with costs dependent 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 would be more detailed and would show underground cables, gas lines, and electric cables. Also included in some consultation fees are costs for staking the route, supervising the construction, and crew scheduling .

  Consulting services average $5,000-$15,000. At engineering companies, consulting costs are charged at the engineering rate of $50 per hour. In one cost study, consulting costs range from $3,000-$3,500 for rural areas to $7,500 for urban areas.

- Construction/materials. The MWR cost study identified construction and material costs (Appendix D). Labor construction costs ranged from $0.97 per foot to $1.55 per foot depending upon distance. Construction costs differ between rural and urban loca-tions. Urban areas require more field work, engineer work, concrete work, and easement attainment. The costs listed in Appendix D are for suburban locations with various open areas, not downtown metropolitan areas. A downtown urban area requires additional concrete work costing $10 per foot or more.

  Material costs are estimated to be $9,672 for rural construction and $15,712 per mile for urban construction. 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 road-ways or railroads, an application usually must be filed to obtain an easement right-of-way. Most easements are obtained as public right-of-ways by formal applica-tion to the city, county, or state entity. If a public easement is obtained, a license is needed to place the cable in this right-of-way. Cities often charge approximately $1 per foot per year for easements. Other entities typically charge a percent of revenues for easements. When crossing private land, it may be necessary to pay for easement rights to the private individual.

- Terminal equipment. Digital end point equipment varies in price according to speed of transmission and capacity. Digital end equipment is usually one unit that functions as the codec, laser trans-mitter, optical receiver, and multiplexor/ demultiplexor (MUX/DEMUX). Equip-ment cost estimates range from $25,000-$57,000, including installation. Digital terminal equipment, connectors, and instal-lation of this equipment costs approximately $70,000. Analog end point equipment costs $6,000. Costs for leasing fiber usually include the costs for all equipment except for the device that converts the video signals generated in the distance education classroom into signals that can be transmitted through the fiber. This device costs approximately $6000 - $8000.

Microwave Systems

Microwave signals are transmitted through the air electromagnetically. Microwaves can carry full motion video. The placement of towers, equipment configurations, federal regulations, and frequency specifications necessitate techni-cal assistance and custom-made bids.

For a short distance, point-to-point system between two schools, microwave would be an appropriate choice. Microwave systems are easy to install, especially if transmitters are placed on buildings.

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 many organizations continue to utilize analog systems. Most companies only install new analog microwave systems to be compatible with previously constructed analog systems. When constructing an entirely new system, digital microwave is generally used because it provides higher quality. Analog is affected by weather and atmospheric conditions that can cause fading, which produces noise and creates a hiss on the line.

<u>What does it cost to install a microwave system?</u>

The average cost to construct a microwave system covering a short distance is $40,000. Long-haul, one-hop systems over 8-15 miles can cost $150,000-$250,000. The use of repeater towers adds expenses for additional electronics, path studies, installation costs, and tower costs. Each repeater tower adds approximately $90,000 in equipment costs and $20,000-$35,000 in tower construction costs.

<u>What are major cost considerations?</u>

- <u>Consultation</u>. Services include (a) path profile to check for obstructions; (b) frequency coordinates to find other frequencies that might interfere; (c) path analysis to determine how much power is required; (d) completion of the FCC application; and (e) tower specifications to note items such as ice and wind load.

  Consulting services cost $2,000-$4,000, with an additional $2,000 for tower specifications. A one-hop path profile/ coordination usually costs about $1,500.

- <u>Tower construction</u>. 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 average 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.

  A 20-foot tower is the minimum height for a transmitter. In order to clear trees, a 50-60-foot height is normally required. To place a dish on a building, the building must be high enough to clear trees and obstructions. Antenna extensions attach to a wall and extend beyond the building roof. A 20-foot tower in Iowa is generally a building or side-mount type and would cost approximately $5,000. An antenna on top of a two-story school building can send signals only a short distance.

  A 100-foot tower costs approximately $20,000. A 200-foot tower costs approximately $30,000 and a 300-foot tower costs approximately $35,000. Construction costs are higher for self-supporting towers, but less land is required since no guy wires are needed. A 200-foot, self-supporting tower costs approximately $200,000. A short, light weight tower for a short distance transmissions may cost as little as $2,000-$3,000. A heavier tower that attaches to the side of a building and extends up to 100 feet will cost about $5,000.

- <u>Land</u>. Land is needed for the tower site. A 200-foot tower requires two acres of land. It is sometimes desirable to lease land if possible. A land lease will usually cost $500-$800 a year in rural areas and as high as $5,000-$6,000 per year in urban areas.

- <u>Equipment</u>. The following equipment is needed at both ends of the system--transmitters, receivers, antennas, hardware connections. This equipment costs on average $45,000 at each end for long haul systems and $11,000 per end for short haul distances.

- <u>Building</u>. It is often necessary to construct a building to house the electronics at each tower site.

Building construction is approximately $1,500.

- Connections to the school. The tower should be located within a mile of the school. If towers can not be located near the school, short haul systems are required to get from the tower to the school. Coaxial cable used to connect the tower to the school costs about $5,000-$6,000 per mile, and an amplifier is needed every 2,000 feet ($500 each). At the school, the cable is hooked to a translator channel box for television reception, or to a VCR connection.

- 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 that there is no interference. Installation and testing of equipment and systems cost up to $15,000-$30,000 per tower location.

- FCC application. A completed FCC application form #402 is required. The application fee is $155. Multiple hops require more than one license. Noncommercial educational broadcasts are exempt from charges (Code of Federal Regulations, 1991, §1.1112 (c)). A letter to the FCC would be necessary to request a fee exemption. The FCC requires that frequency coordinations must be completed by microwave technical experts, at a cost of approximately $1,000 to $1,500.

- Long and short haul systems. The maximum distance between towers is about 30 miles. Any distance over 30 miles would require repeater towers to boost and retransmit signals. Distances closer to the 30 mile limit require higher towers, more powerful transmitters, and larger antennas. Each repeater tower needs two sets of equipment, pointed each direction and adds approximately $100,000 to the cost of the system, plus additional installation and testing costs. Short haul systems can be purchased for as little as $15,000 to $20,000 per site.

Compressed Video Systems

As used here, compressed refers to digital video, audio, and data signals that are processed to reduce the amount of information required for trans-mission. This process reduces the bandwidth requirement. Compressed signals can be sent using any transmission method. Compressed video systems do not transmit full motion video, but do allow users to economically transmit signals on smaller bandwidths.

What does a compressed video system cost?

Equipment is needed to compress signals and change signals from analog to digital. This equipment costs approximately $36,000-$38,000 per site.

- Consultation. These services are often included in the total cost of vendor's packages. Design coordinators provide input about the equipment needed for particular classrooms.

- Equipment. Transmission equipment con-sists of a codec, interface, and a leased transmission line. Codecs average $36,000. CSU/DSUs cost approximately $1,700. Transmission line lease rates vary from $5,000-$20,000 a year, depending on the vendor and the distance.

- Installation. Charges for installing codec equipment are often included in the codec's purchase price, but some vendors charge as much as $1,500 for this service.

- Upgrades. Most vendors now have codecs that can be upgraded by updating their software. This is an essential because this technology is changing so rapidly. These upgrades cost $8,000-$15,000.

- Transmission line lease options. When leasing services, there is normally a one time connection charge of approximately $1,400; this charge is not related to distance. Lease rates vary considerably. The longer the distance, the less per mile per month. Year lease rates range from

$5,000-$20,000 for distances of 3 to 75 miles. Most schools apply for and receive FCC-1 tariff rates. If the origination and receive sites are not in the same Local Access Transport Area (LATA), contacts must be made with the local carrier who will then make arragements with the distant site's carrier.

It is possible to lease terminal equipment (codecs). The list cost is multiplied by a cost factor to arrive at the monthly charge. A $35,000 codec leases for $1,136 per month, or $13,632 a year, based on a 36-month contract. Shorter contracts cost more per month. For a 12-month lease, the monthly charge averages $2,800 (or $33,600 per year).

Other Results

How do the costs vary for distances from 3 miles to 75 miles?

Transmission using fiber and microwave are directly affected by distance. Fiber is affected the most dramatically. The costs per mile are very high and each additional mile can add $12,000-$20,000 to the cost of a system.

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 which costs approximately $6,000. 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 construc-tion, and approximately $25,000 for installa-tion and testing. Path studies for each additional hop cost $1,000-$1,500.

Compressed video systems are the least affected by distance. Most of the cost of a system is in the codec equipment at the end points. Compressed video systems are fairly constant in cost.

What are the recurring and maintenance costs?

Transmission equipment is usually quite reliable. However, service and maintenance are important considerations for these 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.

Fiber. Fiber equipment is reliable and needs few repairs. Replacement of a laser may cost $2,000 to $4,000, but laser failure is not common. Maintenance contracts for end point equipment are about one to two percent of the purchase price per month. This amount averages $3,300-$7,600 per year.

Microwave. Circumstances that require maintenance on microwave systems are wind damage, ice load, electrical storms, and electronic equipment failure. Maintenance contracts vary, and range between one to ten percent of the system's purchase price.

Compressed video. Maintenance contracts range from three to seven percent of the purchase cost. A recurring expense is the lease cost of the transmission line.

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

Fiber. Fiber is superior in signal quality and bandwidth capacities. Fiber is unaffected by the environment and needs little maintenance. Fiber costs per channel capacity are cost-effective. The disadvantages of fiber are high initial cost and the complexity of installation.

Microwave. Microwave transmission for short distances is cost-effective. Short distances use inexpensive towers and relatively low cost transmission equipment.

One disadvantage of microwave is that it is an aging technology, and the majority of frequencies in metropolitan areas have been assigned. Distance education systems require a great deal of channel capacity. In the last five years, the increasing use of cellular phones has decreased the number of available frequencies. For short haul microwave systems (which utilize higher frequencies), there are more frequencies available.

In certain areas, microwave may not be feasible because of the terrain. Microwaves are affected by weather conditions, and some find FCC licensing and adherence to regulations restrictive.

Compressed video. Compressed video is easy to install and is relatively inexpensive as compared to the other systems. For educational purposes, compressed video may technically not be the best, but it is the easiest and often the least expensive to install. Since compressed video does not transmit full motion, images appear jerky at times. However, research data indicate that for most distance education applications, the quality is quite acceptable.

Distance Education Classroom Costs

This section presents the costs for an interactive distance education classroom. Technical experts were interviewed about classroom design, production equipment requirements, types, and specifications.

What does it cost to equip a distance education interactive classroom?

Equipment for the classroom designed for this monograph cost $39,539 for the state-of-the-art classroom, and $21,988 for a basic classroom. The Appendixes also include equipment specifications and cost estimates.

Consulting. Private design consultants charge approximately $5,000 to develop a plan for a complete system. The Media Resources Center at Iowa State University charges $250 for an initial visit and $250 a day plus expenses for additional visits. Installation assistance costs are $30 per hour per person. Consultation costs for installing a complete classroom would average about $4,000.

Room Treatment. Most classrooms are easily adapted for use as distance education classrooms. A room is adequate if there is sufficient lighting for the cameras, no extensive glare problems, adequate wiring, and adequate space. Although most rooms have adequate wiring for distance education equipment, it is necessary to determine the power requirements for all equipment. Technicians can then verify that there are sufficient outlets and amperage levels. General rules to follow include (a) unless it is a special circuit, do not put more than five items to a line, and (b) isolate computers on separate lines.

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 $3,000-$4,000.

Most classroom production equipment is reliable and does not require repair, but replacement costs for broken microphones or cameras may be needed.

Classroom Design. Examples of distance education classrooms are found in the Appendix. The key to the design is the equipment list. Costs reflect current catalog list prices. School systems can expect a 30 percent discount from vendors.

Equipment Descriptions. The size of the representative classroom in the design is 28 feet by 30 feet and will accommodate at least 24 students. Tables are 24 inches x 96 inches, 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.

- Cameras. 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, a zoom lens, and AC adapters. The pan/tilt controller and zoom lens can be eliminated from the cameras pointed at students, but are necessary on the instructor camera. A 2-chip camera produces a higher quality signal in lower light. However, a 1-chip camera is acceptable for most applications. Three-chip, studio quality cameras can be used, but are more expensive.

  The visual presenter (document camera) features a single chip, CCD color camera with manual focus and zoom control. An overhead camera can be ceiling mounted as a substitute for the presenter. However, the visual presenter is easier to install and use.

- Monitors. Twenty-five inch or larger color monitors should be used at the origination and remote sites to display program output. At the origination site, a monitor should also display the remote students. Three 7 inch color monitors are used at the teacher station. One monitor displays the remote site students, one the program output, and one continually shows the document camera's output so the instructor can align materials before sending the signal from this device. The 13 inch color monitors on student tables allow for display of the program video. Individual student monitors are recommended because (a) larger projection screens lose resolution and have a degraded image, (b) the closer the distance, the better the visibility and legibility, and (c) if one monitor of the system malfunctions others are available. At the remote site, an additional monitor is sometimes added in a teacher's or principal's office for supervisory purposes.

  Multiscan monitors automatically accept inputs from any video or personal computer source. If there is a need to transmit computer data, then monitors must be multiscan.

- Audio systems. Although the ideal dis-tance education classroom would have a microphone for each person, two people per microphone is adequate. The best microphones for the distance education classroom are cardioid. Cardioid microphones pick up sounds better from the front than the back. Cardioid microphones are used where ambient noise should be suppressed.

  Student microphones should be low profile, wired, and voice activated. Low profile microphones require minimal installation. The teacher microphone should be a wireless or wired lapel-type.

  Push-to-talk microphones are not recom-mended. They require an action on the part of the student and are not "user friendly." The clicking of the button is also a noise in the system. Frequent repairs are need when this type of microphone is used.

- Media controller. A switcher lets the instructor select and control multiple video outputs, and a remote control manipulates cameras. In a state-of-the-art classroom, a room controller functions as a switcher, controls the local and remote sites, and controls camera functions. It can also have diagnostic functions.

- Rack mount. The rack mount shelving unit fits under or beside the desk. Adapter kits need to be added to shelve individual units ($30-$150 each unit).

- Video distribution. A video distribution amplifier is needed if many monitors are used. This unit divides and amplifies video signals.

SUMMARY

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.

Each medium was found to be 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 system use.

Fiber systems were found to be more complex than the other media. Microwave and compressed video systems had elements that were comparable from system to system. It was most difficult to estimate costs for fiber systems. There are more cost variables to consider, and these variables are not consistent between applications.

If full motion video is necessary, microwave systems are viable alternatives for schools. Microwave systems are cost-effective and easy to install if the transmission distance is less than 10 miles. Microwave is also the least expensive option for short distances. Leasing microwave towers can decrease costs for two-hop systems, but leasing still requires a large investment.

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 systems offer the quickest and easiest solution for creating an ITV network between two schools. A compressed video system can be installed with little need for extensive construction. Most educators say they prefer a full motion system, but research indicates that compressed video is effective and satisfactory and that the picture quality of the compressed video technology is constantly improving. Most viewers do not object to small sacrifices of color, motion, or resolution. Successful users indicate that content takes precedence over image quality.

Concerning the three transmission systems, it was found that:

- Fiber was found to be most expensive and fiber systems were more complex than other media.
- Microwave for distances under 10 miles was a cost-effective way to connect two schools.
- The major costs were (a) system consulting and design, (b) materials, construction, and installation, (c) terminal end point equipment, and (d) maintenance contracts.
- Distance significantly affected the costs of fiber and microwave. Both became cost-prohibitive ways to connect two sites as distances increased.
- Compressed video system costs were the least affected by distance. Most of the costs for this technology were for compression/end-point equipment.
- Most experts recommended using digital technology, which offers superior quality.
- Fiber can be cost-effectively installed by schools short distances from each other.
- Urban fiber construction costs were greater than rural fiber construction costs.
- Microwave frequencies are not available in some 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 the location of microwave towers.
- Towers should be built as close to schools as possible.
- Installing and testing microwave systems was expensive.
- Long haul microwave systems were not cost-effective unless a repeater structure was leased

inexpensively, and dishes were put on buildings.
- One hop microwave costs (1 - 30 miles) increased as the distance increased--higher towers and more powerful transmitters were needed.
- Microwave systems were the most susceptible to malfunctions, 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 for lease rates for DS1 & DS3 decreased as distance increased.
- Lease rates for DS3 were 3 to 8 times the monthly lease rate of DS1.

Conclusions about the interactive distance education classroom were that:

- Usually classrooms do not have to be completely remodeled to be distance education classrooms.
- Basic equipment costs ranged from $25,000 - $30,000.
- Equipment was easily added or eliminated to fit budgets and needs.
- Packages of complete systems cost 30 to 70 percent more than the purchase of individual items.
- Maintenance is not a significant cost variable for classroom equipment.
- Transmission of computer generated signals significantly increased costs.
- There was variation in vendor's equipment packages in relation to capabilities, included options, and prices.

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, they still are effective for linking two schools. Digital fiber is the best choice as far as quality and capacity, but high costs tend to negate this advantage. Fiber is the most complex to install; this complexity contributes to higher costs. High costs make fiber too expensive for two school systems to install without some outside financial assistance. Leasing fiber is appropriate if fiber is in place.

If compressed video is deemed a satisfactory transmission method, overall it is the least expensive to install and is a viable solution, no matter the distance. Compressed video is a cost appropriate solution for longer distances. Both fiber and microwave systems are somewhat cost prohibitive for longer distances.

The standard classroom is easily adapted for use as a distance education classroom without significant remodeling costs. A distance education classroom can be equipped for less than $30,000.

Two-way, interactive television systems are expensive, complex and time-consuming to design, construct, and maintain. Once installed, 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 students and provide instruction, all three approaches can attain that goal on a fairly equal basis. The success of any delivery system, of course, depends upon the quality and usefulness of the content delivered and received, rather than upon the choice of equipment.

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TABLE

Table 1. Comparison of digital fiber, digital microwave, and DS1 compressed video costs

Distance	Transmission medium	Purchase[a] costs for two sites	End point[b] costs for two sites	Lease[c] for two sites	First year total costs[d] two sites	2nd year costs[e] for two sites	5 Year costs for two sites[d]	Average cost per year 5 year period
3 miles	Fiber, purchased	66,000	72,000		138,000		138,000	27,600
	Fiber, leased		12,000	36,000	48,000	33,000	180,000	36,000
	Microwave	35,000			35,000		35,000	7,000
	Compressed DS1		72,000	7,500	79,500	4,500	97,500	19,500
10 miles	Fiber, purchased	212,000	72,000		284,000		284,000	56,800
	Fiber, leased		12,000	38,000	50,000	35,000	190,000	38,000
	Microwave	41,000			41,000		41,000	8,200
	Compressed DS1		72,000	8,700	80,700	5,700	103,500	20,700
20 miles	Fiber, purchased	415,000	72,000		487,000		487,000	97,400
	Fiber, leased		12,000	41,000	53,000	38,000	205,000	41,000
	Microwave	166,000			166,000		166,000	33,200
	Compressed DS1		72,000	10,300	82,300	7,300	111,500	22,340
30 miles	Fiber, purchased	615,000	72,000		687,000		687,000	137,400
	Fiber, leased		12,000	48,000	60,000	45,000	240,000	48,000
	Microwave	213,000			213,000		213,000	42,600
	Compressed DS1		72,000	13,000	85,000	10,000	125,000	25,000
50 miles	Fiber, purchased	993,000	72,000		1,065,000		1,065,000	213,000
	Fiber, leased		12,000	54,000	66,000	51,000	270,000	54,000
	Microwave	357,000			357,000		357,000	71,400
	Compressed DS1		72,000	16,000	88,000	13,000	140,000	28,000
75 miles	Fiber, purchased	1,431,000	72,000		1,503,000		1,503,000	300,600
	Fiber, leased		12,000	76,000	88,000	73,000	380,000	76,000
	Microwave	493,000			493,000		493,000	98,600
	Compressed DS1		72,000	20,000	92,000	17,000	160,000	32,000

[a] Purchase costs refer to all construction, material, and equipment (not end point) costs involved in building the system.

[b] End point costs include transmission equipment, hardware, cables, and power supply, plus codecs which change analog signals to digital signals and compress the signal.

[c] This price reflects one time connection fee.

[d] No maintenance or operating costs are included for purchased systems; lease costs include maintenance and operating costs.

[e] One year lease rate for contract period of 60 months.

APPENDIX A- Considerations For Distance Education Systems

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
   * Economic and technical aspects
   * Procuring easements from the railway or state, city or county
   * Contacting individuals currently utilizing fiber systems
   * Leasing from individual telephone companies, utility companies, cable companies, and large businesses
   * Researching all possible partnerships and funding sources
   * 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
   * Path coordinates
   * Detail map of route
   * 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:
   * Method of installation
   * Staking the route
   * Splices or connectors
   * Installing the fiber
   * Terminal equipment - cost and technical support
   * Initial check 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. The following are options to consider:
   * Service needs
   * Economical and technical aspects
   * Funding and financial planning
   * Contacting individuals currently utilizing microwave systems
   * Availability of frequencies or leasing facilities
   * Land topography and distance
   * 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
   * The distance and number of repeaters needed
   * Selection of sites - must be line-of-sight with no obstructions as trees, or buildings
   * Visual check of lease possibilities and obstructions
   * Frequency band study to find other frequencies that might interfere
   * Setting frequency
   * Path profile to determine tower height and check for obstructions - use topographical map to determine elevations and plot points
   * Tower specifications, e.g., wind and ice load
   * Path calculations to determine equipment parameters/ configurations to meet performance requirements, e.g., 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:
   * Acquiring land-lease or buy
   * Availability of power and access road
   * Getting FAA clearance
   * Filing FCC application which includes an interference analysis and system design
   * FCC tower construction application if over 200 feet
   * Constructing the tower - consider time schedule
   * Installing the transmission equipment; build protective building
   * Beam alignment, equipment lineup and checkout
   * Connections from tower to school
   * Hooking up cable in classroom
   * System warranty
   * Maintenance agreement/fees
   * Maintenance support

Compressed Video System

1. FEASIBILITY STUDY. This is the planning stage. The following are options to consider:
   * Service needs
   * Economic and technical aspects
   * Possibilities for leasing the cable
   * Cost-sharing between two sites
   * Deciding if compressed video has the quality needed for the determined educational use
   * Contacting 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/proprietary standards
   * Full or fractional T lease

3. PURCHASE AND INSTALL.
   * Leasing T1 lines - negotiate rates, maintenance, service priority, time periods
   * Installing equipment - time schedule, costs
   * Technical support for installation equipment
   * Purchasing own classroom equipment or vendor video package
   * Compatibility of all equipment in system
   * Upgrading capabilities
   * Technical hardware and software service support
   * Warranty on equipment
   * Maintenance agreement/fees

APPENDIX B - Cost Estimates For Fiber Systems

FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

FIBER OPTIC CABLE INSTALLATION COSTS				CONSULTATION COSTS						
RURAL AREAS										
DISTANCE, MI	CONSTRUCTION COST/FT	CONSTRUCTION COST/MI	CONSTR'N TECHNICAL	FIELD WORK	DRAFTING	ENGINEERING	OTHER	MATERIALS	TOTAL ESTIMATED COST/MILE	TOTAL ESTIMATED COSTS
3	$1.55	$8,184	$600	$850	$650	$1,000	$1,000	$9,672	$21,956	$65,868
10	$1.40	$7,392	$600	$850	$650	$1,000	$1,000	$9,672	$21,164	$211,640
20	$1.35	$7,128	$600	$800	$600	$950	$1,000	$9,672	$20,750	$415,000
30	$1.30	$6,864	$600	$800	$600	$950	$1,000	$9,672	$20,486	$614,580
50	$1.21	$6,389	$600	$750	$550	$900	$1,000	$9,672	$19,861	$993,040
75	$1.09	$5,755	$600	$700	$500	$850	$1,000	$9,672	$19,077	$1,430,790
100	$0.97	$5,122	$600	$700	$500	$850	$1,000	$9,672	$18,444	$1,844,360

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

FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

URBAN AREAS				CONSULTATION COSTS						
DISTANCE, MI	CONSTRUCTION COST/FT	CONSTRUCTION COST/MI	CONSTR'N TECHNICAL	FIELD WORK	DRAFTING	ENGINEERING	OTHER	MATERIALS	TOTAL ESTIMATED COST/MILE	TOTAL ESTIMATED COSTS
1	$4.00	$21,120	$1,500	$1,800	$1,200	$2,500	$2,000	$15,712	$45,832	$45,832
5	$3.00	$15,840	$1,500	$1,800	$1,200	$2,500	$2,000	$15,712	$40,552	$202,760
CONSTRUCTION:	PLACE 2" PVC DUCT @ 36" DEPTH; PULL CABLE THROUGH DUCT.									
MATERIALS:	CABLE:	$1.00/FT (12-F, SINGLEMODE, ARMORED)				$5,280				
	DUCT:	$0.50/FT (2" PVC)				$2,640				
	MANHOLES:	5/MILE @ $[illegible] EA				$3,500				
	WARNING TAPE:	$0.05/FT				$264				
	WARNING SIGNS:	1/500' @ $50/EA				$528				
	SPLICING:	2 SPLICE/MILE @ $1000				$2,000				
	MISC.					$1,500				
	TOTAL					$15,712				
END EQUIPMENT COSTS										
		LOW		HIGH						
EQUIPMENT COST/END:		$20,000	-	$50,000						
INSTALLATION LABOR:		$5,000	-	$7,500						
TOTAL ESTIMATED COSTS/END:		$25,000	-	$57,500						
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: (MAINTENANCE ON END EQUIPMENT)				$3300 - $7600/YEAR/END						

DIGITAL RADIO SYSTEM
BASIC SYSTEM DUPLEX (Non-Protected)

SHORT HAUL 3 MILES

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

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)

SHORT HAUL 10 MILES

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

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

Equipment	Unit Price	Point A	Point B	Point C	System Total
Transmitter/Receiver	$32,720	1	1		$65,440
Antenna 8 foot	3,200	1	1		6,400
Waveguide (per foot)	13	250	250		6,500
Ant/WG Hardware	2,500	1	1		5,000
Dehydrator	756	1	1		1,512
Charger System 12 Amps	2,095	1	1		4,190
Batteries 96 Amp Hour	937	1	1		1,874
Tower 200 foot	20,000	1	1		40,000
Path Study	1,500				3,000
Installation/Test	16,000	1	1		32,000
					$165,916

DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
BASIC SYSTEM DUPLEX (Non-Protected)

SINGLE HOP 30 MILES

Equipment	Unit Price	Point A	Point B	Point C	System Total
Transmitter/Receiver	$32,720	1	1		$65,440
High Power (TWT)	4,000	1	1		8,000
Auto Power Control	1,550	1	1		3,100
Antenna 8 foot	3,200	1	1		6,400
Waveguide (per foot)	13	320	320		8,320
Ant/WG Hardware	2,554	1	1		5,108
Dehydrator	850	1	1		1,700
Charger System 25 Amps	3,700	1	1		7,400
Batteries 200 Amp Hour	1,500	1	1		3,000
Tower 300 foot	35,000	1	1		70,000
Path study	1,500				3,000
Installation/Test	16,000	1	1		32,000
					$213,468

DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
BASIC SYSTEM DUPLEX (Non-Protected)

TWO HOP 50 MILES
20 mile hop & 30 mile hop

Equipment	Unit Price	Point A	Point B	Point C	System Total
Transmitter/Receiver	$32,720	1	2	1	$130,800
High Power (TWT)	4,000		1	1	8,000
Auto Power Control (APC)	1,550		1	1	3,100
Antenna 6 foot	1,529	1	1		3,058
Antenna 8 foot	3,200		1	1	6,400
Waveguide (WG) per foot	13	320	640	320	16,000
Ant/WG Hardware	2,554		2	1	10,216
Dehydrator	756	1		1	1,512
Dehydrator	850		1		850
Charger System 12 Amps	2,095	1		1	4,190
Charger System 25 Amps	3,700		1		3,700
Batteries 96 Amp Hour	937	1		1	1,874
Batteries 200 Amp Hour	1,500		1		1,500
Tower 300 foot	35,000	1	1	1	105,000
Path study	1,500				4,500
Installation/Test	16,000	1		1	32,000
Installation/Test	24,000		1		24,000
					$356,700

DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)
BASIC SYSTEM DUPLEX (Non-Protected)

FOUR HOP 75 MILES
25 mile hops

Equipment	Unit Price	Point A	Point B	Point C	Point D	System Total
Transmitter/Receiver	$32,720	1	2	2	1	$196,320
High Power (TWT)	4,000	1	1	1	1	16,000
Auto Power Control	1,550	1	1	1	1	6,200
Antenna 6 foot	1,529	1	2	2	1	9,174
Waveguide (WG)per foot	13	280	560	560	280	21,840
Ant/WG Hardware	2,700	1	2	2	1	16,200
Dehydrator	850	1	1	1	1	3,400
Charger System 12 Amps	2,095	1			1	4,190
Charger System 25 Amps	3,700		1	1		7,400
Batteries 96 Amp Hour	937	1			1	1,874
Batteries 200 Amp Hour	1,500		1	1		3,000
Tower 250 feet	30,000	1	1	1	1	120,000
Path Study	1,500					7,500
Installation/Test	16,000	1			1	32,000
Installation/Test	24,000		1	1		48,000
						$493,098

APPENDIX D - Cost Estimates For Compressed Video Systems

(REV. April 20, 1992)

DISTANCE EDUCATION PROJECT

PRELIMINARY EQUIPMENT SPECIFICATIONS AND COST ESTIMATES

DESCRIPTION	MAKE	MODEL	QTY	UNIT	SUB
I. ORIGINATION SITE INSTRUCTOR CONSOLE					
PROG. SPEAKER	ANCHOR	AN-1000X	1	300.00	300.00
COMPUTER	APPLE MAC II SI	W/NU-VISTA BD	1	5000.00	5000.00
VISUAL PRESENTER	ELMO	EV-308/LU-308	1	2600.00	2600.00
SLIDE TO VIDEO TRANSFER	ELMO	TRV-35G	1	2300.00	2300.00
VHS PLAYER	PANASONIC	AG-1730	1	500.00	500.00
VHS RECORDER	PANASONIC	AG-1730	1	500.00	500.00
REMOTE SITE MONITOR	PANASONIC	PVM-8220 IN DUAL CONFIG	1	1200.00	1200.00
LAVALIERE MIC	SHURE	AMS 28	1	200.00	200.00
BACKUP WIRED MIC	SHURE	AMS 24	1	225.00	225.00
PREVIEW/PROGRAM MONITOR	SONY	PVM-8220 IN DUAL CONFIG	1	1200.00	1200.00
FURNITURE/RACKS	WINSTED		1	1000.00	1000.00
FAX MACHINE			1	800.00	800.00
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 COMPRESSED VIDEO CLASSROOM
DATA PRESENTED TO THE CLASSROOM STUDY COMMITTEE

(REV. April 20, 1992)

DESCRIPTION	MAKE	MODEL	QTY	UNIT	SUB
V. REMOTE SITE MONITOR CONSOLE					
FAX MACHINE	?		1	800.00	800.00
VISUAL PRESENTER	ELMO	EV-308/LU-308	1	2500.00	2500.00
VHS RECORDER	PANASONIC	AG-1730	1	500.00	500.00
BACKUP WIRED MIC	SHURE	AMS 28	1	200.00	200.00
PREVIEW/PROGRAM MONITOR	SONY	PVM-8220 IN DUAL CONFIG	1	1200.00	1200.00
REMOTE SITE MONITOR	SONY	PVM-8220 IN DUAL CONFIG	1	1200.00	1200.00
FURNITURE/RACKS	WINSTED		1	1000.00	1000.00
VI. REMOTE SITE STUDENT STATIONS					
FURNITURE	?		8	200.00	1600.00
SPEAKERS FOR SONY MON	ANCHOR	AN-1001	4	200.00	800.00
VIDEO CARTS	LUXOR	ATW-56	2	300.00	600.00
MICROPHONES	SHURE	AMS 22	8	200.00	1600.00
VIEWING MONITORS	SONY	PVM-2530	2	1500.00	3000.00
EQUIPMENT TOTAL					$ 130225.00
VII. INSTALLATION COSTS					
CABLING/CONDUIT	BELDEN & PANDUIT		1	2000.00	2000.00
LABOR					

VIII. LINE LEASING *

IX. SYSTEM MAINTENANCE/SUPERVISION SUPPORT *
MOVING AND SETUP COSTS ($250/DAY)
TROUBLE CALLS FROM ISU TO SITE

TOTALS		
	EQUIPMENT	$ 130225.00
	INSTALLATION	2000.00
	LINE LEASING	
	SYSTEM MAINTENANCE	
	TOTAL	

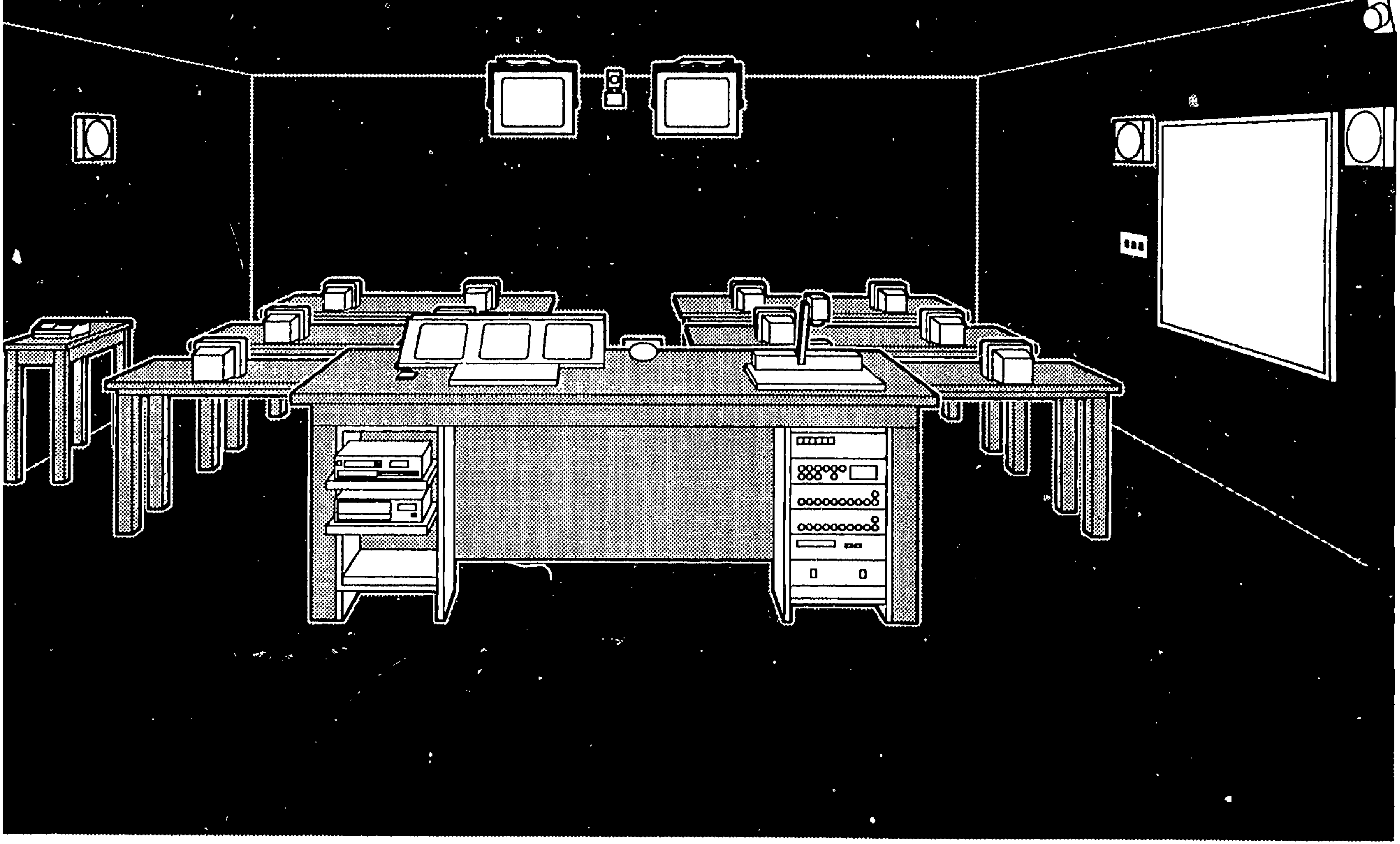
*ANNUAL ONGOING COSTS

APPENDIX E - Classroom Designs and Equipment Lists

APPENDIX E - Classroom Designs and Equipment Lists

Distance Learning Classroom - Teaching Site

View from Front



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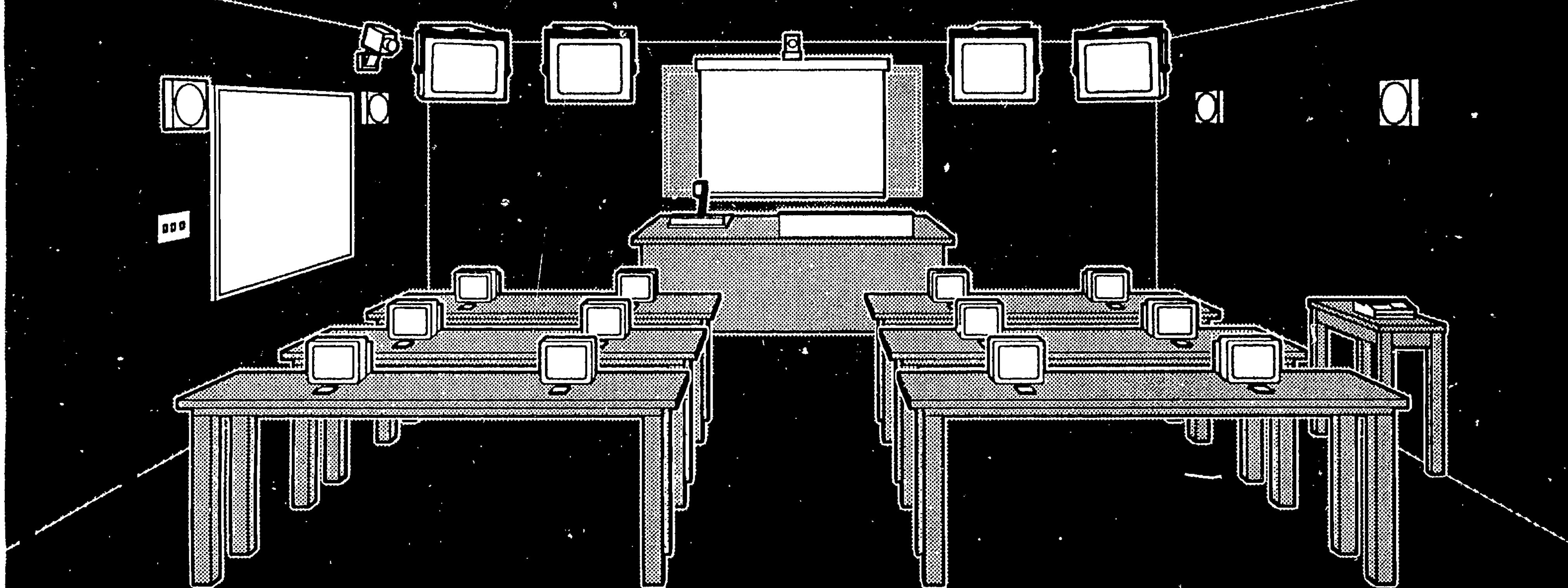
Distance Learning Classroom - Teaching Site

View from Rear



Distance Education Classroom Equipment List
Origination Site

Cameras		Quantity	Cost/Unit	Total Cost
A	Student camera (Panasonic WV-F70)	1	4295	4295
B	Student camera	1	4295	4295
C	Teacher camera	1	4295	4295
	Mounting brackets camera (Pan WV131P)	3	52	156
D	Visual presenter (Elmo EV-308)	1	3100	3100
	lightbar (Elmo LU-308)	1	300	300
Monitors				
E	Monitor, outgoing 25"(Sony PVM2530)	2	1590	3180
F	Monitor, remote site 25"	2	1590	3180
G	Teacher monitor, remote site 25"	1	1590	1590
H	Teacher monitor, outgoing 25"	1	1590	1590
I	Monitor, individual student 12" (NEC PM1271A)	12	525	6300
J	Monitor, teacher 7" (Panasonic BT-S701N)	3	600	1800
	Mounting brackets monitor (ceiling) (Bretford Mfg TVM1)	6	221	1326
Audio				
K	Speakers (Anchor AN1001)	4	163	652
K2	Teacher speaker (Anchor An1000X)	1	324	324
	Brackets (Anchor SB730)	4	43	172
L	Microphone, student (Shure AMS22)	12	210	2520
M	Microphone, teacher/wireless (Telex FMR-25TD)	1	600	600
Teacher station				
N	Audio/Video control (Crestron)	1	6000	6000
O	Teacher control unit			
	Rack mount shelving (Winstead)	1	500	500
	Audio mixer (Shure AMS8000)	1	2800	2800
	Video distribution (Panasonic WJ300B)	2	290	580
	Power strip (Winstead 98700)	1	69	69
	Light/dimmer control (AMXM320)	1	675	675
P	VCR play/record (Panasonic AG1250)	2	350	700
Q	Facsimile (HP200)	1	1200	1200
			EQUIPMENT TOTAL	$52199
			-30%	$36539
	Supplies, cabling, wiring, connectors			3000
			TOTAL	$39539

	Quantity	Cost/Unit	Total Cost
<u>Options for substitution or enhancement</u>			
3 chip camera (Panasonic WVF250)	1	7800	
Tripod for camera (ITE-T30)	1	295	
Large screen monitor 35" (Sony PVM5310)	1	2625	
Multiscan monitors 13" (Sony GVM-1300)	1	1495	
20" (Sony GVM-2000)	1	2300	
35" (Mitsubishi AM-3501R)	1	6900	
b&w teacher display monitors 4" (PVM 411)	1	1540	
Metal cart for monitor (Winstead R3353)	1	210	
Lavalier microphone (Shure AMS2[illegible])	1	235	
Room control panel (PenPal USWest)	1	7000	
Slide to video converter (Elmo TRV-35G)	1	3215	
Film to video converter (Elmo TRV-16G)	1	4290	
Echo canceller (Shure)	1	1640	
Time Base corrector (NOVA 700)	1	2290	
Computer interface (Micro 386 board)	1	2200	
NTSC Genlock card	1	2000	
Video Scan Converter PS 2	1	12995	
Video Scan Converter MAC	1	9995	
Table 96" x 24" Barron	1	606	
Table 18" x 60" Barron	1	483	
Table 60" x 24" Barron	1	518	
Porcelain board/metal board 72 x 48 $6.20 sq.ft.		149	

Acoustic treatment

Carpet	14.00 -16.00 sq. yd
Wall panels	5.60 sq. ft
Drapes	6.25 sq. ft

Riser

	Quantity	Cost/Unit	Total Cost
Materials 8' x 16'	1	160	
Materials 8' x 24'	1	240	
Labor	1	100	

Consultation: $1,250-$5,000

Installation: $2,500-$5,000

Basic Classroom
Distance Education Classroom Equipment List
Origination Site

	Cameras	Quantity	Cost/Unit	Total Cost
A	Student camera w/o pan, tilt, zoom	1	1720	1720
C	Teacher camera (Panasonic WVD5100)	1	2930	2930
	Mounting brackets camera (Pan WV131P)	2	52	104
	Teacher camera control	1	400	400
D	Visual presenter (Elmo EV-308)	1	3100	3100
	lightbar (Elmo-LU308)	1	300	300
	Monitors			
E	Monitor, outgoing 25" (Sony PVM2530)	1	1590	1590
F	Monitor, remote site 25"	1	1590	1590
G	Teacher monitor, Remote site 25"	1	1590	1590
H	Teacher monitor, Outgoing 25"	1	1590	1590
	Mounting brackets monitor (ceiling) (Bretford Mf TVM1)	4	221	884
J	Monitor, teacher 7" (Panasonic BT-S701N)	3	600	1800
	Audio			
K	Speakers (Anchor AN1001)	4	163	652
K 2	Teacher speaker (Anchor AN1000X)	1	324	324
	Brackets (Anchor SB730)	4	43	172
L	Microphone, student (AMS22)	12	210	2520
M	Microphone, teacher/lavalier (ShureAMS28)	1	235	235
	Teacher station			
N	Audio/Video control (Extron Model 8)	1	1495	1495
O	Teacher control unit			
	Rack mount shelf (Winstead)	1	500	500
	Video dist.(Panasonic WJ300B)	1	290	290
	Audio mixer (Shure AMS8000)	1	2800	2800
	Power strip (Winstead 98700)	1	69	69
P	VCR play/record (Panasonic AG1250)	2	350	700
Q	Facsimile (HP200)	1	1200	1200
			EQUIPMENT TOTAL	$28555
			- 30%	$19988
	Supplies, cabling, wiring, connectors		$2,000	$21988