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ABSTRACT

This report summarizes the results of a two year investigation into the feasibility of using telecommunications satellites for educational purposes compared with the use of other delivery systems. Different systems emerge as preferable depending upon such circumstances as topography, number, and geographic distribution of participants, and the number of hours to be supplied. The Executive Summary provides an overview and conclusions about the costs of providing Instructional Television (ITV) by satellite as opposed to non-satellite systems; an examination of the results of several special studies including one on the impact of the new copyright legislation; implications of the forthcoming World Allied Radio Conferences; and a variety of non-cost variables. It includes also a brief review of the Educational Satellite Communication Demonstration and a summary of the finding from a series of case studies reviewing different possible patterns of ITV delivery and usage. The remaining two chapters present an indepth cost analysis of delivery system performance, and the findings from a set of case studies examining characteristics of existing systems in various settings. Appendices include cost components, derivation of comparative cost equations and notes on the revised copyright law. (WBC)

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November 1976

INSTRUCTIONAL TELEVISION:
A COMPARATIVE STUDY OF SATELLITES AND OTHER DELIVERY SYSTEMS

Final Report,
Contract No. NIE C-74-0145

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PREFACE

Two years ago the Educational Policy Research Center began a systematic analysis of the ways in which satellites could be best used--if at all--for educational purposes. We were aware that many, perhaps most, of the previous studies of the educational uses of sophisticated technologies have tended to concentrate on the technologies themselves, not on the educational processes and impacts of the uses of those technologies. Accordingly, we have attempted to make sure that educational considerations and criteria shaped our analysis.

Our project actually evolved into two quite different, though related, tasks. First, we were charged with conducting a study and documentation of the Educational Satellite Communications Demonstration (ESCD) project, a multi-million dollar, federally funded demonstration of the possible educational uses of telecommunication satellites. Our goal was to provide documentation on what actually transpired, as well as to discover lessons that could be learned from this experience. The bulk of our resources were allocated to this effort.

Our second task was to develop a more generalized analysis--one not limited to the ESCD context--of the potential educational role of satellites. Toward this end we created what is essentially a comparative analysis of alternative ways to make instructional television available to learners: satellites; cable; public television; instructional television fixed service; and the distribution of videotapes and videocassettes. Early in our analysis it became clear that none of these methods of delivering instructional television was going to emerge as clearly superior to the others for all possible uses or users. Therefore, we have examined these delivery modes in order to determine their comparative advantages and disadvantages, placing special emphasis on cost considerations.

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Our Annual Report, submitted to the National Institute of Education in January, [illegible], covered our findings with respect to the ESCD.

This Final Report is concerned primarily with the comparative analysis. There are, however, a number of references to the Educational Satellite Communications Demonstration, since it constituted an important source of relevant information. We have included a brief summary of findings from the earlier report in the Executive Summary of the present report.

We are in debt to a great many people for advice and assistance during the course of this project, and it is not possible to name all of them. In fact, it is difficult to even list the range and variety of the different agencies and institutions with which we dealt.

The EPRC research team included the following:

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INTRODUCTION

This report summarizes the results of a two year investigation by the Educational Policy Research Center (EPRC) into the feasibility of using telecommunications satellites for educational purposes. Much of our work, particularly during the first year and a half, was directed towards a study of the operation and implications of the Educational Satellite Communications Demonstration (ESCD). The results of this study were presented in our Annual Report which was submitted to the National Institute of Education in January 1976 and is summarized briefly within this report. Since that time we have focused on an examination of the comparative advantages and disadvantages of of delivering instructional television (ITV) by satellite as opposed to delivering it by some other means, such as cable, public television, mailed videotapes, and microwave broadcasting. For the most part we viewed these systems as equivalent in terms of their utility to educators and students: they are simply alternative ways of getting ITV to places of instruction. However, there are in fact some differences among these delivery systems with respect to such potentially important factors as two-way communication capability and flexibility with regard to instructor control over what programs are viewed and when they are viewed. We have also examined several "hybrid" systems which use two or more delivery systems (i.e., satellite broadcasting with local distribution by cable) to reach the final users.

The central purpose of our study has been to delineate the circumstances under which satellites appear to be a viable means for making ITV available. Our approach has been one of "putting satellites into competition with alternative delivery systems" and seeing which one or ones emerge as optimal in terms of both cost and non-cost considerations. Unfortunately for our analysis, this has not been a simple matter, and we are unable to say that one system is in all cases better than another. Some systems are clearly better than others under certain circumstances, while other systems emerge as more effective under other circumstances. Thus the chief problem (and one which we have largely been forced to "work around" rather than solve) is that there are literally an

infinite number of different possible factors relevant to choices among ITV systems. These include geographic area to be covered; topography of areas to be served; number of participating states, districts, schools, and students; "geographic distribution" or "density patterns" of participants; and the number of hours of ITV to be supplied each day. These matters will be dealt with in detail in the chapter on comparative system costs.

This Final Report is divided into three chapters with several appendices. The first chapter is the Executive Summary. It has been written with an awareness that many readers will not have the time or the interest to read the entire report. For this reason the Executive Summary is available separately from the complete Final Report. The Executive Summary constitutes our summary overview and conclusions about

- The costs of providing ITV by satellite as opposed to non-satellite systems.
- An examination of the results of several special studies which we conducted on such matters as the impact of the new copyright legislation, the implications of the forthcoming (1977 and 1979) World Allied Radio Conferences, and a variety of non-cost variables of the delivery systems.
- A brief review of the Educational Satellite Communication Demonstration which summarized our earlier work.
- A summary of the findings from a series of case studies that we conducted to review different possible patterns of ITV delivery and usage.

The remaining two chapters present an in-depth cost analysis of delivery system performance and the findings from a set of case studies which examined characteristics of existing systems in various settings around the country.

CHAPTER ONE

EXECUTIVE SUMMARY

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BACKGROUND

When we began our analysis of the prospective use of satellites for educational purposes over two years ago, we realized that there were three alternative approaches we could pursue:

(1) We could simply assume that it was inevitable that satellites would be used for educational purposes and bend our efforts towards finding ways of making maximal use of their capabilities as well as minimizing possible misuses or abuses.

(2) Since educational use of the satellites seemed bound up with the use of instructional television (ITV), we could examine the logically prior question of the advantages and disadvantages of ITV as compared to other modes of instruction.

(3) We could assume the merits of ITV across a non-trivial range of educational situations and then view satellites as yet another way of delivering ITV and seek to discover whether satellites offered any particular advantages or disadvantages for providing ITV services.

We settled upon the third of these approaches. The first approach was rejected because we saw the educational use of satellites as neither inevitable nor necessarily advisable. We rejected the second because it would have involved our dealing with issues, albeit important ones, that involved too many variables for a manageable study. These issues tended to fall into three categories: (1) the domain of alternative pedagogies where there is already substantial data indicating that there is no statistically significant difference between the different instructional techniques such as seminar, lecture, tutorial, radio instruction, ITV, CAI, etc.; (2) questions of how, when and by whom ITV was actually made use of when it was made available (a subject which has received surprisingly little research); and (3) highly problematic trade-off questions about whether additional financial resources could best be used by educators for ITV as compared to other educational activities.

Thus we decided to focus our research on an analysis of the comparative advantages and disadvantages of providing ITV by telecommunications satellites.

It must be emphasized that we are not implicitly or explicitly endorsing the value of ITV. Our research simply does not deal with this subject. Rather, we are content to observe that a number of school systems have invested resources in ITV while many others have investigated the possibility of doing so. We anticipate that our research will be of use to educational decision-makers who are considering the introduction, expansion, or revision of ITV use.

In short, our report concentrates its analysis on the relative advantages and disadvantages of different ways of delivering instructional television. Basically there are five different modes of distributing ITV:*

(1) Satellites
(2) Cable
(3) Public Television (PTV)
(4) Instructional Television Fixed Service (ITFS)
(5) Mailing of videotapes or videocassettes.

These basic modes can be combined in two different ways. First, they can be combined vertically using, for instance, satellites for initial distribution to PTV stations that then re-distribute the programs to places of instruction. Second, these delivery systems can be combined horizontally so that one delivery mode serves some schools in the coverage area while another mode serves other schools in the coverage area. For instance, there are a number of possible coverage areas where PTV is accessible to all but a handful of schools. In such areas it might be best to use PTV to distribute ITV to all the schools which it can serve and mail videotapes to the remaining schools. Obviously, it is also possible that the optimal system is one which involves both vertical and horizontal arrangements.

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*We do not deal with the possible educational applications of such developments as video discs, lasers and fiber optics. They may have implications for ITV delivery, but any discussion of them would be quite speculative.

If the alternative delivery systems were identical in their effects (both direct and indirect) then our task would be greatly simplified for we would only have to examine the costs associated with each. The least expensive system would clearly be the best, since it would provide an identical service at least cost. However, these delivery systems do in fact vary with respect to the following factors:

- Flexibility that teachers have in terms of when in the day or the week their classes use ITV.

- Ability of the delivery system to be responsive to the needs and requests of teachers for different kinds of programming.

- Some systems (such as satellite ones) can have two-way communication capabilities built into them as an integral part of their operation, while others (such as the mailing of videotapes) would have to develop ancillary facilities, such as telephone communication, to duplicate this service.

- The organizational requirements and implications of these alternative delivery systems are quite different. A satellite system, for example, tends to require a fairly high degree of centralized decision-making or consensus on what programs will be aired and when they will be aired, while a system of mailing video tapes to schools might be much more decentralized and locally controlled.

- The forthcoming (1977) meeting of the World Administrative Radio Conference (WARC), the international groups which allocates spectrum space for different uses and users, may make decisions which will effectively prevent telecommunications satellites from being used as a regular mode of ITV distribution.

- Copyright and royalty requirements may be different depending upon which of the alternative ITV delivery systems is to be used.

We have highlighted at the outset these ways in which the ITV delivery modes actually are different from one another largely to make it clear that we have not unrealistically simplified the real world problems. It should be noted, though, that some of these differences can be reduced to

questions of cost. For example, PTV or satellites could be seen as fairly inflexible systems with respect to time scheduling--the programming is broadcast at a certain time in the day and teachers must have their classes view the material then. However, there are two basic ways this inflexibility can be substantially reduced. First, the broadcasting schedule can build in repeats so that the same program is aired several times in the course of a day or a week. Second, subject to possible copyright restraints which are elaborated later, the broadcasted programming can be videotaped by the school for subsequent use at the teachers' discretion.

The remainder of this Executive Summary is divided into four parts. The first deals with the comparative costs of delivering ITV by different means. We have emphasized this topic because we realized that many educational decision makers at the federal, state and local levels must be very concerned with the budgetary implications of ITV systems. Very little has been written on this subject. Second, we present a summary of the major non-cost issues surrounding ITV systems, including such topics as the forthcoming WARC decisions and the recently passed federal copyright law. The third section is devoted to a brief review of the Educational Satellite Communication Demonstration and a summary of some conclusions from its evaluation. Finally, the fourth section presents the main implications of the series of case studies of ITV delivery systems.

COST ANALYSIS

There are a large number of factors which must be taken into account in a thorough analysis of the comparative costs of alternative ITV delivery systems. As noted earlier, it is impossible to state flatly that one system is the least costly. Under one set of circumstances one system emerges as least expensive, while another one will cost slightly less under somewhat different conditions. And we have not had any specific geographic area or areas--such as the State of Montana, New York City, or Appalachia--for which we were to design a "least cost" system. Consequently, we have established a more generalized set of objectives. First, we have constructed the basic cost "building blocks" which would allow us (or anyone else) to discover the least cost system for any particular situation. Second, we have experimented with these building blocks or cost components in a number of simulated situations in order to gain some understanding of the general cost advantages and disadvantages of the different systems. These simulations have been based upon the cost components developed in the first part of the analysis.

In all of these studies we deal with annual costs either on a per school (or participating institution) basis, or on a per student basis. While this is the standard and probably most useful way to examine such costs, it masks one very important practical consideration: the initial capital start-up cost. In developing annual cost estimates we divide this initial cost by the number of years of service the equipment is expected to yield before it will have to be replaced. However, such equipment will generally have to be fully paid for at the time of acquisition. This has two major implications. First, users of the ITV system may be confronted with an obvious financing problem at a time when school budgets are severely restricted and when capital may be difficult to borrow. Second, and equally important, the ITV delivery system with the larger capital costs represent very major decisions or commitments that are difficult and very expensive to alter subsequently. Two systems in particular--satellite and ITFS--tend to involve costs and commitments of this nature, and will be discussed more fully later.

All of the analyses summarized here have been made within the following constraints:

- We are considering only systems which involve at least fairly intensive use of ITV. We did not, for instance, examine alternative ways of delivering occasional televised programming or of providing the capacity for live teleconferences, although the cost components which we have developed might be useful to someone wishing to do so.

- We are not examining the comparative costs of delivering ITV to homes. However, our analysis is not restricted to the delivery of ITV to schools, although this is the central subject of our consideration. Generally, we are concerned only with the delivery of ITV to "places of group instruction" which could include pre-school, elementary and secondary schools, factories, colleges, office buildings, and so forth.

- We have been limited to an analysis of alternative ITV delivery systems for the United States. Although much of the data we have gathered would be transferrable to other countries or consortiums of countries, our conceptual framework has been tailored to the conditions existent in the United States. The important point here is not that the United States is uniquely different from most other countries, but that the United States, like many other economically developed nations, has a relatively well developed communications infrastructure. The presence of such an infrastructure means that there already exist ways of delivering ITV--such as public television and cable television. It also means that there are a large number of educational institutions which have personnel who are familiar with the operation of such equipment. In short, the analysis presented here carries with it some very important caveats about its applicability to less developed nations.

When we first began our examination of the comparative cost of different ways of providing ITV to places of instruction, we were a bit overwhelmed by the number and variety of variables with which we had to deal. We had to pay attention to such factors as:

. The number of hours and channels of ITV to be provided each day;

. The number of times a given program might be repeated each day and/or week;

. The number of schools which might be included in the "coverage area;"

. The average number of students or classrooms in the "covered" schools;

. The definition or circumscription of the "coverage area;"

. The geographical dispersion or "density" of these places of instruction;

. The topographic variability of different areas;

. The extent and pattern of the existing communication infrastructure, especially with respect to the availability of cable and public television;

. The extent to which places of instruction already possess at least some of the equipment necessary for ITV;

. The possibilities of providing ITV to one part of the coverage area with one delivery mode, while providing it to another part with a different mode or modes;

. The cash flow problem which is raised by the fact that different ITV delivery systems have differing requirements for "up-front money" to cover initial capital equipment costs.

In a later chapter of this report that deals exclusively with costs, we discuss these variables in considerable detail. Rather than embarking here upon an attempt to summarize the methods we used to analyze the costs of the various delivery systems (and the costs of combinations of such systems), we will present a general summary of the types of situations in which the following ITV delivery modes have comparative cost advantages:

. Telecommunication Satellites

. Instructional Television Fixed Service

. Cable Television

. Public Television

. Mailed Videotapes and Videocassettes.

We begin with a discussion of "common costs" - costs which are incurred no matter which type of ITV delivery system is utilized. We then describe, one by one, the cost advantages and disadvantages of these delivery systems. Next, we discuss the various ways in which these systems can be combined to form "hybrid" systems. We conclude with some general observations on these alternative systems which include some non-cost considerations.

Common Costs

In developing cost estimates for the components of the different ITV delivery systems, it became apparent that a number of the component costs were identical no matter which system was used. Since our major purpose has been to examine comparative costs, the existence of these common costs ("common" to all systems) has allowed us to simplify our analysis by factoring them out and setting them aside on the basis that they have no influence on these comparative costs.

The common costs fall into three categories: in-school costs, system management costs, and costs of developing or renting ITV programming. Briefly, the in-school costs include the purchase of color television sets, videocassette recorders and videocassettes, internal wiring of schools for within-school distribution of ITV, and an amplifier for "boosting" the strength of the signal received by the school. In each case it would be possible to make strong arguments that these are not essential or necessary costs. We view these purchases as options available to participating institutions. As options, they need not be purchased all at once, nor by all participating institutions at the same time. We have included these components because the experience of schools and school districts which have used ITV heavily in the past suggests that the purchase of such equipment is generally considered desirable. However, whether the equipment is purchased or not has no effect on the comparative cost analysis since the purchasing decision is unrelated to the way in which the ITV programming gets delivered to the institutions.

The full costing details of the in-school common costs will be provided in the chapter on comparative costs. It is perhaps sufficient here to simply note that the annualized cost of this equipment is about $2,000 per year for each participating institution, and is based upon a total capital outlay of about $10,000.

The "system management" cost has proved to be rather problematic. There has been a wide variation in the management costs of ITV programs. However, there seems to be no substantial reason to think that the system management costs must vary much from one delivery mode to another. Hence, we have simply included them in the common cost category.

It has also been difficult to determine a workable way to estimate the costs of developing or renting ITV programming. We do have estimates on the cost of developing new programming, but these costs range from $150,000 per hour of programming to materials which are provided free of charge. However, it appears that no matter what these materials cost, they would cost the same whether they were provided by satellite, ITFS, cable or whatever. The case of rented programming is somewhat more complex, involving presumed distinctions between broadcasting modes in such a way that it is difficult to tell how many viewers there are (such as PTV), as opposed to transmission of materials to identifiable audiences (such as by mailing videotapes to specific schools). Actually, the distinction as described here is somewhat more rational and clearcut than the criterion used by suppliers of educational programming. The complications, with some attendant idiosyncracies, are attributable to certain intricacies of copyright laws and royalty agreements. Nonetheless, it appears to be substantially accurate to assume that the cost of renting ITV programming will be roughly the same no matter what the method of distribution.

The effect of creating this category of "common costs" is to simplify our analysis. It means, in starkest terms, that there are fewer variables with which we must deal in assessing the comparative costs of different ways of delivering ITV.

Single Mode ITV Delivery

We turn now to an examination of each of the five alternative ITV delivery modes. The purpose of this is to review the main unique costs (i.e., excluding common costs) for each system as well as to suggest general circumstances under which each possesses cost advantages.

1. Satellite Systems. A satellite system which broadcasts directly from the satellite to participating institutions will almost always involve the largest amount of original capital outlay. We have assumed that time could be rented on a powerful satellite for about $500 per hour for each channel, so the cost of purchasing and launching a satellite does not enter into our computations (except in the form of the rental costs). However, there remain major capital costs:

- The uplink transmitter and associated transmission equipment. The uplink requires a large antenna which sends signals up to the satellite so that the satellite can rebroadcast them to the participating institutions. It is also necessary to maintain at least a small studio and equipment to process the ITV programming. In some, possibly rare, situations it might be possible to buy time on an existing uplink facility. Otherwise, an initial capital cost of about $250,000 is necessary.

- Broadcast receiving equipment. Each participating institution requires an antenna and related equipment to receive the satellite broadcasts. Such equipment costs, by current estimates, about $6,000 for each participating institution.

In addition, there are two major operating costs unique to a satellite system. We estimate that it costs about $200,000 per year to operate the uplink and studio broadcasting facilities. In addition, there is the previously mentioned charge of about $500 per hour for the satellite. Since there are about 180 school days in the year, there is a satellite

cost of about $90,000 for each hour of daily programming ($500 per hour multiplied by 180 days). Thus one hour of satellite time for each of the 180 school days costs about $90,000, two hours for each day costs about $180,000, and so forth.

What all of this means in general terms is that use of a satellite system to deliver ITV directly to places of instruction would probably involve the following considerations in order to be judged as advantageous in terms of its cost:

- A very large number of participating institutions are required in order to "spread" the large system-wide cost over many users. Otherwise, the costs per institution are prohibitively large.
- The system must be operated quite intensively in terms of the number of hours per day it is used in order to reduce the per hour cost.
- The satellite system tends to be more cost advantageous in serving widely dispersed schools (generally over at least several states). However, it tends to be more expensive than a cable or public television delivery system in areas already heavily served by these modes.
- As noted earlier, the capital costs associated with satellite delivery of ITV are large, and a decision to develop such a system would generally involve an 8 to 15 year commitment to use this technology.

2. Instructional Television Fixed Service (ITFS) uses microwave frequencies to transmit ordinary television signals to receiving stations which use straightforward converters to convert up to four channels of video/audio to standard VHF channels. Though restricted to 10 watts of output power per channel, ITFS systems can achieve line-of-site coverage with adequate received power because transmitting and (especially) receiving antennas can be designed to have high gains in the direction of interest. Some ITFS systems are configured with FM audio uplinks allowing "talk-back" from television classrooms to instructors (see case studies on the Stanford and the University of Southern California ITV systems).

ITFS signals can be carried around or over line-of-site obstacles by using a series of repeaters with adjacent transmitters having line-of-site between them. Since such repeaters with their associated equipment are expensive, local topographical features, along with consideration of the geographical density of receiving sites, are the principal determinants of ITFS cost.

An ITFS system, like a satellite one, involves a considerable initial capital outlay. The major capital costs include:

- Communications towers upon which to place the antennas. The cost of such towers is extremely variable, and depends upon the topography of the coverage area. In an ideal situation--perfectly flat terrain or an area with one hill upon which to place the tower--the cost can be quite low, e.g., $5,000 to $10,000. In other, perhaps "more normal" situations it can go as high as $300,000 or more.

- The transmitters cost about $15,000 for each channel. An ITFS system can have up to four channels, so this cost can be around $75,000 for each tower with a set of transmitters.

- The capital cost of equipment for receiving the signal is about $1,500 for each receiving site.

- At least one central broadcast studio is necessary for originating the programming. Such programming can be pretaped or live. In more elaborate ITFS systems there can be more than one broadcasting studio.

The annual operating costs of an ITFS delivery system are, with several relatively minor exceptions, exclusively those which we have referred to above as common costs, i.e., costs incurred about equally by any of the different ITV delivery modes.

In general terms, an ITFS delivery system has relative cost advantages and disadvantages of the following sort:

. If schools or other participating institutions are in line-of-site with some central location, an ITFS system can have distinct cost advantages over the other delivery modes.

. If the intended coverage area is not substantially served by PTV or cable and is too small for a satellite system to be economical, ITFS may be the least-cost system.

. Even if the coverage area is fairly large--say a state as large as Nebraska--ITFS might be less costly than a satellite system unless there is a need for more than four channels.

. A potential disadvantage of ITFS is that there is a very considerable original capital outlay for all of the necessary equipment. As noted earlier, this drawback also applies to a satellite system. However, this problem is somewhat smaller for ITFS since it is possible to begin with a core ITFS system in one reasonably confined area, and expand it with additional transmitters later. Nonetheless, the capital costs of an ITFS system do pose a problem with respect to original capital outlay and its attendant long-term commitment to "go with the decision."

. ITFS possesses an intrinsic advantage over a satellite system which might serve the same coverage area in that ITFS is much more flexible in terms of allowing for greater local decision-making about which educational programs will be "aired" and when they will be "aired."

3. Cable Television. Cable television--when it is available--appears to be far and away the least costly method of distributing ITV. The cost of such service will vary from one cable company to another. Very frequently, however, cable companies have made channels available to educational institutions at little or no cost. Cable companies are currently required by the FCC regulations to provide all customers with the broadcssts of the areas' commercial and public television stations. In this way many schools already have access to ITV which is carried by a local PTV station. We are especially concerned here, however, with the possibility of an additional channel or channels being made available to educational users.

For modern systems using good quality cables and linear amplifiers, the additional costs incurred in providing extra channels appear to be extremely modest. In some cases no additional capital equipment needs to be installed at the cable company's transmission facility (called a "headend"); in others additional modulators and videotape machines may be needed. Some operators affix an additional charge for "hooking-up" a participating institution to the cable system. Furthermore, some companies might assess an operating cost charge which usually would be quite small.

Under a new ruling put into effect in the summer of 1976, the FCC has effectively allowed for new cable TV systems to be installed without set-top converters. Such systems will have the capacity for carrying many more channels than the CATV customer can receive without a converter. If instructional television were demanded by schools, it would be a simple matter to cablecast signals over unused portions of the cable spectrum (with the addition of a modulator per channel at the headend which costs approximately $2,500, plus converters at each school which are available at less than $100).

All other costs associated with cable television delivery appear to fall into the "common cost" category.

In short, then, the cable television mode of ITV delivery has extraordinary cost advantages over the other systems. It is virtually impossible for any of the other systems to even come close to it in terms of cost advantages. Its major drawback is that it is not available in all areas. As will be discussed in a later section, when cable television uses a converter and thereby controls access to specific channels for specified institutions, there may be advantages in terms of ITV programming availability and cost:

4. Public Television. Public television has served in the past as a principal distributor of ITV. Often, in fact, public television stations have been created and funded by educational units (generally by a state

education agency). We may now, however, be entering a transitional period in which the public television stations which are not operated by educational agencies will be much less enthusiastic about providing educational institutions with daytime ITV programming. In the past, many PTV stations have seen daytime educational programming as having a very low-opportunity cost--in many cases the alternative was simply not to broadcast. There are some indications that this may be changing and that a number of PTV stations feel that they could offer daytime programming that would provide a truly viable alternative to the offerings of commercial television. It may be that the new Public Broadcasting Service satellite system, which will make three channels available for the distribution of programming to PTV stations, will provide a sufficiently attractive range of programming that many PTV stations will find it increasingly difficult to justify devoting daytime hours to the broadcasting of ITV to local schools. At this point these possibilities must be viewed as unknowns. But they are real possibilities which cannot be ignored.

There is only one major cost (apart from common costs) associated with delivering ITV by public television: the broadcast fee. We assume that the participating institutions, a school district, the state agency, or some combination of these units will be charged for the operating and capital expenses associated with the PTV broadcasts. These costs cover a wide range, depending upon such factors as the size of the transmission tower and the type and amount of other broadcasting equipment maintained by the PTV stations. Based upon a survey of a number of PTV stations' costs, we have developed a mid-range estimate of about $150 per hour for transmission and monitoring costs. Since we are assuming in all cases considered here that ITV will be used on a very regular and intensive basis, we have estimated the cost of providing one hour of ITV each school day for an entire school year: 180 days times $150 (for one hour each of these days) equals $27,000. Thus the cost (apart from common costs) of providing an hour of ITV per day to all of the schools in a PTV station's coverage area is about $27,000 per year. Two hours per day would cost about $54,000, and so on.

The following sorts of observations can be made about the comparative advantages and disadvantages of delivering ITV by public television:

- Where cable television also covers the PTV coverage area and has unused channel space, PTV will almost always be more expensive than cable in terms of actual cost. However, in terms of costs charged to local educational units there may be little difference between the systems if state funds are used to subsidize the PTV station.

- Except for very large coverage areas--ones that would generally involve more than ten PTV stations all providing the same ITV programming at the same time--PTV will be less expensive than satellites.

- PTV works best when there is fairly flat terrain and where the receiving institutions are located fairly close together. These are also the circumstances under which ITFS works best. An advantage of ITFS is that it can have four channels, while PTV has only one. An advantage of PTV is that it requires almost no initial capital outlay (except for the common costs), while ITFS has a very considerable initial cost.

- A number of PTV stations may become increasingly reluctant to devote daytime hours to broadcasting ITV. In such cases the PTV stations may be willing to broadcast during otherwise "down" time (in the midnight to 6 a.m. period) allowing schools to videotape materials for subsequent use. Timing devices can be used to automatically turn videotape recorders on and off so that no personnel would have to be present.

5. <u>Mailing of Videocassettes or Videotapes</u>. Perhaps one of the more obvious--if less electronically sophisticated--ways of delivering ITV is to simply make copies of programming on videotape or videocassettes and then mail them to the participating institutions. Such a system requires very little by way of initial capital outlays. There already exist central "libraries" from which programming can be rented. The cost of making videotape or videocassette copies is estimated to be about $5 per hour for each tape. Given 180 school days, the copying cost of providing one hour

of ITV a day for each of the 180 days would be about $900 per year for each participating institution. Two hours per day would then cost $1,800 per institution each year, three hours would cost $2,700, and so on.

We have already assumed that each institution would purchase three videocassette machines. This was included in the common costs. However, with the greater use of videocassettes involved in a copying and mailing system, it seems reasonable to assume that the participating institution would require additional videocassette players. Two additional such machines would involve an annual (pro rata) cost of about $650 per institution. This would represent an added initial outlay of about $3,000.

There are some distinct cost advantages and disadvantages to an ITV delivery system which is based upon copying and then mailing videocassettes to institutions:

- The capital costs are relatively modest which means that institutions need not feel that they are taking a major "plunge" when experimenting with such a system.
- Institutions can order only the programming that they want and can use it when they wish and need not make their own recordings to attain scheduling flexibility.
- This kind of system is most advantageous in terms of costs when only a low number of schools is involved; especially if the schools are widely dispersed or are not served by PTV or cable. If the terrain is rough making ITFS expensive (due to the need for relay towers), mailing tapes can have a cost advantage over ITFS for coverage areas which include as many as 25 to 50 schools, especially if multiple channels (more than six hours of ITV per day) are not required.
- One perhaps surprising result of our analysis was that for very large ITV systems--ones involving around 200 participating institutions or more--satellite delivery becomes less expensive than

mailing videocassettes. Cable and PTV, assuming they are available, overtake the cost advantages of a system of mailing cassettes at much lower numbers of participating institutions, with cable almost always being less expensive.

HYBRID SYSTEMS

Until this point we have only discussed and compared "pure" systems -- ones which involve only one mode of ITV delivery. There may in fact be a number of situations in which single-mode delivery will be optimal. But there also will be a variety of circumstances in which it will be best to use two or more delivery modes to serve the same coverage area. These we refer to as "hybrid systems."

There are two basic forms of hybrids -- vertical and horizontal. A vertical hybrid is where one mode, such as mailing videotapes, is used to deliver ITV to central points (such as a PTV station) for subsequent broadcast to participating institutions. A horizontal hybrid exists when two or more modes are used to deliver ITV to different parts of a single coverage area, such as using cable to deliver programming to institutions within its service area while reaching all other participating institutions by ITFS. Of course, it is possible that a system might be both a vertical and horizontal hybrid.

Most systems will probably involve some form of a "vertical hybrid" since it will be necessary to get the ITV programming to the central place from which it will be mailed or transmitted. Apart from point-to-point microwave, generally only satellites and mailing systems can be used for this first distribution step.

Many systems would also require a horizontal hybrid configuration. For instance, in many cases it would be optimal from a cost perspective to use cable television to provide ITV to those institutions readily served by cable; to use PTV to provide ITV to all of the remaining institutions that can be served by it; and to determine whether a system of mailing videocassettes or ITFS (or some combination of the two) would be the least cost method of serving all of the remaining schools.

In some cases the area or particular institutions to be covered will inevitably be determined by technological and topographical/geographical considerations. In several of the case studies which we examined this became quite evident. PTV currently serves a number of elementary and secondary schools. However, all of the schools in a given district can not necessarily receive the signals, and sometimes they are just left out of the system with no "compensating" ITV distribution (such as having videocassettes mailed to them). Similarly, ITFS can often interconnect a number of schools quite easily, but not necessarily all of the schools in the district or districts involved. Again, there is no necessity that all of the remaining schools be provided with ITV by an alternative mode of ITV delivery. However, if the ITV system is considered to be educationally attractive, the non-served schools can raise understandable objections.

It appears that under current cost configurations, the potential role of telecommuncations satellites for delivering ITV directly to institutions is rather narrowly circumscribed. In brief, there must be a very large number of schools (generally more than several hundred), which are:

- not currently served by PTV or cable television.
- willing and able to agree upon common broadcast schedules.
- willing and able to cover the very large initial capital costs as well as guarantee their participation in the program for 5 to 10 years.
- willing to commit their institutions to a fairly intensive use of ITV (or at least payment for such service) for a 5 to 10 year period.
- capable of organizing themselves (or being organized) financially and otherwise even though this would frequently involve inter-state consortiums.

These appear to be rather formidable barriers to the development of systems which involve the transmission of ITV directly from satellites to schools. There are possible exceptions such as Alaska, but given current cost structures the exceptions appear to be quite rare. Therefore, the major prospective use of satellites systems in the delivery of ITV to educational institutions seems limited by cost considerations to a point where they are only feasible if used in combination with other systems. Specifically, satellite systems can be seen in the role of distributing programming to PTV, cable, ITFS, and copying-and-mailing systems so that they can then redistribute or rebroadcast the programming to participating institutions. And even then, satellites must compete with a copying-and-mailing system for this kind of service.

We have singled out one particular form of hybrid for special discussion. We do so because a number of recent developments suggest that it may have some major implications for providing educational institutions with ITV. Moreover, it suggests the sort of ingenuity which local educational leaders may have to exercise in order to discover and realize the best way of delivering ITV to their particular schools.

We noted earlier that PTV stations may become increasingly reluctant to provide schools with the use of their facilities for daytime broadcasting of ITV. This can be attributed to a number of factors, one of which has considerable potential implications for ITV availability. A satellite network is currently being established which will interconnect almost all of the public broadcast stations in the nation. Funding sources have been secured by the Corporation for Public Broadcasting, construction contracts have been let, and long term agreements with Western Union have been obtained by which three Westar transponders will be leased on a permanent basis with an option for a fourth. The major uplink will come from the Washington area, with auxiliary uplinks in at least three other cities. The Corporation for Public Broadcasting has argued that over the long run the move to the satellite will allow for cheaper distribution of program material than is presently

possible through microwave links. But in addition the satellite system will make possible the simultaneous distribution of multiple television (and radio) signals.*

This raises a very interesting set of issues and possibilities. Most PBS stations have only one transmitter on the air, typically on a UHF channel. Clearly, the proposed satellite distribution system will create the technical means for distributing a greater number of hours of programming than can be put on the air on a single channel. Whatever the source of programming--a serious problem, but not one that is directly germane to the present line of inquiry--there will undoubtedly be some mix of instructional television and adult programming coming from the satellite to local PBS stations. There the programs from Westar may be expected to meet one of the following outcomes: some programs will be ignored, some directly broadcast, some directly routed to another medium, some taped for subsequent broadcast via the station's own VHF or UHF facility, and some taped for subsequent use in another medium. 'Another medium' is a deliberately general expression which may include any or all of the following: instructional television fixed service, cable television, or a copying-and-mailing system. Each of these 'other' media will serve as an intermediary distribution system for the PBS station to schools (as well as to other users, especially in the case of CATV).

It will be noted that this casts the local PBS station in a conduit role, for in addition to playing a part in delivering ITV via its over-the-air transmitting facility, it also could provide program sources for intermediate ITV delivery systems within the community, including cable, ITFS, or copying-and-mailing.

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*See "Telecommunication Reports" of August 16, 1976, for an explanation of the financial arrangements for this enterprise. See also "A Public Broadcasting Satellite Interconnection System" by John Ball of PBS.

This may accurately depict a major means of ITV delivery within the next five years if several important conditions are met. First, we suppose that as an essential part of their service to communities, PBS stations will be mandated to play an important role in the delivery of instructional television to school classrooms. We believe this is an important proviso because for a variety of reasons--most having to do with funding--many PBS station managers would prefer to use their valuable over-the-air UHF (or VHF) channels for broadcasting programs that have wide audience appeal. There are thus real and powerful pressures to minimize ITV hours vis-a-vis other broadcast hours, and a richer source of good quality mass audience-targeted programming will cause these pressures to mount. It follows that unless ITV delivery is mandated, it may suffer. On the other hand, if ITV continues to be mandated and programming is available from Westar, PBS stations may be expected to look to means other than their over-the-air channels for ITV distribution. Thus, our second important supposition is that such other means will be both legal and feasible.

The legal issues revolve around the interface between the non-profit public interest sector (public broadcasting and public schools) and private enterprise in the shape of a cable television franchise primarily designed to provide home entertainment for a fee. The regulatory structure presently affecting cable television expressly forbids cable operators from receiving program material via a hard wired electronic medium (cable or microwave) from a PBS station.* There are no similar legal structures which would seem to limit the mailing of tapes (to CATV headends or directly to schools) from PBS stations, or the linking of ITV with ITFS facilities. (See our case study on the Berks County, Pennsylvania ITV system for an operating example of an analogous arrangement.)

Nonetheless, it appears important to examine carefully the legal restrictions regarding hardwired interconnections between PBS stations and CATV front ends, for the public interest may be better served by allowing--indeed, encouraging--such interconnections.

*See Educational Broadcast Facilities Acts.

There are three kinds of "feasibility" criteria which hybrids of the sort considered here must meet if they are to become functional: technical, organizational, and economic. Technical problems will likely be the most easily overcome. Perhaps the most severe technical problem is interference at the satellite receiver terminal, but engineers have already completed preliminary site studies which will be used to determine the optimum solutions. Managing the interfaces between cable, ITFS, and cassette systems has become, from the technical point of view, largely routine. Organizational feasibility may well be more difficult to achieve. The efforts of a variety of organizations must be coordinated including the sources of programs, the local PBS station, school media people, the school board itself, and (in the case of a cable intermediary) cable operators and city councilors. A host of problems may arise in such a massive coordination, but if a few pilot systems are found to be practical, the way will be easier for those who follow. Of course, economic feasibility will fundamentally determine the shape of any ITV system, but as discussed above, the particular implementation which evolves will most likely be the one which costs the least at the local (school district) level. When all costs are taken into account, the kind of hybrid system described here may or may not be the most cost-effective mode of delivering the same instructional services.

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NON-COST CONSIDERATIONS

Of necessity, the cost analysis is largely based upon the assumption that the different modes of delivering ITV render identical service to users, and that they vary only with respect to how they manage to get the audio and video signals to classrooms. For the cost analysis, the mode of delivery, therefore, is seen as a "technical" question best left to engineers with the only matter of interest to educators being the discovery of the least cost method. However, these delivery systems in fact possess differences which can have major implications for educators.

As noted earlier, the ITV delivery systems vary with respect to the following factors:

- Scheduling flexibility. The systems differ according to the degree to which individual teachers can arrange the ITV presentations to fit the particular time schedules and instructional sequences of of their classes.
- Responsiveness. The systems vary in their ability to be responsive to the needs and requirements of teachers for different kinds of programs. This has to do with the variety of programming which each system can make available.
- Two-way communication capabilities. Some systems (such as the satellite and cable systems) can have two-way communication capabilities built into them as an integral part of their operation, while others (such as the mailing of videotapes) require such ancillary facilities as the telephone in order to duplicate this service.
- Administrative structures. The organizational requirements and implications of these alternative delivery systems are quite different. A satellite system, for example, tends to require a fairly high degree of centralized decision-making or consensus regarding which programs will be aired and when they will be aired, while a system of mailing videotapes to schools can be more subject to decentralized, local control.
- International restrictions on use. Aside from the cost differences, the systems may vary in their basic availability since several systems are subject to external control over their use for educational purposes. Specifically, the forthcoming (1977) meeting of the World Administrative Radio Conference (WARC), the international group which allocates spectrum space for different uses and users, may make decisions which will effectively prevent telecommunications satellites from being used as a regular mode of ITV distribution.

Copyright restrictions. Copyright and royalty requirements may be different for the various ITV delivery systems. The major distinction here is between those systems which are viewed as "open" in that it is ostensibly difficult to delineate or control the viewers of the programs (such as PTV broadcasts which are available to anyone with a television set), as opposed to those systems which are considered "closed" such as the mailing of video cassettes to specific users.

The purpose of this section is to explain briefly how these factors vary from system to system and to provide a brief assessment of their impact and consequences for educators.

A) Flexibility with Respect to Time.

Previous studies have indicated that teachers attach considerable importance to being able to control when ITV programs are to be presented to their classes. In many cases teachers have spurned the use of ITV because it was not available when they wanted it. This concerns not only when in the day, but also on what day or days, the ITV is available. In other cases there have been class scheduling problems relating to such mechanical matters as some schools having classes begin "on the hour" while other schools have their classes begin at other times. It is not always easy to get schools to change their class scheduling to conform to ITV schedules, especially if the ITV only involves a limited number of classes in each school.

Obviously, some of the ITV delivery modes are more flexible with respect to scheduling than others.

Satellite systems which broadcast directly to schools are perhaps the most limited in this regard for two reasons. First, they must broadcast at certain times, and the timing is sure to be undesirable for some schools and some teachers. Second, in order to be economically competitive, a system of delivering ITV by satellites directly to schools must involve an extremely large number of schools. This means that the systems will be unable to

accommodate or respond to the scheduling needs of very many schools or teachers.

A satellite broadcast system can partially compensate for this deficiency in two ways. First, the schools can use videotape machines to record programs broadcast by the satellite, and teachers can then use the videotapes or video cassettes when they want. However, this involves added costs for videotape recorders and personnel in each school. Another problem with this is that in order to be economically competitive with other delivery modes, even a large satellite system must be used quite intensively--generally no less than six to eight hours per day. If much of this broadcasting has to be recorded by each of the school's, then the extra costs for in-school equipment and personnel become very large. There may also be copyright problems which will be discussed below. Second, specific programs can be broadcast two or more times in the course of a day, week, or month. This makes the program more available, thus increasing scheduling flexibility, but increases broadcast time and therefore transmission costs. Third, unlike most PTV stations, satellites are capable of using several channels simultaneously. This can extend their ability to provide "repeats" of ITV programming at different times.

ITFS is much like the satellite system with respect to scheduling flexibility. Programming is generally a broadcast medium to a large number of institutions, which leads to some inflexibility, although not as much as with satellites. There are ways to at least partially offset this disadvantage. Receiving institutions can be equipped with videotape machines for recording programming for later use. And, as with satellites, ITFS has the capability of delivering multiple channels which allows for repeated transmission of specific programs several times in the course of a day or week. In fact, none of the ITFS operations with which we are familiar fully utilize their channel capacity, which means that all of them could provide more "repeats" than they now do.

Public television has limitations similar to satellites and ITFS except

that the coverage area for PTV (unless supplemented by repeater stations) generally involves a smaller number of schools. The restriction on scale means that PTV delivery will generally permit a greater degree of accommodation of the broadcast schedule to the needs of participating institutions. Also, as with any other system, the receiving institutions can be equipped with videotape machines which allow them to record ITV and replay it at their convenience (within copyright limitations). On the other hand, PTV stations usually possess only one channel, giving them much less flexibility than a multi-channeled system.

Cable television is almost identical to PTV in terms of scheduling flexibility if only one channel is available. However, if multiple channels are provided then cable delivery of ITV can become extremely flexible since it combines a fairly small coverage area with a powerful capacity for "repeat" transmission.

Mailing of videocassettes is the most flexible delivery system. Participating institutions receive cassettes or tapes which they can use at their convenience.

B) Responsiveness to Different Needs of Different Classrooms

It seems quite clear the teachers will have different perceptions of the kinds of ITV programming that will most benefit their classes. Frequently, schools and school district administrators, and even students will want to contribute to decisions about programming. The question then arises: How responsive can these ITV distribution systems be to the variety of different classroom needs? The system which can provide the greatest choice and variety in its programming may be judged as the superior system overall on the strength of this aspect alone.

A comparison of the alternative delivery systems with respect to variety of programming very closely parallels the preceding discussion of scheduling flexibility. The mailing of videocassettes directly to schools obviously

permits the highest degree of choice and variety: each institution or class can get what it requests. Concerning the other four delivery modes there is, again, an interplay between two main considerations:

- The number and kinds of institutions or classes in the coverage area,

  and

- The number of channel-hours (the number of channels times the number of hours the channels are available) which the system utilizes.

Essentially, the smaller the number of institutions or classes involved in the system, the greater will be the ability of each institution or classroom to determine what particular programming will be transmitted. At the same time, a larger system can use its multiple channel-hours to increase the variety of programming made available. In the case of both large and small systems there may be a trade-off between using the available channel-hours to increase scheduling flexibility via repeat broadcasts or using it to increase the menu of available programs. Such a trade-off, of course, will not exist if there is unused channel capacity. The case studies we conducted suggest that ITV systems are often not used to full capacity.

Apart from mailing videocassettes, multi-channel cable transmission--where available--appears to have very considerable advantages over PTV, ITFS and satellite delivery. Satellites and ITFS are, again, similar in that they have a capabiltiy for multiple channels, with ITFS having the advantage of smaller coverage areas.

C) Two-Way Communications

One of the claims made in support of the use of telecommunications satellites is that they not only possess a capability for delivering audio and video signals to places of instruction, but also can transmit audio

signals from places of instruction back to some central studio. After investigating this potential capability we have come to the following conclusions:

- Except for Alaska, which lacks a telecommunications infrastructure, a two-way or "interactive" capability can be developed for any of the other ITV delivery systems by using teletype, microwave, radio, or telephone. Furthermore, these systems are generally less expensive than providing two-way communication by means of the satellite. The underlying logic here is quite simple. Satellite delivery systems must involve a large number of students, or else they will cost too much. If they involve a large number of students then each participating institution will be limited to a fairly small number of communications with the central studio each year. By contrast, the cost of telephone calls is very low.

- Two-way communication is generally more educationally useful when there is a relatively small number of participants interacting. However, in order to be competitive in terms of costs, a satellite system must have a <u>very</u> large number of participants. Thus an interactive or two-way capability may be a more viable adjunct to an ITFS, PTV or cable system than to a satellite system.

- It appears that the best prospect for satellite use of the two-way audio capability is some form of a "time-sharing" mode. This could involve, for instance, computer assisted instruction conducted by satellite. Such use seems advantageous because it allows each participant to use the system rather intensively thereby justifying the capital cost of the two-way equipment.

Aside from the issue of two-way communication capabilities, proponents of satellite-based systems point out that such systems are usually the best for distributing live programming of any sort. While the systems do vary with respect to their ability to provide line coverage of events, this aspect of system performance is probably trivial (with a few exceptions) from an educational perspective.

D. Organizational and Administrative Considerations

The alternative modes of ITV delivery carry with them very different ramifications for the ways in which they are organized and administered. The major concerns here fall into two categories:

- Level of decision-making and local control.
- Pre-conditions for initiating a large-scale ITV system, especially one which has large "start-up" or capital costs.

The level of decision-making is an extremely important issue for it has to do with the extent to which teachers, students, schools, and local communities can control the nature and operation of the ITV system which has been constructed to serve them. We are dealing here with a question of size. In order to be economically viable, satellite systems must be quite large, perhaps including several or more states. The other systems can also involve a large number of users although this is not necessary.

As was emphasized in the earlier discussion of scheduling flexibility and programming diversity, the larger the number of participants in any particular system, the less voice each has in determining what is to be transmitted and when it is to be transmitted. Even if, for instance, the multiple channels available on satellites or ITFS systems were such as to provide the same ratio of "channel hours to participating institutions" as a geographically more confined one, this does not necessarily mean that the two systems would be comparable in terms of local control over operations. The larger system will have, almost by necessity, a more complex multi-tiered hierarchy for decision making.

The second area of organizational and administrative issues concerns the problems and preconditions for intitiating ITV delivery systems. Some systems are much more complex and difficult to establish than others. We have already emphasized the fact that some ITV delivery modes--especially ITFS and satellite--require a much greater original capital investment than others. And we noted that these large capital costs raise two major difficulties: securing funds

to finance these "front-loaded" costs and making decisions to "go" with a particular ITV system for a 10 to 15 year period. Unfortunately, this understates the nature and extent of the obstacles confronting the creation of such a system, for it suggests only the problems that would be confronted by individual schools or school districts. The development of a geographically extensive ITV system would in reality involve a compounding of these problems since there would be a large number of schools, school districts, or states making their individual decisions and choices about such a system; some way would have to be found to orchestrate these decisions. The following sorts of issues might be anticipated:

- How will decisions be made about who pays how much for what services?
- Will participating institutions have to sign, for example, ten-year agreements guaranteeing that they will participate in the system? If institutions drop out, costs are increased for those institutions still participating.
- What sorts of bargaining processes will be involved in getting schools or school districts to participate in such a system? What sorts of guarantees will the prospective participants demand?

E) International Restrictions on Use

There is a basic difference between satellite-based and other systems for ITV delivery in that the future availability of satellite-based systems is open to question. The scope of possible educational satellite services will be determined by international agreements regarding the size and function of satellites, their locations in the geostationary orbit, and the allocation of spectrum space.

The United States is a member of the International Telecommunications Union (ITU) which is the regulatory agency responsible for establishing international rules for radio, television, and frequency allocations. In 1977, the ITU will convene the World Administrative Radio Conference on Broadcasting Satellite Service (1977 WARC). The 1977 WARC will set world-wide rules for

satellite communications in the $12GH_z$ band. The main topics to be addressed concern the division of the equatorial geostationary orbit into discrete "slots" for every country and the regulation of the type of satellite service (fixed or broadcast) that will be allowed to use those slots.

The distinction between fixed and broadcast service satellites is an important one and impacts on the ultimate nature of satellite-based delivery systems. The term "fixed service" has its origins in describing point-to-point terrestrial microwave systems. For the case in point, it also refers to satellites whose effective radiated power is so low that only a high gain, large aperture receiving antenna can gather enough power to achieve good quality reception. Hence, fixed service satellites entail expensive receiver sites. In order to be cost effective, such sites typically redistribute received signals to a large group f users. "Broadcast servic." is a term used to signal the operation which . result from utilizing a satellite whose effective radiated power is sufficiently high that small receiving antennas can gather enough power to achieve adequate reception. Broadcast service satellites allow inexpensive receiver sites, which in turn makes it economically feasible to service only a few users per site.

While the distinction between fixed and broadcast satellites seems clear in principle, in practice the differences may not be so great. The satellite used in the ESCD, the experimental ATS-6, is what might be called a medium-powered satellite that falls between this division between "direct broadcast" and "fixed service." Medium-powered satellites provide "fixed broadcast" service to modestly priced receiving terminals (called "community receivers") because they redistribute the satellite signals to small groups of local users.

There are a number of issues surrounding the relative desirability of adopting the traditional versions of either the fixed service or broadcast satellites. Most immediately apparent are differences in the size and configuration of the cost of either system. The large receiving terminals needed for fixed service satellites are too expensive to be afforded by schools or school districts. On the other hand, the receiving terminals for direct broadcast satellites are inexpensive and can be afforded by most users, but the high-powered satellites are very expensive and would only be feasible through the cooperative aggregation of an extremely large number of educational

organizations. To further complicate matters, direct broadcast satellites have an uncertain political destiny. First, there are international complications in their potential use for propaganda broadcasting direct to individual homes. Second, the fact that broadcast satellites may consume large amounts of scarce orbital and spectrum resources is greeted unenthusiastically by commercial fixed service users. Finally, direct broadcasting would compete with terrestrial broadcasting industries and arguably violate the FCC's "local control" doctrine.

After considering these and other issues, it would seem that a compromise, medium-powered "fixed-broadcast" satellite might be both the most affordable and politically realistic hope for educational users in the future.

It now appears that the United States may urge an "evolutionary planning" approach at the 1977 WARC. The U.S. position is designed to promote maximum flexibility in the development of new satellite systems while, at the same time, protecting the long range interests of smaller nations and permitting the development of new services, including satellite broadcasting directly to community receivers and--in the more distant future--to homes. The specific resolutions of the 1977 WARC and a related WARC meeting in 1979 should have wide-ranging consequences for the configuration and ultimate feasibility of satellite-based systems for ITV delivery.

F) Copyright Restrictions

Copyright and royalty arrangements will have an impact on the relative cost and usefulness of the different systems for ITV delivery. During October 1976, Congress passed and sent to the White House a bill containing the first complete revision of the copyright law since 1909. We decided to conduct a brief examination of the possible impacts of the new copyright law on the use of satellites and other technologies for delivering educational services. Of particular interest was the question of whether the new law would tend to favor or preclude expansion of certain types or configurations of delivery systems. After reviewing the history and a variety of documents pertaining to the development of the new copyright law, the most significant general finding at this point is almost a non-finding; no one is certain about the possible impacts of the new law, either in general, or as concerns specific delivery systems. In its review of the situation, however, the EPRC has identified four critical issues relevant to the nature of ITV delivery.

1) To what extent will royalty payments required under the compulsory licensing provisions of the law effect the ability or proclivity of ITV delivery systems to distribute quality instructional programming which includes materials covered by the copyright law?

Considerable discussion of the impact of royalty payments for public broadcasting and cable occurred during hearings on the copyright law. Eventually, a compulsory licensing provision was written into the law. Under compulsory licensing, lump sums will be paid to a central fund and distributed to those who claim some copyright usage. What is not yet clear, however, is the impact of the royalty arrangements spelled out under that provision. Cable television systems, for example, will have to pay a lump sum fee for broadcasting television programs. The actual size of that fee is determined by the size of the cable system. If the payment of these royalty fees becomes a financial strain on the resources of the cable operators, they will probably curtail some of their services with a resultant negative impact on the use of these cable systems to deliver instructional programs.

2) To what extent will required royalty payments discourage producers from utilizing copyrighted materials as part of quality instructional programming?

This issue is closely related to Issue #1 but looks at the problem from the perspective of the producer or author of materials, rather than from the perspective of the delivery systems. If the copyright law impacts negatively on the producer of materials such that materials are no longer developed or developed with inferior quality, then the educational role of any of the delivery systems is affected. One example of the problem concerns the use of music by public broadcasters. Under the new law, restrictions are set on the rights of public broadcasters to play musical works without paying royalties. The public broadcasting lobby argued for special considerations and received some attention under the compulsory licensing provision. It is still too early to tell what impact these new regulations will have on the use of music in instructional programming. More generally, it is still too early

to tell what impact any of the new law's requirements will have on the activities of producers and developers of instructional materials.

3) To what extent and in what ways will limitations on non-simultaneous secondary transmissions by cable systems reduce or enhance the likelihood of cable being a major distributor for instructional programming?

The new copyright law states that any non-simultaneous transmission by a cable system may be subject to law suit as an act of infringement unless: a) the program on videotape is transmitted no more than one time to the cable's subscribers; b) the program is transmitted without deletion or editing; c) the owner of the cable system prevents duplication of the videotape by his company or others; d) each quarter the owner of the cable company submits an affidavit attesting to the steps taken to prevent unauthorized duplication of copyrighted programs. On the surface, it would appear that the new law may have some impact on cable as a means of delivering educational services, particularly to local schools. Given that it would be illegal for a school to tape a program from cable transmission and that the program could only be transmitted once, a major flexibility problem is posed for the incorporation of the programs into the instructional schedules of each school and class. After the law has been operational for some time, this problem may be worked out. In any event, cable systems may still represent an effective mode of delivering services to adults and to children outside of an institutional context.

4) To what extent will time and number of copy limitations impact on the development and use of ITFS, or a system of mailing videotapes from location to location?

This issue concerns the provision in the new law known as "ephemeral recordings." Under the terms of this provision, a local district could make one copy of a copyrighted program, and could use that one copy for transmission purposes for a period of six months, at which time the copy is to be destroyed. In respect to motion pictures and audiovisual materials, the law states that 30 copies may be made and used for a period of 7 years. Initially it does not

appear that these limitations will have a dramatic affect on local school usage. Thirty copies should suffice in most districts for mailing purposes. A seven year time limit may be a problem for some programs, but certainly not very many.

In summary, these four issues outline some of the varying impacts that the new legislation is likely to have on all systems for ITV delivery. It is apparent from the legislation itself that Congress recognizes the imperative to walk a fine line between protecting the rights of ownership for those who produce materials, while maximizing the possibilities for educators to make the best instructional use of the materials without being subject to undue bureaucratic and financial entanglements. In drawing this "fine line" between the producers and educational consumers, the legislation is unavoidably subject to ambiguity and questions of interpretation. Much of the operational meaning of the law will have to be defined by regulations which are presently being written and finally in the courts on a case-by-case basis.

The extent to which the law ultimately affects the nature of each system for ITS delivery will probably depend upon such characteristics as whether the system is open or closed, and whether the system facilitates the flexible use and reuse of the materials at the local level. While these characteristics may improve the educational utility of a delivery system, they also threaten the producer's ability to realize a financial gain from the use of his materials. Since the intent of the law is to create a balance between the material producer's rights and the educational consumer's need for quality educational materials, any delivery system which operates to the advantage of one party over the other will be subject to corrective restrictions that will maintain the balance. Exactly how this balance will look in practice remains to be seen.

It should be noted that the forthcoming regulations and litigation may result in a protracted period of uncertainty in which producers and distributors of ITV programming are extremely cautious and restrictive about making their programming available. If this occurs, then the larger ITV systems may have

some very distinct advantages over smaller ones, since they have a much greater capacity--through pooled resources--to develop their own programming. The smaller ITV systems, however,[3] might be able to compensate by forming consortiums for producing programming.

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THE EDUCATIONAL SATELLITE COMMUNICATIONS DEMONSTRATION

The project which marked the first substantial Federal investment in finding educational applications for communications satellites (and whose evaluation provided the initial impetus for this study) was the Educational Satellite Communications Demonstration (ESCD). It was the educational portion of a series of projects known as the Health-Education Telecommunications Experiment, sponsored jointly by the National Aeronautics and Space Administration (NASA) and the Department of Health, Education and Welfare (DHEW).

The ESCD's operational period covered essentially the summer of 1974 and the 1974-75 school year, using the ATS-6 satellite to broadcast color television to small antennas at rural schools and similar sites. Many sites also had equipment permitting two-way voice communications.

The various regional project sponsors each submitted reports on their activities. These reports contain a great deal of data on project management, the composition of audiences, and participant response to program formats. The final reports are cited in the bibliographic note at the end of this chapter, but in most cases the cited report was accompanied by additional material involving many volumes. Questions pertaining to the availability of particular items should be addressed to NIE.

In its first-year report, the EPRC published a discussion of the ESCD's early history at the Federal level and the accomplishments of two of its three regional projects (in Appalachia and the Rocky Mountains). A description of the third regional project (in Alaska) was contained in the reports of Practical Concepts, Inc. (PCI), the contractor selected by NIE to evaluate that project.

A reviewer of this large amount of literature on the ESCD would recognize a difference in perspective common to many studies of social action demonstrations. The reports, written by the project sponsors,

were written from the perspective of people with the difficult job of making a demonstration work under trying circumstances and harrowing time pressures. Although an indispensible source of data on project operations and occasionally self-critical on matters of detail, these reports do not raise questions about the usefulness or significance of the projects themselves. It would have been remarkable if they had done so.

The EPRC report took a different tack. It attempted to assess (in the words of its contract) "the lessons to be learned from the satellite demonstration." It agreed with project sponsors that the demonstrations (a) were launched under difficult time constraints, (b) were managed with competence and dedication, and (c) produced television programs and other products which were generally well-received by both institutional and individual users. The EPRC report tended to disagree with the project sponsors about what could be legitimately inferred from the whole enterprise, especially on the potential contribution of communications satellites to American education.

The purpose of this chapter is to summarize EPRC's conclusions regardin what could be learned from the ESCD on a demonstration-by-demonstration basis and as a whole. The passages on Alaska represent an attempt to summarize the most important conclusions of PCI's work on the same topic-- the lessons of the ESCD. For the sake of brevity, only the main lines of the original analyses are presented here. For a fuller discussion, the reader is referred to the earlier EPRC and PCI reports and, for more details and a different perspective, to the reports of the regional demonstration sponsors.

Federal Policy Formation

In its history of the development of the ESCD at the Federal level, the EPRC attempted to analyze the ideological, bureaucratic and political factors that gave the ESCD its final form.

To greatly oversimplify a complex story, the EPRC concluded that the driving force behind the ESCD was a group of agencies and individuals who very much wanted to see a communications satellite network created to serve the public interest, but who were willing to leave to others the task of specifying exactly what those public interests were. The other agencies and individuals who ultimately inherited the project, with all its gathered momentum, were forced to create a rationale for a system which had already taken shape, and they were never entirely successful in doing so. As a member of the staff of the Office of Education put it:

> ...Was it to be a demonstration of satellite-delivered services, <u>or</u> a national video production project--<u>or both</u>? There never was any logic "before the fact" underlying a decision that it should be the two together.

<u>Appalachia</u>

The Appalachian Educational Satellite Project (AESP) was planned and carried out by the Appalachian Regional Commission (ARC), a multi-state, quasi-governmental body created in 1965 under the Appalachian Regional Development Act. The AESP was something of a departure from the usual role of ARC, which previously had tended to stimulate and coordinate developmental programs but not to operate them.

The AESP consisted of several program series in the teaching of reading at the elementary school level and of career education (various levels, K-12). The audiences for these programs consisted of public school teachers meeting for evening classes at 15 sites across the Appalachian region.

Five of the sites were equipped with a VHF console which permitted voice questions to the AESP central studios at the University of Kentucky in Lexington, and the other ten with teletype equipment permitting written questions. Each receiving site had a staff person present, but he or she was not selected for expertise in the subject matter of the broadcasts.

A variety of formats were used for the broadcast portions of classes, ranging from videotaped materials prepared by the AESP to lectures and panels featuring experts in the topics covered by a series. All questions were received off-the-air before being given to on-camera panelists. Participating teachers received free printed materials and could arrange to receive free college credits.

In general the EPRC concluded that the AESP was a success in terms of the stated goals of its sponsor, but that this success had less to do with any technical characteristics of the satellite system than with the skill with which its sponsors developed materials and organized themselves for promoting the programs.

The technological goal of the AESP was to demonstrate that the satellite-based system could be used to transmit television broadcasts to remote communities (plus transmit back questions and comments from them). In that respect the system functioned extremely well.

The educational goal was to develop, distribute and evaluate teacher in-service courses for remote communities, and this, of course, was done. The AESP evaluations stressed the teachers' acceptance of the materials and their acceptance of the delivery system. The EPRC comment was that participating teacher attitudes were likely to have been influenced by "program publicity, staff enthusiasm, and the facts that the course was free, novel, and tinged with a science-fiction quality."

With regard to the glamorous "live interaction" (two-way voice communication) aspects of the programs, EPRC commented that there was not very much of it relative to more conventional non-interactive program formats and that screening questions off-camera made spontaneity difficult. The feasibility of using telecommunications to run a "seminar" as the word is normally used in college teaching was not demonstrated, but the difficulties in attempting to do so were.

While praising the competence of the AESP project staff, the EPRC maintained that no logical connection had been established between the technological and the educational objectives of the project. Our first-year report on the AESP concluded that "...the major achievements of the AESP can be largely attributed to the characteristics of the program that were not satellite-dependent, even though the glamour of the ATS-6 satellite may have acted as an important catalyst." It further noted that teacher acceptance of specific programs appeared to correlate with conventional measures of courseware quality and that these, in turn, correlated with how much time had been available to prepare materials and how much money had been spent on them.

The Rocky Mountain Region

The largest component of the ESCD served an eight-state area in the Rockies. It was called the Satellite Technology Demonstration (STD) and was conducted by the Federation of Rocky Mountain States (FRMS), a non-profit organization founded in 1966 to promote regional development.

From September 1974 through May 1975, the STD broadcast color television programs to 56 rural junior high schools and 12 public television station reception areas. Of the 56 school sites, 24 were equipped with "interactive" terminals permitting two-way voice communication with the Denver studio and through it with each other.

The STD broadcast in four formats: 1) "Time Out," a sixteen-week series of daily programs on career development for junior high school students; 2) "Careers and the Classroom" a bi-weekly, year-long in-service series on career education for public school teachers; 3) "Footprints," a series of ten topical evening programs for general public viewing, and 4) a "Materials Distribution Service" (MDS), transmitting catalog-listed films and tapes for videotaping and later classroom use by participating schools.

As was the case with the AESP, the EPRC judged the STD to have met its objectives with considerable success but not to have established a connection between its educational goals and the satellite-based delivery system.

The MDS, which provided free films and videotapes which could be replayed at a time of a teacher's own choosing, was tremendously popular at all schools where the service was available. The EPRC judged it to be the most promising model for replication of any demonstrated in the ESCD.

In the case of "Time Out," the STD data documenting its popularity with teachers and students was persuasive, but the STD's post-project interviews with teachers and administrators indicated that most planned to use considerably shortened versions of the series in post-demonstration years. The EPRC report commented that "Time Out" appeared to be a case of "too much of a good thing."

"Careers" received mixed ratings by participating teachers, who apparently based their impressions on the relevance and quality of individual broadcasts rather than the fact that the broadcasts arrived by satellite.

The evening series, "Footprints," failed to attract more than a handful of viewers at most sites. The median per-site attendance for the year was two. The EPRC felt this had little to do with the quality of the programs, which were judged to be generally good. The problem was rather the simple unwillingness of people to drive miles at night to watch television from a seat in a junior high school classroom. Our report concluded that "Footprints" provided additional evidence that almost anything (organization, environment, program content, incentives, etc.) is more important to viewers than the technology underlying a particular telecommunications system.

Evaluating the impact of two-way voice communication ("live interaction") was more difficult because of early sound difficulties caused from VHF transmission over the ATS-3, an older satellite than the ATS-6. The EPRC report concluded that a more fundamental problem than technical difficulties was that at best only a few participants could hope to talk during any given program. With a very large audience, only a few could talk more than once or twice a semester. Basically, the economic attractiveness of satellite-based systems lies in their ability to reach mass audiences, but meaningful participation in a discussion requires small groups. We judged these two desirable outcomes to be incompatible with each other.

The STD management and engineering staff deserved much of the credit for the technical success of the demonstration. (It operated an uplink facility near Denver which served the other two regions as well as the Rockies.) Most of the STD's educational material was popular with users. Because the STD did vary broadcast formats and tried to reach several different audiences, it was possible to learn much more from the project as a whole than was true in Appalachia, even though the STD had its failures along with its successes.

The EPRC's principal disagreement with the conclusions of the STD's final report was that the STD staff felt that the project had demonstrated a demand for satellite-based telecommunications services among Rocky Mountain schools and other potential users. The EPRC felt that what had been demonstrated was a demand for free telecommunications services if provided under conditions that caused the least possible disruption of existing teaching and administrative practices.

Alaska

The ESCD/Alaska was conducted by the Alaska Governor's Office of Telecommunications (GOT). It reached 15 small and remote Alaskan villages with programs in spoken English for children ages 5-7 (named BOLD, for

"Basic Oral Language Development") and health education for children aged 8-10 (named "Right On"). An adult program on public affairs was known as the "Alaska Native Magazine," and there were some teacher training activities. All programs involved varying amounts of two-way voice communications.

The evaluation contractor, Practical Concepts, Inc. (PCI), concluded that the ESCD/Alaska had very significant impacts on Alaskan affairs and institutions. The most important of these was that it "contributed to Alaska's ability to 'standup' to RDC Alascom/Globecom (the leading commercial developer) and negotiate for a suitable commercial telecommunications system for the state." Related effects were stimulating the growth of the GOT, developing programs especially aimed at rural villages, and contributing to an apparent willingness on the part of the State to pay a greater share of the costs of future telecommunications systems.

In regard to NIE's mission to stimulate understanding of educational issues, PCI concluded that "ESCD's payoff in terms of educational experimentation was trivial when considered in terms of total cost." It reserved judgment on future NIE involvement in Alaskan telecommunications projects, but said emphatically that NIE should have nothing more to do with educational demonstrations using the ATS-6 "if the use of the ATS-6 is the driving function for demonstration design."

PCI urges that high priority be given to using videotaped materials and voice telecommunications to address the "high school problem" (the uprooting of Alaskan rural youths from their native villages because of the non-existence or serious inferiority of village secondary schools). In its January 1976 "Executive Summary and Supplement" volume, PCI expanded its list of possible projects but continued to insist that the decision to use or not to use a satellite-based system for program delivery was a technical and economic question, not an educational one. The report said:

> Satellite television cannot be justified on the basis of real time viewing, live video programming, or live interaction incorporated with video programming. The remaining function performed by <u>satellite television</u> is access to programming.

To a greater extent than EPRC's studies of the Appalachian and Rocky Mountain projects, the PCI report made specific recommendations concerning the procedures future Alaskan demonstrations should follow. Its reports placed special emphasis on measures to ensure Native Alaskan participation in all [illegible] of planning and operations.

Retrospective

More than a year has passed since the last broadcast of the ESCD, and in that time the ATS-6 satellite has gone to India and back. Standing at a little distance in time from the ESCD (and remembering that a year is not very much time), what can be said about it as a whole?

First, from the outset it was clear that it was more promotional than educational. Its Federal and regional sponsors sometimes referred to it as an "experiment" and sometimes as a "demonstration," but only the latter word was used with even approximate accuracy. There was never anything experimental about it. Its technology was amazing but already well-tested, and its program designs were well-executed but unencumbered by anything resembling experimental controls.

Second, there may have been nothing wrong with that. There is an excellent case to be made for the Federal government demonstrating the benefits of new technologies from contour plowing to solar energy. If American schools in the 21st century make extensive use of television and voice communications with remote points by satellite, the ESCD will be noted as a pioneering effort, and criticisms of its design will be forgotten or dismissed as the way the nearsighted often see the bold.

There is some luck in these matters. The analysts who advised King Ferdinand and Queen Isabella against financing Columbus knew very well that the world was round and, in fact, had calculated its circumference more accurately than he. He believed that he could reach the Indies; the royal counsellors knew that his small ships could not hold enough provisions for the voyage. What neither knew was that there would be a new continent in the way.

At present, except perhaps for Alaska, the irrelevance of the ESCD to Federal policy seems almost total. That could change overnight, however. The fact that the Federal government spent between $18 million and $34 million on a demonstration of communications satellites in education is important in itself. (Another chapter of the EPRC first-year report explains why the above cost estimate is so vague. Basically, the difference between estimates hinges upon how much of the cost of the ATS-6 and its launch should be charged to its users.) Such expenditures create their own momentum. We would conjecture that if a prior commitment had not been made to move the ATS-6 satellite to India, the political pressure for continuing the ESCD projects would have been irresistable.

In conclusion we wish to re-emphasize that we believe the various regional sponsors of the ESCD did their jobs competently and with dedication. We know for a fact that they worked very hard. They prevailed over unforgiving deadlines, Federal funding delays and policy changes, and the thousand problems that the operating managers must face. It seems a shame that they must also endure the musings of evaluators who can prepare their reports long after the event.

Nevertheless, we emphasize that the regional projects were, for perfectly understandable reasons, oriented almost exclusively toward providing their users with certain kinds of services. They could scarcely have secured the high acceptance they did secure if this had not been so. This service orientation, however, militated against an orientation toward

experimental design. In the absence of any coherent Federal pressure toward experimentation the result was that not much could be learned about the relationship, if any, between the delivery system and educational objectives.

In short, the EPRC first-year assessment concluded that the ESCD was well done, but the official statements as to why were either vague or unconvincing. A year later we still believe the ESCD was a striking example of the pressure exerted by sophisticated technology to find applications simply because it was there.

Like our colleagues at PCI we recommended that future NIE demonstrations involving satellites be designed with emphasis on testing the cost-effectiveness of alternative ways delivery existing materials or, in any circumstance where a system appears to enjoy a technical advantage, on the willingness of users to pay some reasonable share of its costs. More than anything else, what insulated the ESCD from potentially useful criticism during both its formative stages and its operation was that neither its sponsors nor its presumed beneficiaries had to pay for it.

Bibliographic Note

The conclusions of the Educational Policy Research Center, Syracuse Research Corporation, pertaining to the ESCD are contained in The Educational Satellite Communication Demonstration, Annual Report, EPRC, December 1975 (SURC TR 75-652). As noted in the preceding narrative, the report contains separate chapters on the Appalachian and Rocky Mountains projects (but not Alaska) and sections on the ESCD as a whole, including its early history and costs.. The management of the Appalachian project took strong exception to the report's comments on the AESP.

The Appalachian Education Satellite Project: Final Report, was submitted in the fall of 1975 by the Appalachian Regional Commission and the University of Kentucky. There is a separately bound executive summary.

Between early 1973 and early 1976, the University of Kentucky staff completed a "Technical Report Series" in 12 volumes. Nine of the volumes deal with evaluation, meaning primarily the reaction of participating teachers to the AESP materials and their performance on tests. One volume is an early overview of the AESP; another deals with technical performance of the equipment; and another discusses ways of projecting costs.

The Final Report, Satellite Technology Demonstration was also submitted to NIE in the fall of 1975. It is well-organized and contains more detail on the operations and outcomes of the STD than the other reports contain on the projects they cover. There is a separately bound executive summary. In addition, the Federation of Rocky Mountain States (FRMS) submitted 26 brief technical reports covering a wide range of subjects from equipment performance to evaluation methodology. Written by members of the STD staff who were most closely involved with specific operating problems, many of the reports should be very useful to researchers (and presumably future project managers). The STD also submitted to NIE case studies of the impact of the project on three local school sites.

The first annual reports from Practical Concepts, Inc. are contained in two volumes submitted in November 1975: Implications of the Alaska Education Satellite Communications Demonstration for Telecommunications and Education Policymakers. Volume I is subtitled Analysis of the Demonstration, and Volume II, Supporting Materials. In January 1976, PCI submitted a third volume subtitled Executive Summary and Supplement. As the title implied, it was a summary of earlier conclusions but contained some new material, especially suggestions for future NIE projects in Alaska.

The Office of Telecommunications, Office of the Governor of the State of Alaska produced a final report entitled ATS-6 Health/Education Telecommunications Experiment; Alaska Education Experiment in two volumes dated September 30, 1975. Volume I contains a description of all aspects of project operation and ends with recommendations pertaining to future

demonstrations. Volume II is an appendix containing copies of pertinent documents and reports from individual reception sites.

Although the ESCD received a considerable amount of journalistic coverage, most of it favorable and a small amount of it hostile, it received very little serious analysis during its operating phases. Most of the material which appeared in educational journals and magazines aimed at a general readership were either descriptive or obviously promotional in nature.

Researchers wishing more details on the availability of materials pertaining to the ESCD are advised to consult notes in the above volumes, especially those issued by EPRC, PCI, and FRMS. Special mention should be made of a study by Bert Cowlan and Dennis Foote completed for the Agency for International Development (AID) during the summer of 1975. It is entitled A Case Study of the ATS-6 Health, Education and Telecommunications Projects.

CASE STUDIES

The EPRC has conducted case studies of nine operating instructional television systems. We did so for several reasons. First, we needed empirical data for the cost analysis, and we quite naturally sought the input of organizations and institutions which have had experience in developing and operating ITV systems. Second, we wanted to assure, to the extent possible, that both our cost and non-cost analyses did not become divorced from reality in their effort to offer generalized conclusions. The case studies provided a real-world test of some of our central assumptions. Finally, we anticipated that we might learn much from the case studies in terms of what could be called "practical experience." This objective was open-ended in that we did not know what we would find, but thought that contact with a store of practical experience might suggest new areas for analysis or important caveats on our conclusions that we would otherwise have missed.

It is the nature of case study methodology to "suggest" not to "prove." Case studies sacrifice the statistical security of large numbers in order to provide a more intensive and in-depth analysis of "what is really going on" in a handful of situations. Accordingly, any conclusions offered here must be considered tentative and exploratory.

Such caveats not withstanding, we were reassured to find that the themes which emerged from the case studies were quite generally supportive of the conclusions drawn from our other analyses. This can not, of course, be considered as an independent confirmation of such results since there were mutual inputs and interactions along the way. But many of the findings concerning such fundamental factors as land contour, geographical density of receiving sites in the coverage area, and size of the total area covered are clearly independent of such criss-crossing influences.

The following is a brief distillation of the major outcomes of the case studies:

.Costs per student contact hour varied enormously across the nine sites--by factors of ten or more. However, the dominant source of variance was the cost of developing new programming material.

.One source of per-site cost differentials was the fact that prices of major equipment have declined considerably as technological improvements and mass production have far outpaced inflation. Hence, systems which have been developed recently tend to be less expensive than their counterparts which were constructed earlier.

.The patterns of ITV applications and user preferences which emerge from these case studies is less predictable than the findings on cost-related issues. Most systems demonstrate an increasing tendency to use videotapes within a school to achieve scheduling flexibility, even if there are multiple broadcasts over whatever electronic delivery system is used. For example, the Hagerstown system--long a model of central control over ITV programming and use--is moving rapidly toward a decentralized system for reasons of educational philosophy as well as convenience.

.A number of ITV systems are not fully utilizing their capacity in terms of potential channel hours. In fact, a number of them are only using about half of the capacity.

.There appears to be a rather surprising lack of information on ITV utilization, including such fundamental data as who watches it and who does not watch it and why.

.Different levels of instruction have very different ITV scheduling requirements. Elementary teachers generally require only moderate flexibility in scheduling. Since one teacher usually has responsibility for teaching all subjects to the same set of students all day long, the teacher can adjust the daily schedule to conform to ITV availability. Furthermore, course coverage is more likely to be standardized across a system, and the main source of variation is simple scheduling.

.By contrast, junior high and high school teachers not only have ordinary timing problems but additional ones which arise from variations in classroom style and emphasis. At these levels teachers generally teach one subject to a number of different classes, making scheduling much more difficult. In addition, instructors frequently have more discretion about whether to use all or part of a series or of a single program.

.Somewhat paradoxically, the college-level classes studied appeared to require least flexibility in scheduling. The main reason, of couse, is that a fixed time for class is simply taken as a given by participants, just as it would be in a college classroom. Participating students are not, of course, going from one class to another all day long in the manner of public school students. Two of the systems discussed, the University of Southern California and Stanford are quite different from all the others in that they use two-way voice communications between students and instructional staff. Both employ an ITFS system to deliver ITV to area business firms whose employers are enrolled as part-time students. The two-way interaction format, of course, dictates a firm schedule for classes. However, we note that some of the participating companies tape classes upon the request of students whose travel schedules preclude attendance on a given day.

.Two of the systems studied, those in Broward County, Florida and the New York Archdiocese, reserve substantial portions of their broadcast capacity for responding to special requests on a call-in basis. User demand to date has been relatively low. The reasons for this are not clear.

.One trend runs somewhat counter to other generalizations about "flexibility." There is a tendency for ITV programming to be dominated by series formats rather than individual programs. Although using a series requires more advance planning than using a single program, the per-hour costs of series are substantially lower than those of "specials," because vendors' handling, advertising and accounting costs are about the same in either case. There appears to be, however, a decided preference toward series which can be broken into shorter units of a few related installments.

We also discovered a large amount of continuing experimentation with different patterns of use. There was a general preference for short programs over long ones but no clear preference for greater or lesser exposure to ITV as distinct from face-to-face instruction. In fact, as teachers acquire more experience in the use of ITV, some distinctions of this sort begin to break down. Many schools would like to move toward situations where a teacher can work directly with some part of a class while the remainder of the class watches instructional television.

Throughout the case studies, we have attempted to suggest some ways of making cross-system comparisons. We hope that readers will find them useful. The systems studied, however, were not constructed to suit the convenience of analysts. Collectively, they provide examples of the importance of the caveats attached to our cost models and tend to confirm what we inferred from the ESCD experience: The range of technological solutions to educational problems is extremely wide, with no single technology emerging as consistently superior to the others.

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CHAPTER TWO

ITV DELIVERY SYSTEMS--ESTIMATING AND COMPARING COSTS

I. INTRODUCTION

This chapter introduces a number of cost related considerations which carry policy implications for ITV delivery systems. The major portions of this chapter present cost models which demonstrate cost estimation techniques in a comparative cost context. The cost estimation model in Section II, sometimes referred to as the "complete cost model" effectively provides a general checklist of costs incurred in constructing and operating an ITV system and provides a sample of how to calculate cost estimates. The comparative cost model of Section III is a reduced and generalized version of the complete model of Section II. The comparative model is used to derive general but tentative conclusions regarding which of the five basic delivery modes studied [high-powered satellite direct broadcast to schools, cablecasting over existing cable systems, Instructional Television Fixed Service (ITFS), PTV broadcasting, and the mailing of videocassettes] have cost advantages under different circumstances.

Some extensions of the basic models of Sections II and III are discussed in Section IV. Flexibility in scheduling and local control of programming are key issues. Other topics in Section IV include hybrid delivery systems, those systems employing more than one of the five basic delivery modes, two-way communications as an additional feature available to most ITV delivery systems, and the pros and cons of using pre-packaged computerized models in cost estimation and analysis.

Section V presents some additional topics. First is a discussion of formal cost modeling which concludes that cost comparisons between systems cannot be made validly unless all the components of the system are optimized and independent of one another. The second selected topic suggests that the existence of sharable costs does not mean that the optimal size of a delivery system must be large, and the third topic examines how the different vantage points of decision makers or educational planners at different levels of government influenc

their calculations of optimal costs. Some summary remarks are contained in Section IV.

As mentioned above, the bulk of this chapter is concerned with cost modeling. Sample cost estimates are produced for each of the five aforementioned delivery modes serving a hypothetical region. The estimates are made by calculating the costs of system components with component cost dependent upon variables such as user requirements, topographical characteristics, the number and distribution of schools, equipment prices and other factors. The five delivery modes have some cost components for which the cost computations are identical. These common cost components are factored out of the comparative cost model. The comparative model helps to generate general implications as to which delivery mode has a cost advantage under certain circumstances such as system size. It should be noted that all the results of Sections II and III are dependent upon the specific assumptions made in produc the cost estimates--change the assumptions and the results can change. For this reason, the cost estimations of Section II are best treated as samples for those who are curious about how to construct cost estimates. Likewise, the results of the comparative analysis can only be held as tentative

While this chapter of this report is concerned with costs, it is recognized that the determining factors in deciding to install and use an ITV delivery system may not (or should not) hinge upon cost considerations alone. Ease of use, familiarity with the medium, teacher acceptance, and the belief or lack of belief of the educational effectiveness of ITV could be paramount concerns. Also, the relevance of the cost issue is limited by whethe or not there is the money to invest in a delivery system. For those systems which require a large organization with many schools and heavy initial investments there are the problems of getting such a large group together and of persuading everyone to commit the initial funds. Some systems like mailed materials and ITFS can be put together incrementally--one or two school districts can begin with a small offering of programming with the possibility of allowing the system to grow by gradually adding users and increasing the

level of service. The most important points are that a delivery system should be designed to fit the needs of the potential user population and that an ITV system should not be installed just because the technology is available.

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II. THE COST ESTIMATION MODEL -- THE COMPLETE MODEL

Cost estimations are calculated using building blocks called cost components. Examples of components include "management" and "programming" (both production and acquisition); both of these components are calculated at a high level of aggregation. On the other hand, some components such as "reception equipment" located at the school could have been included in a more aggregated component such as "broadcast and engineering." This was not done because much cost information related to the peculiarities of the different distribution modes would have been lost by aggregating further. Many such decisions were made which represent trade-offs between aggregation with its inherent loss of information and disaggregation.

Actually, more than one cost model was constructed. The first to be presented is the most complete from the standpoint of including costs which would be likely to be incurred by a delivery system. Other cost models were constructed specifically to facilitate cost comparisons between modes of delivery. The emphasis of this research has been on making such comparisons, and the comparative version involves a subset of the components of the complete model.

The Complete Cost Model

The cost model (or models if one for each delivery mode is counted separately) is composed of additive cost components. The components have their origins in program budgeting; that is, each component is related to an activity required for the operation of a delivery system. For any delivery system total cost can be estimated by summing the appropriate components. This summation process is not always straightforward if hybrid systems are involved; however, considerable care is taken to keep the estimation procedure similar to simple addition.

For the sake of simplicity, cost components were maintained with considerable conformity across the different five basic delivery modes. This is demonstrated in a matrix presentation of the components by mode of delivery (Table 1).

The columns represent the type of delivery mode while the general class of costs or cost components are designated by rows. An X in the appropriate column signifies that the given cost components could be nonzero for the delivery mode in question. Note that most components are nonzero.

A numerical example helps in explaining the cost model. In this case, the complete model is used to estimate the cost of delivering a predetermined level of instructional services to all the public schools in a region. First, the cost components are introduced, then calculations are performed component-by-component for each system.

TABLE 1

COST MODEL COMPONENTS BY SYSTEM

Component	Satellite	ITFS	Mailed Materials	PTV Broadcasting	Cable-casting
Satellite Rental	X	-	-	-	-
Uplink Facility and Studio	X	-	-	-	-
ITFS Transmission	-	X	-	-	-
ITFS Broadcast Studio	-	X	-	-	-
Mailing and Dubbing	-	-	X	-	-
PTV Broadcast Fee	-	-	-	X	-
Cable "Rental"	-	-	-	-	X
Interconnection	-	X	-	-	X
System Management	X	X	X	X	X
Programming	X	X	X	X	X
Display Equipment	X	X	X	X	X
Videocassette Machines	X	X	X	X	X
Videocassettes	X	X	X	X	X
School Wiring	X	X	X	X	X
School Headend	X	X	X	X	X
School Reception	X	X	X	X	X

An X indicates a probable non-zero value for the component in the given system.

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We start with a hypothetical region which approximates the size and population of a state like Virginia with some 1,400 schools with 1,200,000 students in a land area of approximately 40,000 square miles. Schools are assumed to have an average of 20 rooms (though this can be treated as an average). We can assume that the state has decided to provide instructional programming to all its public schools by using one of the five delivery modes: satellite, ITFS, cablecasting, PTV broadcasting, or mailed materials (videocassettes). Educational planners decide that 24 unique hours of programming per day will be delivered to each school. The cost of providing services at the designated level can be estimated for each delivery mode on a component-by-component basis.

However, a few words should be said about the notion employed here about service levels. It is for the sake of simplicity that unique hours of programming per day are specified. Under most circumstances, repeats would be scheduled to provide flexibility in viewing. Instead, flexibility is built into the system by assuming that each school possesses videocassette machines and a stock of cassettes to produce in-house flexibility. The basic problem is that the systems are not strictly comparable, especially with regard to such features as viewing flexibility and teacher control. It is necessary to impose some conformity upon the systems, and this is a simple way. Given this assumption, cost estimation may proceed.

Some points are common to the different systems and, while they are treated in greater depth in the appendix on cost components, can be touched upon here. All capital costs are annualized by simply dividing their purchase price by their expected "life" in years. Many studies use discount factors to reflect the time-value of money, inflation, and expected obsolescence of the equipment. Given the uncertainties surrounding these influences on the discount rate, we chose the simplest assumption, setting the rate equal to zero. This would not do for an administrative

body seeking to make cost estimates for planning purposes, but the resulting errors are within acceptable bounds for our purposes which require only first order cost approximations. In this same line, the delivery system described herein is expected to simply keep operating with capital equipment being replaced as it wears out. Furthermore, for any schools already possessing equipment, it is assumed that the annual costs of that equipment are simply imputed to the system's operation -- sunk costs are dismissed as a factor. Also, all dollar values are assumed to reflect real resource-using or social costs. This is a common, if vulnerable, assumption in the analysis of public investments and will be maintained here.

The first part of the numerical example, the satellite-based system, set the pattern for the other delivery modes discussed. The satellite-based mode is described in the most detail since some aspects of the explanation of its functioning are applicable to the other systems. The costs are estimated on the basis of average relationships so that the hypothetical region appears to possess a uniformity impossible to find in any actual region. It is simply as though instead of summing the numbers 80, 90, 110 and 120 to get 400, we used four times their average (4 X 100) to get the same total. At an aggregated level, this does not create errors in the cost estimates.

Satellite-Based System Cost Estimate

A satellite-based system implies a high-powered satellite functioning similarly to the ATS-6 during the ESCD. There is one central broadcast studio which transmits 24 hours of daily programming over four channels to a satellite which in turn broadcasts over four channels directly to schools. Each school possesses its own low-cost receiver. The need for four channels is a result of an average school day being limited to about 6 hours with no provision made here for split sessions or other possible schedule-disrupting influences. It is assumed that the required channel space and broadcast time are available at a constant $500 per hour per channel rental fee.

From the receiving equipment at each school, the signal passes into the school headend where it is amplified and distributed throughout the school via the internal wiring. Note also that requiring each school to have its own receiving equipment is a "worst case" since if schools are clustered they can share equipment.

Flexibility is provided by equipping each school with videotaping equipment and a supply of cassettes. Each school possesses 8 televisions which can be moved from room to room. The particular stock of capital equipment each school possesses can be thought of as a state-wide average.

The above verbal description is summarized in Table 2 in dollar amounts. Two things stand out in Table 2. First, the sharable costs or those costs which can be averaged out over all the schools (and students) in the state are three times the onsite costs, costs accrued at every school. This suggests that cost savings can be realized through

TABLE 2

ESTIMATE OF THE ANNUAL COST OF A SATELLITE SYSTEM*

Component	Annual System Cost in $	Per School Annual Cost for 1,400 Schools
Satellite Rental	$ 2,160,000	$ 1,543
Uplink Facility and Studio	228,750	163
System Management	180,000	129
Programming	12,960,000	9,257
Sharable Costs	$15,528,750	$11,092
Display Equipment	$ 1,030,400	$ 736
Videocassette Machines	1,449,000	1,035
Videocassettes	672,000	480
School Wiring	257,600	184
School Headend	80,500	58
Receiving Only Terminal	1,207,500	862
On-site Costs	$ 4,697,000	$ 3,355
Total System Costs	$20,225,750	$14,447

*Derivations of estimates can be found in the back of this section or in more detail in Appendix A.

economies of scale. Secondly, the dominant single cost is programming, making up almost half of total costs and 83% of the shareable costs, suggesting that most cost savings would arise from schools' pooling resources for program development and production. Of course, the numerical size of the programming component is the result of our assumption that each hour of programming would cost approximately $15,000 to produce and the cost would be spread over only five years. (See Appendix A, the programming component.) However, without programming costs, sharable costs are lower than on-site costs. This implies that without the need to pool resources for program production, the economic advantages of bigness fade.

ITFS Based System Cost Estimate

It is assumed that ITFS can be used to completely cover all the schools in the region. Because of the terrain and distribution of schools, 16 ITFS stations are required for total coverage. Each station is located at a school. Twelve of the transmitting sites are repeaters and four require equipment to play the programming and inject it into the system. Each station operates with four channels and has a broadcast antenna costing an average of $20,000. (One of the most variable of costs is for antennas. The $20,000 is, again, an average figure for all the sites across the region.) Pre-programmed videocassettes are supplied to each of the ten program origination sites. Each school is equipped with a receiving antenna and has, as in the satellite system, a headend and internal distribution system. Table 3 summarizes these assumptions and provides the cost estimates.

Generally, in this example, costs are lower for ITFS than satellite. A much larger number of ITFS broadcast (or land circumstances causing

TABLE 6

ESTIMATE OF THE ANNUAL COST OF
AN INSTRUCTIONAL TELEVISION FIXED SERVICE SYSTEM*

Component	Annual System Cost in $		Per School Annual Cost for 1,400 Schools	
ITFS Transmission	$ 147,200		$ 105	
Control Broadcast Studio	23,000		16	
Interconnection	94,080		67	
System Management	180,000		129	
Programming	12,960,000		9,257	
Sharable Costs		$13,404,280		$ 9,574
Display Equipment	$ 1,030,400		$ 736	
Videocassette Machines	1,499,000		1,035	
Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend	80,500		58	
School Reception	241,500		173	
On-site Costs		$ 3,730,400		$ 2,665
Total System Costs		$17,134,680		$12,239

*Derivations of estimates can be found in back of this section or in more detail in Appendix A.

higher transmission costs such as a taller and more expensive tower) would result in parity. Again, programming costs are dominant.

Mailed Materials

A central copying or dubbing facility distributes programming to each school. Each school has a sufficient stock of cassettes so that the cassettes may be used repeatedly. Cost estimates are contained in Table 4. This appears to be an immensely expensive system in which the dominant expenditure is dubbing and mailing the educational material to each school. Partly, this is a result of each school receiving the dubbed materials. If schools in a district shared the materials via a bicycling system, this component's figure could be reduced by a considerable degree, perhaps by a factor of four or five. Also, the school reception equipment in this case is actually composed of videocassette machines which are fairly expensive. As these machines fall in price, as they appear to be doing, this technology will become more attractive. Finally, if programs are to repeated, considerably fewer cassettes would be required.

Cablecasting

Wherever it exists, cable is a viable option for the distribution of ITV. Three complications arise. First, cable may not cover the entire region. Second, within any area ostensibly covered by cable, not every school may be near the cable. Third, while most cable operators will make available one channel for education use, this capacity would be inadequate for more than about 6 broadcast hours per day. The first two complications can simply be treated as given. Another mode may be necessary for complete coverage. For broadcast capacity, it may be possible to take advantage of transmission space in-betweeen the regular VHF channels normally

TABLE 4

ESTIMATE OF THE ANNUAL COST OF A MAILED MATERIALS SYSTEM*

Component	Annual System Cost in $		Per School Annual Cost for 1,400 Schools	
System Management	$ 180,000		$ 129	
Programming	12,960,000		9,257	
Sharable Costs		$13,140,000		$ 9,386
Mailing and Dubbing[b]	$32,928,000		$23,520	
Display Equipment	1,030,400		736	
Videocassette Machines	1,449,000		1,035	
Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend	80,500		58	
School Reception	1,932,000		1,380	
On-site Costs		$38,348,000		$27,392
Total Systems Costs		$51,488,900		$36,778

[a]Derivations of estimates can be found in the back of this section or in more detail, in Appendix A.

[b]These costs could be reduced by, say, two-thirds if each program was repeated twice.

used by cable operators. By installing special equipment at headend and coverters in the schools, this unused space could be utilized at relatively low-costs. However, its availability and the fee for its use would depend upon the cable operators and aggreements reached by bargaining. This example portrays a low-cost case from the viewpoint of the schools since only charges associated with the special equipment needed at the cable headends are incurred by the state to obtain the necessary channel space. In the example, 80% of the schools in the state are reached by 80 cable systems. The remaining 20% of the schools are assumed to be scattered and are reached by mailing videocassettes to them. The cost results are summarized in Table 4a.

Table 4a differs slightly from the preceding Tables because it is derived from a system using two delivery modes. As a result, for example, not all sharable costs are incurred in common by all the schools. The cable rental is incurred only by the 1,120 the cable serves; however, the dollar value of the cable rental is still averaged over all 1,400 schools to calculate the per school annual cost to maintain consistency with the estimates for the other delivery systems.

The striking aspect of the cost estimate is the magnitude of the Mailing and Dubbing component while this service is provided to only one-fifth of the schools. Table 5 makes the point more clearly with 100% of the schools being served by cable. Table 4a, however, is probably a more realistic case except that the percentage of schools covered by cable would be lower as a figure for an entire region. The calculations in Table 5 are based upon

TABLE 4a

ESTIMATE OF THE ANNUAL COST OF
A CABLE ITV DELIVERY SYSTEM[a]

Component	Annual System Cost in $		Per School Annual[b] Cost in 1,400 Schools	
Cable Rental	$ 80,000		$ 57	
Interconnection	1,881,600		1,344	
System Management	180,000		129	
Programming	12,960,000		9,257	
Sharable Costs		$15,101,600		$10,787
Mailing and Dubbing	$ 6,585,600		$4,704	
Display Equipment	1,030,400		736	
Videocassette Machines	1,499,000		1,035	
Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend (cable)[c]	135,240		97	
School Headend (mail)[c]	16,100		12	
School Reception (mail)[c]	386,400		276	
On-site Costs		$10,531,740		$ 7,523
Total System Costs		$25,633,340		$18,310

[a]This system employs a mix of cable and mailed materials as delivery modes.

[b]All costs are still spread over all schools in the system through some of the sharable and on-site costs do not belong to 100% of the public schools in the state.

[c]Cable refers to the 1,120 schools served by cable, school to the 280 served by mailed materials.

TABLE 5

ESTIMATE OF THE ANNUAL COST OF
A PURELY CABLE BASED DELIVERY SYSTEM*

Component	Annual System Cost in $		Per School Annual Cost for 1,400 Schools	
Cable Rental	$ 1,000,000		$ 714	
Interconnection	2,352,000		1,680	
System Management	180,000		129	
Programming	12,960,000		9,257	
Sharable Costs		$16,492,000		$11,780
Display Equipment	$ 1,030,400		$ 736	
Videocassette Machines	1,449,000		1,035	
Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend	169,050		121	
On-site Costs		$ 3,577,450		$ 2,555
Total System Costs		$20,069,450		$14,355

*Derivations of estimates can be found in the back of this section or in more detail, in Appendix A.

100 cable systems serving all 1,400 schools. The cost difference is immediately apparent.

Besides programming, the key cost is interconnection, meaning supplying the programming to the cable headends. It is presumed that a videocassette of each hour's worth of programming is supplied to each headend. If arrangements could be made so that the cassettes of programming could be bicycled between stations, this component would be reduced.

PTV Broadcasting

The problem that besets cable, incomplete coverage, can also plague PTV broadcasting. The stations are in place and cover most of the schools within broadcast range, though translators and repeaters can be used to extend the signal. Another limitation to PTV broadcasting is more severe; it is limited to about 6 hours of programming per day. As demonstrated by the case with cable, using a system of mailing instruction materials on a large scale to supplement another medium is very costly. The estimates in Table 6 are based upon 100% coverage of schools and 6 hours of programming daily instead of 24, broadcasted by 12 PTV stations.

The Cost Components

The derivations of the estimates recorded in Tables 2-6 are presented in this section. A brief description of each component and an equation summarizing the equation used in computing its cost estimate are included. More description is included in Appendix A. A number of components which are identical are listed first. They are Display Equipment, Videocassette Machines, Videocassettes, School Wiring, System Management, and Programming.

TABLE 6

ESTIMATE OF THE ANNUAL COST OF
A PTV BROADCASTING SYSTEM*

(6 Broadcast Hours)

Component	Annual System Cost in $		Per School Annual Cost for 1,400 Schools	
Broadcast Fee	$1,944,000		$1,389	
System Management	180,000		129	
Programming	3,240,000		2,314	
Sharable Costs		$5,364,000		$3,832
Display Equipment	$1,030,400		$ 736	
Videocassette Machines	1,449,000		1,035	
Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend	88,550		63	
School Reception	48,300		35	
On-site Costs		$3,545,250		$2,5[illegible]
Total System Costs		$8,909,250		$6,365

*Derivations of estimates can be found in the back of this section or in more detail, in Appendix A.

COMPONENTS CONSTANT ACROSS SYSTEMS

Display Equipment Color receiver/monitors plus stands.	[8($400)/5] (1.15) (1,400) $400 = price of a color television 8 = (average) number of televisions per school .15 = maintenance and operating cost as a percentage of annual capital costs 5 = annualization factors 1,400 = number of schools
Videocassette Machines Schools use videocassette machines to provide flexibility in internal distribution of programming.	3 ($1,500/5) (1.15) (1,400) $1,500 = price of a videocassette machine 3 = number of videocassette machines per school .15 = maintenance and operating cost as a percentage of annual capital cost 5 = annualization factor 1,400 = number of schools
Videocassettes Schools require a stock of videocassettes to complement their videocassette machines. The stock's size is a function of the school's requirement of ITV use.	($20/5) (5 X 24) (1,400) $20 = price per cassette 5 = annualization factor 24 = daily number of hours of programming 5 = number of days in an average school week - interpreted as the length

School Wiring

Each school is wired to facilitate the internal distribution of programming.

(120/15) (20) (1.15) (1,400)

$120 = price of wiring a room

20 = average number of rooms per school

15 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital costs

1,400 = number of schools

System Management

A central agency manages the operations of the delivery system.

$180,000

$180,000 = annual management cost

Programming

Money spent for the development and production and acquisition of programs.

(15,000/5) (24) (180)

$15,000 = cost of an hour of programming

5 = annualization factor

24 = daily hours of programming

180 = number of school days

ADDITIONAL SYSTEM SPECIFIC COMPONENTS

SATELLITE

Satellite Rental

Fee paid for the use of the satellite based upon a constant per hour per channel rate.

180 ($500) (24)

$500 = satellite rental

180 = number of school days

24 = daily number of hour of programming

Uplink Facility and Studio The uplink transmitter plus broadcasting studio equipment necessary for transmission.	$200,000 + ($250,000/10) (1.15) $200,000 = operating cost $250,000 = original capital expenditure 10 = annualization factor .15 = maintenance and operating cost as a percentage of annual capital cost
School Headend An amplifier is located at the school headend.	($500/10) (1.15) (1,400) $500 = amplifier cost 10 = annualization factor .15 = maintenance and operating cost as a percentage of annual capital cost 1,400 = number of schools
School Reception Each school requires a receive-only terminal.	($6,000/8) (1.15) (1,400) $6,000 = price of the reception equipment 8 = annualization factor .15 = maintenance and operating cost as a percentage of annual capital cost 1,400 = number of schools

ITFS

ITFS Transmission ITFS transmission equipment including a tower and transmitters are located at schools.	[($20,000 + $60,000)/10] (1.15) (16) $20,000 = average initial tower cost $60,000 = transmitting equipment cost for 4-channel capacity (repeater or transmitter

ITFS Broadcast Studio

Broadcast studios are required to provide program origination.

($50,000/10) (1.15) (4)

50,000 = broadcast studio original cost

10 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

4 = number of required program origination sites

Interconnection

The cost of distributing the programming to the ITFS program origniation sites for subsequent redistribution. The interconnection mode is video-cassettes.

[($20/5) (20 x 24) + ($5 x 24 x 180)] (4)

$20 = price of a cassette

5 = annualization factor

20 = number of school days in a four week period-interpreted as the length of time needed to [illegible] the cassette

24 = daily number of hours of programming

$5 = dubbing fee

180 = number of school days per annum

4 = number of ITFS program origination sites

School Headend

An amplifier is located at the school headend.

($500/10) (1.15) (1,400)

$500 = amplifier cost

10 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

1,400 = number of schools

School Reception

($1.500/10) (1.15) (1,400)

MAILED MATERIALS

Mailing and Dubbing

Each cassette a school owns is used repeatedly; material is dubbed onto it; it is mailed, used, and mailed back.

[($20/5) (20 X 24) + ($5 X 24 X180)] (1,400)

$20 = price of a cassette

5 = annualization factor

20 = number of school days in a four week period-interpreted as the length of time needed to circulate the cassette

24 = daily number of hours of programming

$5 = dubbing fee

180 = number of days in the school year.

1,400 = number of schools

School Headend

An amplifier is located at the school headend.

($500/10) (1.15) (1,400)

$500 = amplifier cost

10 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

1,400 = number of schools

School Reception

School reception equipment consists of videocassette machines.

[4($1,500)/5] (1.15) (1,400).

$1,500 = price of a videocassette machine

4 = number of machines

5 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

CABLECASTING

Cable Rental

It is assumed that institutional arrangements can be made so that only a marginal cost will be charged to the system.

(\$2,500/10) (4) (100)

\$2,500 = price per channel of capital equipment installed at the cable headend to access the channel

10 = annualization factor

4 = number of channels

100 = number of cable systems

School Headend

Switch, converter per channel, and amplifier are required at the school headend to facilitate the internal distribution of the signal.

(\$1,200/10) (1.15) (1,400)

\$1,200 = price of the headend equipment

10 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

1,400 = number of schools

Interconnection

The cost of distributing the programming to the cable headends for redistribution. The interconnect mode is videocassette.

[(\$20/5) (20 X 24) + (\$5 X 24 X 180)] (100)

\$20 = price of a cassette

5 = annualization factor

20 = number of school days in a four week period-interpreted as the length of time needed to circulate the cassette

24 = daily number of hours of programming

\$5 = dubbing fee

180 = number of school days per annum

100 = number of cable headends

PTV - BROADCASTING

Broadcasting Fee

A "fair" share of operating and capital expenses is charged per hour per station for use of PTV facilities.

(\$150) (6) (180) (12)

\$150 = charge per hour per station

6 = daily number of hours of programming

180 = number of days in the school year

12 = number of PTV stations

School Headend

A converter and amplifier are placed at the headend.

(\$550/10) (1.15) (1,400)

\$550 = price of converter and amplifier

10 = annualization factor

.15 = maintenance and operating cost as a percentage of annual capital cost

1,400 = number of users

School Reception

Each school requires an antenna and mounting.

(\$150/5) (1.15) (1,400)

\$150 = price of reception equipment

5 = annualization factors

.15 = maintenance and operating cost as a percentage of annual capital cost

1,400 = number of schools

Summary

The preceding listing of cost components, especially when viewed together with the Appendix A on the components, is the most important part of this section. The cost estimates themselves are of secondary importance with the illustration of how they are calculated taking precedence as a simplified example of how estimates can be constructed. In this respect the Appendix is even more useful.

The cost estimates themselves are the product of the circumstances found in the hypothetical state and do not imply generalizable results. Actual cost estimates for a school district, consortium of school districts, state or multi-state region would have to be based upon the engineering necessities imposed upon the delivery system by the area's characteristics and on items which require decisions by the involved educational planners. While calculating cost estimates in this paper can help provide a guide to estimation, the procedures provide more utility than the actual estimates themselves.

However, some useful computations can be performed to provide some general results in pointing out where certain delivery modes have a comparative cost advantage in providing a given set of required services under a given set of region characteristics. This is the task of the next section which pares down the complete model to a more compact comparative cost model in which the costs computed for components are written as functions of certain key variables and parameters.

III. COMPARATIVE COST MODEL

The comparative cost model is a reduced and generalized variant of the complete cost model presented in the preceding section. It is reduced because a number of cost components that are the same regardless of delivery mode are eliminated from the comparative analysis, and it is generalized because variables replace certain of the numbers used in the component listings in the complete model. The comparative analysis attempts to answer one question: "Under what circumstances do some delivery modes have a comparative cost advantage over other delivery modes?" Components used are combined into compact expressions which are first-degree functions of the different variables expressed in cost-per-school terms. These functions are solved pairwise for those values of selected variables, for which the per school cost is lower for one delivery mode.

Components

The listing of cost components which follows is not written in as general form as possible. Effectively, all the numbers on the cost components listing of the complete model could be replaced by symbols representing variables. However, in order to emphasize certain variables at the expense of others only a few of the numerical values have been replaced by letters symbolizing variables. The remaining numerical values can be thought of as parameters. The most important variables treated here are the number of schools served, the number of hours of programming transmitted, and a variable summarizing some of the effects of the distribution of schools geographically. The components common to all delivery modes are Programming, Management, Display, Videocassette Machines, Video-cassettes and School Wiring. The remaining components have been generalized

SATELLITE SYSTEM

Satellite Rental

Fee paid for the use of the satellite. Total for the system for one year.

$(180)(\$500)(Q_S)$

.180 = number of school days per year.

Q_S = number of hours of programming per day.

\$500 = satellite rental fee per hour.

Uplink Facility and Studio

The uplink transmitter plus broadcasting studio equipment necessary for transmission.

$\$200{,}000 + (\$250{,}000/10)(1.15)$

\$200,000 = operating cost.

\$250,000 = original capital expenditure

10 = annualization factor.

.15 = maintenance and operating as percentage of annual capital cost.

School Headend

An amplifier is located at the school headend.

$(\$500/10)(1.15)N_S$

\$500 = initial cost of amplifier.

10 = annualization factor

.15 = maintenance and operation cost as a percentage of annual capital cost.

N_S = number of users.

School Reception

Each school requires receive only equipment to receive the satellite signal.

$(\$6{,}000/8)(1.15)N_S$

\$6,000 = price of a terminal.

8 = annualization factor.

.15 = maintenance and operation cost as a percentage as annual capital cost.

N_S = number of users.

Cable Rental

It is assumed that institutional arrangements can be made so that only a marginal cost will be demanded for the users of the system.

$(\$2,500/10)\ c\ h\ N_C$

$2,500 = per channel of capital equipment installed at the cable headend to access the channel space.

10 = annualization factor.

c = number of channels.

h = number of cable headends per school.

N_C = number of users.

School Headend

A switch and amplifier is required at the school headend to facilitate internal distribution of the signal. Also, a converter is needed for each channel.

$(\$1000/10)(1.15)\ N_C + (\$50/10)\ c\ (1.15)\ N_C$

$1,000 = price of switch and amplifier.

$ 50 = price of converter.

c = number of channels.

10 = annualization factor.

.15 = maintenance and operation as a percentage of annual capital cost.

N_C = number of users.

Interconnection

The cost of distributing the programming to the headends for redistribution. The distribution mode is dubbed videocassettes.

$[(\$20/5)\ (20Q_C) + (\$5Q_C\, 180)]\ (hN_C)$

$ 20 = price of cassette.

5 = annualization factor.

20 = the number of school days in a four week period, interpreted as the required stock of cassettes.

$ 5 = cost of mailing and dubbing one hour of programming.

180 = number of days in a school year.

Q_C = hours of programming per day.

N_C = number of users.

h = number of cable headends

INSTRUCTIONAL TELEVISION FIXED SERVICE

ITFS Transmission

A tower with an ITFS transmitter is required for each channel.

$\{[\$20,000 + \$15,000I]/10\}\ (1.15)\ (t\ N_I)$

$20,000 = initial tower cost.

$15,000 = transmitter cost.

I = number of ITFS channels.

10 = annualization factor.

.15 = maintenance and operation cost as a percentage of annual capital cost.

t = number of transmission sites divided by number of users.

N_I = number of users.

School Headend

An amplifier is required at the school headend to facilitate internal distribution of the received signal.

$(\$500/10)\ (1.15)\ N_I$

$500 = price of an amplifier.

10 = annualization factor.

.15 = maintenance and operation as a percentage of annual capital cost.

N_I = number of users.

School Reception

School reception equipment consists of an antenna, mounting, and converter.

$(\$1,500/10)\ (1.15)\ N_I$

$1,500 = price of reception equipment.

10 = annualization factor.

.15 = maintenance and operation as a percentage of annual capital cost

N_I = number of schools.

Interconnection

The cost of distributing the programming to the ITFS transmission sites for redistribution. The distribution mode is dubbed video cassettes.

$[(\$20/5)(200_I) + (\$5Q_I 180)](t' N_I)$

$20 = price of cassette.

5 = annualization factor.

20 = the number of school days in a four week period-interpreted as the length of time a program might be kept.

$ 5 = cost of mailing and dubbing one hour of programming.

180 = number of days in a school year.

Q_I = hours of programming per day.

N_I = number of users.

t' = number of central studios divided by number of users.

Central Broadcast Studio

A central studio is required to provide the programming origination.

$(\$50,000/10)(1.15)\, t' N_I$

$50,000 = Central Studio Cost.

.15 = maintenance and operation as a percentage of annual Capital cost.

t' = number of central studios divided by number of users.

N_I = number of users.

Videocassettes	672,000		480	
School Wiring	257,000		184	
School Headend	88,550		63	
School Reception	48,300		35	
On-site Costs		$3,545,250		$2,5[illegible]
Total System Costs		$8,909,250		$6,365

*Derivations of estimates can be found in the back of this section or in more detail, in Appendix A .

cost as a percentage of
annual capital cost
5 = annualization factor
1,400 = number of schools

Videocassettes

Schools require a stock of videocassettes to complement their videocassette machines. The stock's size is a function of the school's requirement of ITV use.

($20/5) (5 X 24) (1,400)
$20 = price per cassette
5 = annualization factor
24 = daily number of hours of programming
5 = number of days in an average school week - interpreted as the length of time a program might be kept
1,400 = number of schools

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hour of programming

MAILED MATERIALS

Mailing and Dubbing

Each cassette must be used repeatedly; material is dubbed onto it; it is mailed, used, and mailed back.

(180) $\$5 O_M N_M$ + (\$20/5) (.20)

\$ 5 = mailing and dubbing cost.

O_M = number of hours per day.

180 = number of school days per year.

N_M = number of schools.

\$ 20 = price of a cassette.

5 = annualization factor.

.20 = number of school days in four weeks--interpreted as the turnover time for each school's stock of cassettes.

School Headend

An amplifier is located at the school headend.

(\$500/10) N_M (1.15)

\$500 = price of an amplifier

10 = annualization factor.

.15 = maintenance and operation as a percentage of annual capital cost.

N_M = number of users.

School Reception

This refers to videocassette recorder/players.

[m (1,500)/5] (1.15) N_M

\$1,500 = price of a videocassette recorder/player.

m = number of videocassette machines per school as a function of O_M

5 = annualization factor.

.15 = maintenance and operation as a percentage of annual capital cost.

N_M = number of schools.

PTV BROADCAST

Broadcast Fee	$\$150 Q_B\ 180 b N_B$
A fair share of operating and capital expenses is charged for use of PTV facilities.	$150 = charge per hour. Q_B = hours of programming. 180 = number of days in a school year. b = number of PTV stations per school. N_B = number of users.
School Headend	$(\$50/10)\ N_B\ (1.15)$
A converter is placed at the school headend.	$50 = price of a converter. 10 = annualization factor. .15 = maintenance and operation as a percentage of annual capital cost. N_B = number of users.
School Reception	$(\$150/5)\ N_B\ (1.15)$
Each school requires an antenna and mounting.	$150 = price of reception equipment. 5 = annualization factor. .15 = maintenance and operation as a percentage of annual capital cost. N_B = number of schools.

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In order to derive the comparative cost equations for each system, the expressions for each component can be simplified and added. This procedure is given in Appendix B. Table 7 contains the resulting equations, equation set C, which form the nucleus of the comparative model. Equations C.1 - C.5 refer to satellite, cable, ITFS, mailed materials, and PTV, respectively.

Direct comparisons between the equations can be made to obtain some [illegible] sense of which systems possess comparative advantages.

First, for all systems except satellite, most sharable costs belong to those components not included in the competitive model. For satellites the exceptions are the satellite uplink facility and the satellite rental fee. Because of this, the satellite mode provides the only system with declining comparative costs per school as the number of schools increases. Effectively, this lends a "bigness" bias to satellites--satellites will appear more advantageous, vis a vis the other delivery modes, the larger the user population to be served by the system.

For the other important variables Q (with c, I, and m) and the distribution indicators, h,t,t', and b, the inferences are not so clearly drawable because variables are interactive. However, neither satellite nor mailed materials are affected by the distribution of the schools in the area served by a system so, the larger the values of h,t,t', and b, the more favorably the circumstances for satellite and a mailing system. Effectively, this means the more dispersed the population for ITFS, the greater the technologically based incumbrances on the system (e.g. topographical features requiring the placement of extra [special] broadcast sites or studios to ensure coverage of the entire population*).

*Actually, special circumstances would probably incur extra costs at certain sites as well as perhaps requiring extra broadcast sites.

TABLE 7

Equation Set C

(C.1) Satellite Comparative Cost per School $= \bar{s} = \frac{228,750+90,000Q_S}{N} + 920$

(C.2) Cable Comparative Cost per School $= \bar{c} = 250ch + 980Qch + 6c + 58$

(C.3) ITFS Comparative Cost per school $= \bar{k} = 2,300t + 1,725It + 5,750t' + 980Q_I t' + 230$

(C.4) "Mailed" Comparative Cost per school $= \bar{m} = 345m + 980Qm + 58$

(C.5) PTV Comparative Cost per school $= \bar{b} = 27,000Q_B b + 92$

Variables

- N = number of schools
- Q = hours of programming per school day
- C = number of cable channels, C = 1 if $0 < Q \leq 6$, C = 2 if $6 < Q \leq 12$, etc.
- I = number of ITFS channels, I = C
- m = number of videocassette machines per school, M = I = C
- h = school distribution indicator, h = number of cable headends per school
- t = school distribution indicator, t = number of ITFS transmission (origination or repeater) sites per school
- t' = school distribution indicator, t' = number of ITFS broadcast studio sites per school. ITFS broadcast studio sites coincide with ITFS origination sites and t' is usually expressed as a function of t.
- b = school distribution indicator, the number of PTV broadcast sites per school

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The variables which summarize the geographical distribution of schools implicitly include any technological factors which could influence the ratio of the number of schools per broadcast site (PTV stations or ITFS) or the number of schools per cable headend. The three distribution variables are h for cable headends, b for PTV broadcast stations, and t for ITFS. These three variables are interpreted as:

$$t = \frac{\text{number of ITFS transmission sites,}}{\text{number of schools}}$$

$$h = \frac{\text{number of cable headends,}}{\text{number of schools}}$$

$$b = \frac{\text{number of PTV broadcast stations,}}{\text{number of schools}}$$

then the products tN, QN, and bN provide the number of transmission sites. For example, if the number of ITFS transmission sites in a region was four with 32 schools, the t = .125. ITFS involves a second variable, t': t refers only to the transmission equipment, tower and transmitter or repeater. t' refers to the ITFS broadcast studio. At at least one ITFS transmission site, there must be a broadcast studio in which the transmission originates. The other broadcast sites could be repeaters which receive and repeat the signal, effectively extending the area of coverage of the one originating transmitter. Topographical and technological factors dictate the ratio, t', the number of studios divided by the number of schools. The variable t' is usually expressed as a function of t.

To illustrate the effects the different variables have on comparative advantages, numerical examples are developed below. This process involves setting two equations equal and solving for one of the variables in terms of the others. Values can be substituted for the independent variables to generate values for the one dependent variable. For example, comparing

ITFS and satellite, we can solve for N in terms of Q, t, and t' and by substituting numerical values for Q, t, and t', generate the corresponding values of N at which for a greater value of N, comparative satellite cost per school is lower. Table 8 provides results of this type. The equation used to generate Table 8 was.

$$N = \frac{228,750 + 90,000Q}{1,150 + 2,300t + 1,725It + 5,750t' + 980Qt'}$$

The table indicates that the satellite fares better as both Q and N increase, and, of course, as the schools are more highly dispersed (a higher t value), the more competitive satellite is. This would be especially true if most ITFS transmission sites were also origination sites. It should be noted that presently most ITFS sites are not repeating stations but each maintains a broadcast studio.* This is probably due to the traditional way ITFS has been used with small isolated systems instead of large consortiums of school districts.

Table 9 helps to introduce another perspective. Using the same equations but with N fixed at N = 3,000,** for different functions t' = f(t) and different levels of Q, Table 9 gives the values of t above which satellites are cheaper. The T values in the [illegible] give the number of ITFS transmission sites corresponding to the t values. The best case for satellites is for Q = 24, t' = t, t = .04 with 120 ITFS transmission sites providing coverage for the 3,000 schools.

* NAEB memorandum.

** New York State has over 3,000 public schools.

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TABLE 8

COMPARATIVE COSTS OF SATELLITE AND ITFS

Q = 6

t' = 1/8t		t' = 1/4t		t' = t	
t	N	t	N	t	N
1.00	171	1.00	129	1.00	52
.20	2,233	.20	.208	.20	323
.15	8,851	.15	2,521	.15	477
.10	n.a.	.10	n.a.	.10	909
				.05	9,887

Q = 12

t' = 1/8t		t' = 1/4t		t' = t	
t	N	t	N	t	N
1.00	193	1.00	147	1.00	60
.20	1,598	.20	1,050	.20	343
.15	2,937	.15	1,707	.15	486
.10	18,116	.10	4,569	.10	834
				.05	2,923

Q = 18

t' = 1/8t		t' = 1/4t		t' = t	
t	N	t	N	t	N
1.00	200	1.00	144	1.00	69
.20	1,413	.20	981	.20	347
.15	2,278	.15	1,487	.15	482
.10	5,871	.10	3,070	.10	794
				.05	2,241
				.03	8,278

Q = 24

t' = 1/8t		t' = 1/4t		t' = t	
t	N	t	N	t	N
1.00	204	1.00	175	1.00	65
.20	1,328	.20	1,095	.20	348
.15	2,026	.15	1,629	.15	480
.10	4,274	.10	3,185	.10	774
.05	n.a.	.05	6,981	.05	1,985
				.03	2,112
				.02	32,953

TABLE 9

COMPARATIVE COSTS OF ITFS AND
SATELLITE SERVING 3,000 SCHOOLS

N = 3000

	Q =	6	12	18	24
t' = 1/8t	t =	.22	.17	.15	.13
t' = 1/4t	t =	.17	.13	.11	.10
t' = t	t =	.07	.05	.05	.04
	T =	660	510	450	390
	T =	510	390	330	330
	T =	210	150	150	120

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Table 10 provides comparisions for satellite and cable systems. Generally, cable does not fare as well versus satellite as ITFS does except in the case where t' = t. Also, this suggests that except for the case where most ITFS transmission sites also have their own broadcast studios, ITFS has a comparative cost advantage over cable. The determining factor is the interconnection costs which is why the number of ITFS studios becomes such a critical factor.*

TABLE 10

Satellite and Cable Comparisons

Q = 6		Q = 12		Q = 18	
h	N	h	N	h	N
1.00	146	1.00	114	1.00	105
.13	3,000	.16	1,117	.16	881
.17	4,131	.14	1,510	.14	1,068
.16	6,160	.10	3,000	.043	2,400
.14	N.A.	.07	N.A.	.046	N.A.

For Q = 6, mailed materials become comparatively more expensive than satellites at N greater than 150, with the necessary N decreasing as Q increase Cable is always cheaper than mailed materials as is ITFS unless t > (1/2)at (i.e. average, one broadcast studio serves no more than two ITFS transmission sites).

PTV is the most common over-the-air disseminator of ITV but is limited to one channel and approximately 6 hours per day of broadcast time. Satellite

*These comparisons neglect both the possible lack of total coverage in any given area by cable and the possibility of a limited number of channels.

**This figure is almost tripled if programs are repeated twice.

compares favorably to PTV if more than five PTV stations are required to provide coverage to the user population. On a more local basis, cable is comparatively less expensive if, to serve a given user population, fewer than twenty cable stations are required compared to one PTV station. For ITFS, even in the worst ITFS case where $t' = t$, ITFS has the competitive advantage if fewer than 11 ITFS transmission sites are required to cover a population versus one PTV station. On a slightly different basis of comparison, the distribution of videocassettes is favored over a PTV station only if the number of schools in the PTV station's broadcast area is less than 25.

Summary

The preceding sections use some complicated computations to reach some rather basic and intuitively appealing results. First, as a mode of delivery, satellite is best suited for serving a large population of several thousand schools with a commitment to using a large number of broadcast hours per day. Satellite's cost advantages compared to other delivery modes such as cablecasting and ITFS show especially well when the user population is widely distributed.

Advantages are less clear when comparing other delivery modes. ITFS and cable are closely matched. ITFS fares better when it is organized on a broad scale so that repeaters can be used to extend one original signal instead of each school district owning its own system complete with broadcast studio. On a one-to-one basis, with single school districts making their own arrangements, cable is apt to be a better choice where it is available.

Mailed materials have their place at the other end of the spectrum from satellites. They have that advantage as a system in the smallest of systems serving only a few schools. PTV is best situated to serve highly concentrated populations but with a total system size too small for the economies of scale associated with satellites to become effective.

Many important issues have been ignored that are to be examined in later

sections. Paramount among these is the issue of flexibility. The term "flexibility" as used here integrates several aspects of serving users on a more individual basis: tailoring programming to special needs, providing scheduling flexibility, and providing teachers with more in-classroom control. Generally, the flexibility issue is treated as an extension of the model described in this section. Additional extensions which receive attention in the next section include "hybrid" systems, systems using more than one delivery mode and some discussion of the use of two-way communications.

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IV. EXTENSIONS OF THE BASIC COMPAR...IVE COST MODEL

Section III presented the most basic cost comparisons betw delivery modes. Simplifications were used to facilitate obtaining results and to allow for a less complicated explanation of how the model works. This section presents a number of extensions of the comparative model. The extensions help to examine issues such as flexibility, hybrids, and two-way communication.

Flexibility

Flexibility in scheduling costs extra in most of the syst One way of achieving flexibility is to be sure that each school possesses videocassette machines. However, some delivery modes a herently more flexible than others, and the comparative analysis be adjusted to take account of this. Of all the systems, one bas upon mailed videocassettes provides nearly complete scheduling fl bility since each school could construct its own schedule. On t other end of the spectrum, a satellite-based system offers one sc for all the schools. For the other delivery modes, some flexibil be provided at cable headends, ITFS broadcast studios, and PTV sta with schedules arranged to suit the subsets of the total populati which they serve.

One aspect of flexibility can be quantified. If each hou of programming is repeated at least once, then mailed materials b a more competitive delivery mode. For example, if each program i repeated twice, then for 12 hours of daily broadcast time over th satellite, each school would need only 4 hours daily of videocass recorded programming. The effect of this is to increase the crit N, that number of schools for which a satellite-based system begi

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demonstrate a comparative cost advantage, by a factor of 2.5 for this case of 12 hours of broadcast time with no repeats (from $N > 143$ to $N > 380$). Likewise, this necessity of repeating programs helps a mailed materials-based system vis-a-vis other broadcast systems. Also, since cable and ITFS use videocassettes to distribute programming to their respective transmission origination sites, they also benefit from the repeating of broadcasts. Of course, the competitive benefit vis-a-vis satellites which these two delivery modes derive from the re-use of videocassettes in repeat broadcasting is inversely related to the number of broadcast sites. However, the most important effect of repeats are on the competitive costs for the mailed materials, since in this mode each school is, effectively, its own transmission site.

Other aspects of flexibility, as the term is used here, are not so easy to quantify. First, only by the schools' themselves possessing copies of the programs are teachers provided with control over how and when materials are to be used. This teacher control over program use is one aspect of flexibility, the importance of which should not be underestimated since teacher control can be an important determinant of teacher acceptance of a medium and therefore, of the educational effectiveness of the medium.

A second aspect of flexibility which is difficult to quantify is responsiveness in tailoring programming to the needs of localized populations. A dramatic illustration of the need for such tailoring comes in other countries where sizable segments of the population speak different dialects and require programming each in their own dialects. In the United States, too, there is a large number of Spanish-speaking citizens plus native American languages. Besides increasing programming costs, for example, in the case of satellite, additional channels would be needed to provide sufficient coverage. For ITFS, local transmission origination sites would suffice to meet localized

language needs. However, if transmission coverage areas still cut across ethnic divisions, then, as for satellites, the solution is more channels. Along a somewhat different line, different types of programming may be required to serve different population needs. For example, rural children need films of cities for enrichment/experience viewing while city-dwelling children would profit more from viewing farms. Aside from the effect on programming costs, local control over the broadcast mode again negates some of the need for building additional transmission capacity into the delivery system.

Hybrids

By a hybrid system is meant a delivery system which utilizes more than one delivery mode. Actually, any system which requires interconnection, say by mailed videocassettes as in the cases of cable and ITFS as suggested in the previous sections, is a hybrid system if the definition is employed broadly. In practice, schools are served by several of the media. Films and filmstrips are prevalent in the schools which receive PTV broadcasts, one delivery mode effectively supplementing the other. The point is, if the use of many media by schools is viewed as a coordinated effort, this is a type of hybrid. Another case occurs if one delivery mode cannot provide service to all the schools to be included in the system. A hybrid system could use different modes to ensure total coverage.

The last case mentioned above, that of partial coverage over the total service area, will be termed horizontal hybridization. The use of more than one delivery mode to serve the same school is also defined as a form of horizontal hybridization. The case of using one delivery mode as an interconnecter is termed vertical hybridization. It should be noted that there can occur cases of joint vertical and horizontal hybridization. Consider this scenario: cable covers 60% of the schools in a state. The decision could be made to use cable for the 60% which can be

TABLE

HYBRID COMPARISONS: CABLE, MAILED MATERIALS AND SATELLITES

Scenario

N = Number of schools in region = 3,000.

N_C = Number of schools covered by cable = .6N = 1,800.

N_S = Number of schools covered by satellite = .4N or N = 1,200 or 3,000.

N_M = Number of schools covered by mailed materials = .4N = 1,200.

Q = Number of daily broadcast hours = 18.

c = cable channels = 3.

m = videocassette machines = 3.

Number of repeats of each program = 2.

Number of cable headends = 180 (h = .10).

Mailed Materials-Cable Hybrid

Cable Component: $250 (hN_C) + (58+6c)N_C + 980 (1/3) Q_C (hN_C)$

Mailed Component: $58 N_M + 345 mN_M = 980 (1/3) Q_M N_M$

Mailed Materials-Cable Comparative cost = $9,697,800

Mailed Materials-Cable Comparative cost per school = $3,232

Satellite-Cable Hybrid (N_S = .4N)

Cable Component: $250 c (hN_C) + (58+6c)N_C + 920 (hN_C)$

Satellite Component: $228,750 + 90,000 Q_S + 920 N_S$

Satellite-Cable Comparative cost = $3,390,150

Satellite-Cable Comparative cost per school = $1,130

Satellite System (N_S = N)

Satellite: $228,750 + 90,000 Q_S + 920 N_S$

Satellite Comparative cost = $4,608,750

Satellite Comparative cost per school = $1,536

Assuming that some sort of ETV system is to be installed, hybrids will come about if they offer cost savings compared to "pure" systems. Clearly, a very important determinant will be the sort of communications facilities or infrastructure existing in the coverage area. (To a certain extent, one type of system may also come about if some type of delivery mode is preferred *a priori* to cost considerations, because it has been already accepted in the region. It is not only a matter of what is in place in terms of communication equipment, but also of what is customarily used.) The problem of which delivery modes to use, how to use them (as either direct to schools or as a means of interconnecting other modes), how many (and which) schools any delivery mode should serve, and for how many hours of programming can be thought of as a complicated mathematical programming problem. Cost per school would be the objective function to be minimized, with side constraints that limit the *coverage* of some types of systems--e.g., cable--or limit the capacity of broadcasting time of some delivery modes.

Two-Way Communications*

Two-way communications is a feature available to almost any of the delivery systems, except, realistically, mailed videocassette, since without simultaneous reception of a live program, two-way is meaningless. Satellites provide two-way capabilities, and a portion of the ESCD demonstrated its operability, though the cost of ground reception stations increases by several thousand dollars to provide sites with a "talk-back" capacity. ITFS also has two-way potential (see the Stanford and USC case studies) as does cable. Finally, there are always phone lines, except in Alaska.

An important point to remember about two-way is that in a question-response or group discussion type situations only one individual can use the "talk-back" capacity at one time. Since satellites have cost advantages only with large audiences, it is unclear how important two-way potential is

*Two-way here refers only to a "talk-back" capability, not two-way video.

served by the cable and mailed materials for the remaining 40%. Another option would be to use direct satellite broadcast to the uncovered 40% plus using satellite to interconnect all the cable headends by placing a low-cost receiver at each central cable station. Alternatively, satelitte could be used to broadcast to all schools. Comparative costs are estimated below for the satellite-cable hybrid and the mailed materials-cable hybrid. Note that each hybrid has vertical and horizontal aspects.

The scenario is built around a region with 3,000 schools. Some multi-state agency has decided to ensure each school of 18 broadcast hours of ITV daily, representing some combination of first-run and repeated programming such that, overall, each program is repeated twice. Three options are open for the region; a cable-mailed materials hybrid, a cable-satellite hybrid, and a pure satellite system. The first hybrid suggests that videocassettes would be mailed to those schools not covered by cable and that the cassettes would be used to issue the programming to the cable headends with 180 headends in the state. The second hybrid suggests the use of satellite direct broadcast from a high-powered satellite to low-cost receiving equipment located at the cable headends and the schools not covered by cable. The third "pure" system implies direct satellite broadcast to all schools. Using the comparative equations of the preceding section allows us to make cost comparisions. Table 11 contains the comparative cost estimates plus information summarizing the scenario. The results of the preceding section would suggest that satellite would be cheaper than mailed materials for providing the service to the 40% of the schools not covered by cable, and Table 11 suggests that the mailed materials-cable hybrid would be a considerably more expensive choice than the other two options. However, the satellite-cable hybrid is a less expensive alternative than the pure satellite system. This is a case in which the additional cost of using a secondary delivery system, the cable, is more than offset by the savings of reducing the number of receiving sites. This result raises some very important issues.

for satellites in mass educational uses. Telephone calls could turn out to be cheaper if only because busy signals are free. There are other circumstances in which a kind of two-way potential for satellite could be important. This would be the case for interactive computer/satellite systems such as PLATO (see Perrine, 1975). However, this goes beyond the scope of this report.

Computerized Cost Model

The complete and comparative cost models developed in the preceding sections can be "extended" in another sense--they can be put on a computer. Given the slightly informal treatment of the cost models of this chapter, a computerized model was not necessary though one was developed to see if advantages could be gained by using a high-speed data processing machine.* However, the simplicity of the calculations made a computerized treatment unnecessary. This concluding portion of Section IV suggests how a computerized model could be utilized to good advantage.

Calculating cost estimates by hand (i.e., by electronic calculator) may be tedious, but allows the individual making the estimates to be sure that the peculiarities of the region in question are fully taken into account. A pre-packaged computer program generally lacks the adaptability to be all things to all people. Of course, a program can be written specifically for a region and for the problem to be addressed. However, unless the cost calculations are long, or complicated and repetitive, it might be easier and cheaper to do the computations manually. There are three cases in which a general computer model could be useful.

First, in the case of hybrids mentioned above, finding the best (i.e., least cost) system can be likened to a mathematical programming problem. Computers are well suited to solving problems of this type. A difficulty would occur in attempting to provide a "pre-packaged" program generally applicable to many regions, since there is a trade-off with estimating accuracy.

*A program listing of SRC's model written in Fortran IV is available at our research corporation in Syracuse.

Sub-routines, generally, are a second instance where a computer model would be necessary. An example makes the point. We use a very simple "high-powered satellite" mode of delivery in our comparative analysis. However, just how "high-powered" a satellite should be from a cost perspective is, in effect, a cost optimization problem. Several computer programs have been written to cost optimize the number, placement, power, and other aspects of satellites for different user requirements placed upon a satellite based communications system.* The driving factor in the optimization problem is the trade-off between the cost of receiving stations which varies inversely with the broadcast power of the satellite and the cost of the satellite which varies directly with broadcast power of the satellite. The determining factor tends to be the number of receiving sites though other complicating factors intervene.

The third instance where a general computer model is useful is when a local educational planner gains information he otherwise would not be able to obtain or utilize without the model. For example, if the model turned out to be the best source of equipment price information available to him because of the expense of collecting such information, a prepackaged model would be desirable, although information of this type becomes dated very quickly.

Generally, the point is this. A computerized model is necessary to answer questions complicated by cost interactions among user requirements, local communications infrastructures, system size, population distribution, and technological requirements. A computerized model is unnecessary to make first approximations and to find generalized "lessons," even if the latter are somewhat oversimplified.

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*See, for example, Stagl, et al. Computer-Aided Communication Satellite System Analysis and Optimization and the references therein.

V. SELECTED TOPICS

This section presents three additional topics for discussion. Addressed are different problems of formal cost modeling and cost optimizing.

Formal Cost Modeling

This sub-section outlines a very general and abstract introduction to cost estimating from a formal perspective.

The complete cost estimating model of Section II of this chapter can be expressed as a vector of m components:

$$\begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ \cdot \\ \cdot \\ \cdot \\ C_m \end{bmatrix}$$

Each component is a numerical value, corresponding to a component or cost center in a Planned Program Budgeting System. As long as each component's cost estimate is independent from all the others, then total cost is simply the sum of the components:

$$\text{Total Cost} = C = \sum_{i=1}^{m} C_i .$$

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Each component is estimated from a set of data or variables. For example, let N represent a set of demographic variables, Q a set of user requirements; T, technical factors; and, P, financial factors. Then, the ith component can be written as :

$$C_i = c_i(N, Q, T, P).$$

In the complete cost model in Section II and the comparative model of Section III, the cost components were linear in any one variable. In such a simple case:

$$C = c_1(N,Q,T,P) + \ldots + c_m(N,Q,T,P)$$
$$= f(N,Q,T,P).$$

This formulation works in making comparative estimates as long as (a) the cost estimate for each component represents an optimum cost arrangement and (b) the estimate for each component is independent of the estimate for every other component; then the summation of the component estimates yields an optimized cost for the total system. This allows for the comparison of cost estimates for different systems defined over the same set of variables. If the components are not independent, then there is no guarantee that the summation of individually optimized cost estimates yields an optimal estimate for the entire system. The importance of the simplifying assumptions used in constructing the complete and comparative models is now clear. If they are not made (or are not valid), then the comparisons between delivery systems based on different modes are not valid.

Two basic methods are available for making cost estimates. A deterministic or nonstochastic technique was used in this report. For a delivery system of a certain size and description, a technologically determined amount of equipment is required (for example, each school has a receiver terminal), so given the price of the equipment, a major part of the costs of the system is readily computable. There was no estimating

of parameters using statistical techniques. This stochastic approach is the second method; however, the data necessary for employing this method were not available.

Sharable Costs and Optimal System Size

Section II of this chapter and Appendix A suggest that certain costs will be relatively insensitive to the number of users or schools being served by a delivery system. As a result, this class of costs can be termed "sharable." The larger the system in terms of number of schools, the lower each school's share. Figure A demonstrates the effect of "adding" schools to a system. For example, let Q_0 represent a fixed number of hours of programming owned by the delivery system. An increase in the number of schools could lower the share of this cost for each school from P_0 to P_1. All savings of this sort can be plotted against the total number of users or schools in the system. This is illustrated in figure B with the vertical axis measuring dollar savings and the horizontal axis the number of users. The curve S depicts the savings. S flattens out since the total value of the sharable costs is fixed. Figure B indicates that the larger the system, the better.

However, increasing the number of schools in the system can also increase certain types of costs. For example, if schools have scheduling preferences, interference with these preferences represents a cost. Figure C contains a curve labeled C which shows costs of this sort increasing with system size. The vertical distance between the curves S and C provides a measure of net welfare gain from increasing system size. The optimal size of the system corresponds to the point of maximum net welfare. The curve W duplicates the vertical distance between S and C and demonstrates a maximum at $\bar{N}$. Clearly, the way the curves are drawn illustrates that

FIGURE A

Joint Consumption

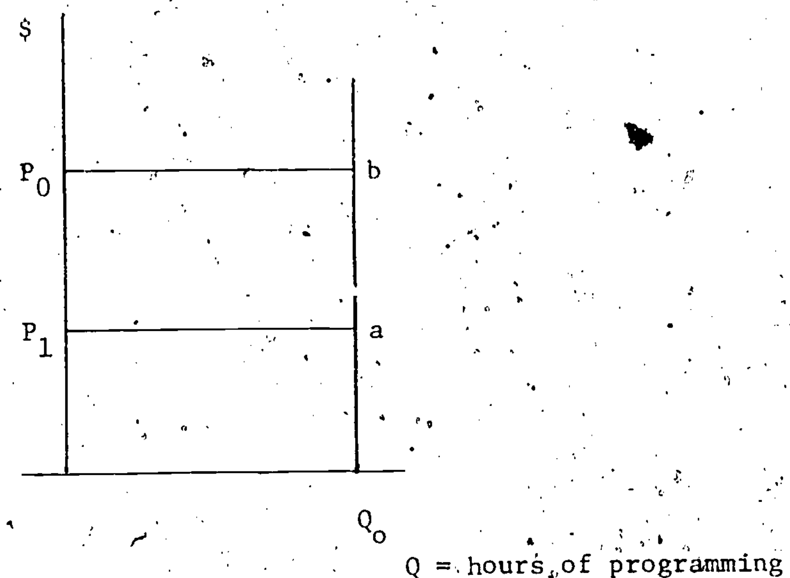


FIGURE B

Cost Savings

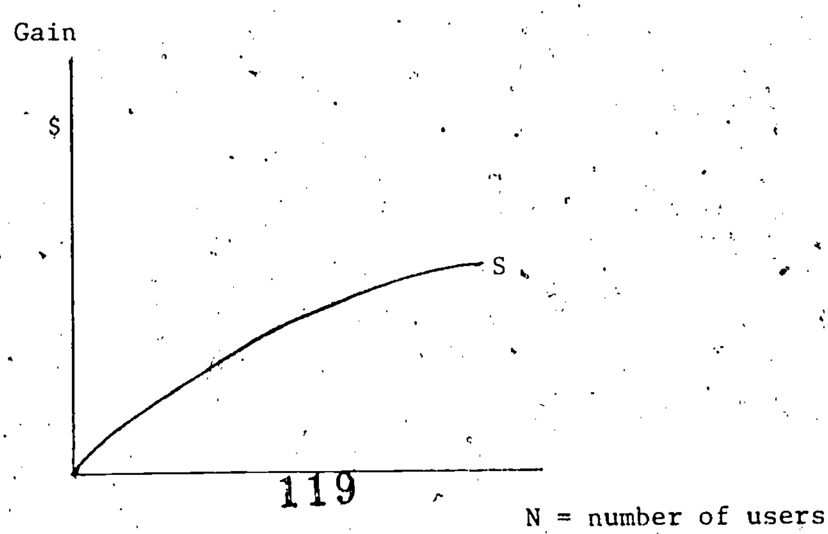
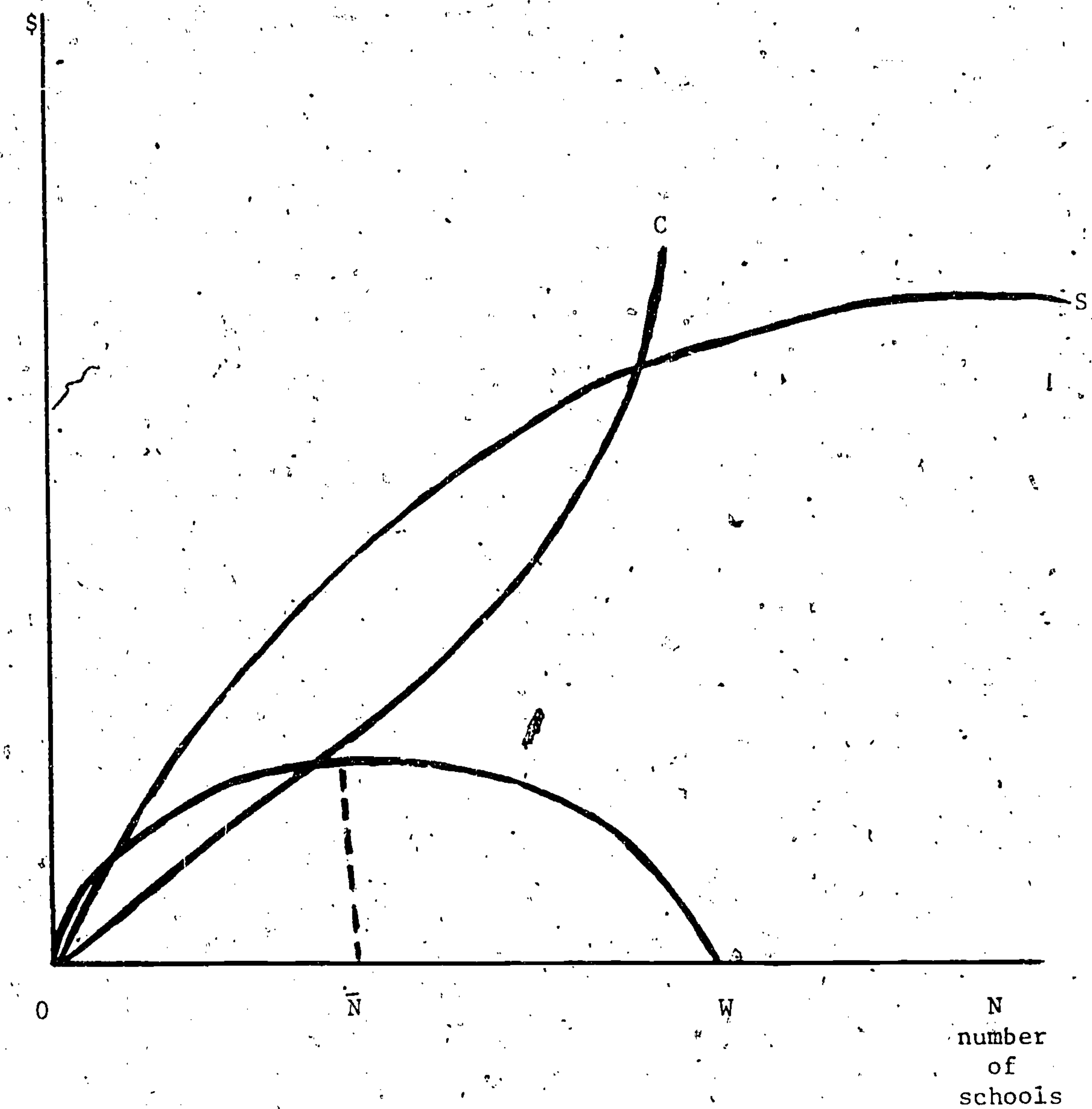


FIGURE C

Optimal Size



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"large" may not be the best type of system. Issues of local control of programming and scheduling and the possibility of a larger system being more insensitive to user preferences than a smaller system have suggested the way that the curve C should be drawn. The exact location of the curves is not the point, but rather that besides economies of scale in media systems there can occur diseconomies of scale.*

Costs and Levels of Decision-Makers

Depending upon the decision-maker and his perspective, different alternatives can appear cost-optimal. Take for example the case where a state has made accurate cost estimates for a variety of ITV delivery systems and has hit upon a cost optimal way of delivering services. The state planner may find that some local school district will disagree with his choice because, for the local district, some other option will provide the service at lower cost. Perhaps, the state wants to go satellite direct but one local district can get all the cable transmission capacity it wants for free because the local cable operator has excess channel space and is highly cooperative. Of course, some compromise could be reached between the state and local district, but this example illustrates that incompatibilities can arise.

Other circumstances can arise so that optimal cost solutions to ITV delivery problems do not suddenly seem so optimal. For instance, the least cost way of providing ITV to a school district is actually by mailed videocassettes; however, the local district would have to pay for the entire videocassette system itself and has found that if a relatively more expensive ITFS system was to be installed, a large share of the cost would be paid for by either state or federal money. The optimal decision for the school district would be to go ITFS; although in terms of total cost, the mailed materials system would be optimal. This illustrates an important point. Dollar and cents decisions are not based upon what the cost of decision is to society at large, but rather what the cost

*See above, the discussion on flexibility.

is to a subset of the total population which happens to contro decision. There is often a divergence between what economists social cost and the costs influencing decision makers.

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VI. CONCLUDING REMARKS

The preceding sections were concerned almost exclusively with considerations of the cost of ITV delivery systems. Remembering that the issues examined in this chapter have been treated with this cost perspective, here are some summary points:

1. Programming costs are a dominant feature of ITV systems, the degree of dominance depending upon the quality and expense of the individual programs and upon the level of commitment to ITV in terms of hours of non-repeated programming.

2. Of all available delivery modes, high-powered satellite direct broadcast to schools appears to possess the highest degree of sharable costs --those costs that can be spread over large user populations. Satellites are most competitive with other delivery modes when the number of broadcast hours is large, the number of schools served is large, and the geographical area is large.

3. Very few other general conclusions can be drawn from the analysis because the costs incurred by most of the delivery modes are highly sensitive to localized variables such as population distribution and the topography of the coverage area. If the population is dense with a flat terrain with few obstructions, ITFS might be the desirable delivery mode. However, if cable systems are in place and schools have access to channel space with only nominal charge, cable could be a better choice. Generalizations cannot be expected to apply to specific areas.

4. Hybrid systems which employ more than one delivery mode to serve a user population can provide cost savings and are as likely to develop as are pure systems using only one delivery mode. The existing communications infrastructure in a region is highly relevant in determining the choice of a delivery mode.

5. Scheduling flexibility and local and teacher control over the media's use are central factors that are likely to influence both the cost and acceptance of ITV. The larger the system, the less local control and flexibility (or the more expensive it is to provide those features). The inherently most flexible system which offers the most local and in-classroom control is mailed materials.

6. Perhaps the most important issue surrounding the development of ITV delivery systems, especially large scale systems, may not be total cost or comparative cost, but how much they cost whom. Local school districts will favor services they can receive at little direct expense so as not to strain their already aching budgets, while other decision-makers will likewise be aware of the possibility of funds coming from other levels of government. The Federal Government can very much influence the future of ITV in this country by making aid available to states and school districts for certain types of systems based upon particular delivery modes or by making or not making aid money available at all.

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CHAPTER THREE

A COST-SERVICE STUDY OF NINE SELECTED ITV SYSTEMS

I. INTRODUCTION

Background

The distribution and use of ITV in the United States today is at a crossroads in its evolution. Revolutionary technological advances over the past decade--ones which are everywhere affecting our society--have also radically changed the "state of the art" in ITV distribution. Prices of standard equipment have plummeted, making it more affordable, while innovations such as small videocassette recorders for student and teacher use have opened-up opportunities that were unthinkable a decade ago. These advances have also prompted changes in the legal restrictions on ITV distribution and videotape copying.

This progress in the affordability and availability of new ITV technology and courseware over the past ten years has been paralleled, however, by deteriorating budgetary conditions in many schools due to inflation, tax-payer revolt, and falling enrollments.

A new factor is the Corporation for Public Broadcasting's possible interest in gradually releasing Public Television stations from their ITV duties in order to increase services to the larger home market. This could eventually affect more than 90 percent of all ITV-using schools who depend on Public Television to meet their ITV needs.

ITV's future will be determined in large part by whether the legal and technological progress will improve the availability, affordability, and individualized learning quality of ITV enough to off-set its disadvantages. And alternatives to VHF/UHF mass-media may have to be found which distribute ITV in better and cheaper ways. Meanwhile, there are many people who have experience in the advantages and problems of ITV. That experience should be available to decision-makers.

Selecting The Case Study Systems

A desire to complement our analysis of the Educational Satellite Communications Demonstration (ESCD) influenced our initial criteria for selecting case study sites. The ESCD had been built exclusively around a satellite-based distribution system. Since neither institutional users nor student participants paid for the services they received, the demonstration provided little basis for discovering user preferences among alternative program formats.

As a way of enhancing our understanding of ITV delivery system alternatives, the EPRC decided to look at nine existing ITV systems that do not use either satellites or traditional Public Television. These include non-traditional Public Television, school district-owned multi-channel broadcasting, two-way "live" interactive broadcasting which simulates the college classroom, distribution via cable, and the transporting of videotapes that students and teachers can use in their own ways. Besides this general "diversity" criterion, four other more specific selection criteria were used:

1. The nine systems are all operational, not experimental;
2. The nine systems are successful and self-sufficient and have proven their abilities to meet enough of the needs of their educational constituents to survive and grow;
3. Each of the systems attempts to use its ITV conveyance technologies to meet the specific needs of its assortment of constituents at the least cost; and
4. The nine systems span a range of sizes from 12 ITV receiving sites in the University of Southern California system to 700 sites in the Cleveland, Ohio system.

The Data Base

The data base for the studies consists of some quantitative information about (a) user demographics, (b) technical system capacities, (c) the ITV programs and services dispensed to users, and (d) system costs. It also includes qualitative judgments about the most appropriate applications of each

technology. That data base has been established through the cooperation of the administrators of the nine systems.

These administrators have displayed sufficient creative resourcefulness to keep their systems improving and expanding without relying on Public Broadcasting's financial support. The EPRC, unfortunately, did not have the time or resources to survey teachers and students to find out about their attitudes toward the ITV system they use. Instead, we had to rely upon the administrators' judgments of their constituent's needs and the technical changes in their systems required to meet those needs.

Purpose and Structure of the Study

The purpose of the study is to compare the costs and services of different ITV systems. Estimates of the values of the services are dependent on both the contexts of each system and on the attitudes of its administrator. The analytical goal is therefore (1) to describe each system's services and how well it meets the needs of its constituents (as perceived by its chief administrator) and (2) to associate these descriptions and evaluations of the services with differences in the costs of providing them.

The study is therefore divided into two parts. The first part contains the case studies. Here emphasis is placed on identifying the things about each system that are distinctive and notable. The case study approach makes it possible to think of each system in terms of its potential as a model for other ITV systems in the future.

The second and briefer part compares the systems to one another in terms of the things they have in common. Here emphasis is placed on the general cost and service advantages or disadvantages of the conveyance technologies used in the separate systems described in the first part.

The Basis for Cross-System Comparisons

Cross-system comparisons of costs and expenditures are relatively problem-free in the following case studies. The budgets of different systems vary considerably in how the elements and activities of each system are classified, but conversations with administrators have enabled us to develop common cost categories that individual budgets can be translated into.

Comparing the services provided by these systems has proven more difficult. Cost-effectiveness evaluations of each service require measuring quantities of service in terms of common units that are applicable to all of the case study systems. Usually planners and researchers evaluate ITV systems in terms of how much the consumption of the system's services cost. The most popular unit of measurement is the "student-contact-hour." Final evaluations are then framed in terms of "costs per student-contact-hour."

However, only two of the case study systems have surveyed their teachers to find out how many students are using and consuming ITV. This has forced us to develop new measurements of service that are based on data that most of the systems (seven of the nine) do have available.

Two kinds of measurements are used in the case studies. The basic unit of measure for both is the "potential classroom contact hour." This unit differs from the "actual student contact hour." First, it does not take into account whether there are any students in the classrooms or whether the TV set in the room is turned on. It measures only potential consumption.

Second, this unit is based on the TV-equipped classroom, not the student consumer. This is because most of the systems studied here did not know how many students are in the average TV-equipped classroom to which they conveyed ITV.

The first of the two kinds of measures is called "Volume of Service."

It measures how much service each system provides and is a function of (1) how many classrooms in the system are equipped with TV sets, and (2) how many total hours of ITV are conveyed to those classrooms.

The second kind of measurement is called, "Potential Classroom Consumption." It measures how much ITV could realistically be used or consumed by the TV-equipped classrooms in the system. This measure modifies and decreases "Volume of Service" measures in two ways:

1. According to the volume of service measure, if an ITV distributor conveys 4 channels of programs to a classroom's TV set simultaneously, it records this as "4 potential classroom contact hours." But, since no TV set can display 4 channels simultaneously, "Volume of Service" does not realistically measure how much ITV could be consumed by anyone in that classroom. The "potential classroom consumption" measure corrects this by recording only "1 potential classroom contact hour."

   However, this more realistic measure of potential consumption ignores the important fact that the 4-channel system is providing the classroom with 4 alternative programs to choose from. Since freedom of choice and program variety are considered desirable by educators, "Volume of Service" is not discarded in favor of just "potential consumption" as the only measure of a system's offerings.

2. According to the "Volume of Service" measure, high school programs can be consumed by elementary classrooms, and vice versa. The "potential classroom consumption" measure corrects this unrealistic assumption by decreasing the size of the measurement to exclude high-school classroom contacts with elementary programs and elementary-school classroom contact with high school programs.

   Because there are so many exceptions in which programs primarily intended for classes at one level are used by classes at another level, "Volume of Service" is not discarded.

To sum up, services in seven of the case study systems are measured in these two ways:

1. "Volume of Service" (ND, potential classroom consumption) where

the "ND" indicates (a) that the measure is non-specific in regard to the consumability of different types of programs by different types of classrooms, and (b) that it is sensitive to the diversity of channels the system offers the classroom.

2. "Potential Classroom Consumption" (I-S, potential consumption) where the "I-S" indicates (a) that the measure is institution-specific (elementary/high school classrooms and programs), and (b) that it counts only once programs that are simultaneously conveyed to the same TV set.

* * * * *

ACKNOWLEDGMENTS

EPRC want to express its gratitude to the administrators who devoted so much of their time and energy to providing us with information about their systems. As is not unusual in research projects, we asked for and received much information that was not ultimately used, but the administrators were never lacking in cooperation and patience. They are not, of course, responsible for errors, nor do they necessarily agree with all of our interpretations of the data they provided.

CASE STUDY I

INSTRUCTIONAL TELEVISION CENTER, ARCHDIOCESE OF NEW YORK

Overview

The outstanding features of this system are as follows:

1. Its annual operating budget has been kept remarkably small in comparision to other systems largely because of its comparatively small outlays for ITV programming and administrator salaries and because of the dedication and energy of its supporters.
2. The unusual geographical and population distribution features of the system have made necessary the creation of a large and elaborate ITFS transmission system. This system provides data for estimating the capital costs of an ITFS system in a setting that is adverse and unaccommodating.
3. The ITV conveyance capacity of the system is large enough to permit five telecasts of each program, a frequency level that teachers indicate is adequate for scheduling convenience.

Introduction

This first of the case study systems is a member of the Catholic Television Network (CTN), a loose confederation of ten instructional television fixed service (ITFS) systems serving mainly parochial schools in eight metropolitan areas in the U.S. Three of the ten CTN ITFS systems serve the New York metropolitan area (New York, Brooklyn, and Rockville Center). The others are located in Chicago, Boston, Detroit, Miami, Milwaukee, Los Angeles, and San Francisco--the confederation's headquarters. Reaching 1748 receiving sites daily over 32 channels, the CTN has striven for ten years to reduce expenses for its members by sharing costs for program acquisition and for new equipment. The CTN cites the following as ITFS technology's advantages over normal ITV broadcasting (from the CTN public information brochure):

* Four channels can broadcast different programs simultaneously.
* ITFS can target smaller audiences with specialized needs.
* Individual call-ins can be served with "special request" programs.
* ITFS transmitting equipment costs considerably less than standard TV.

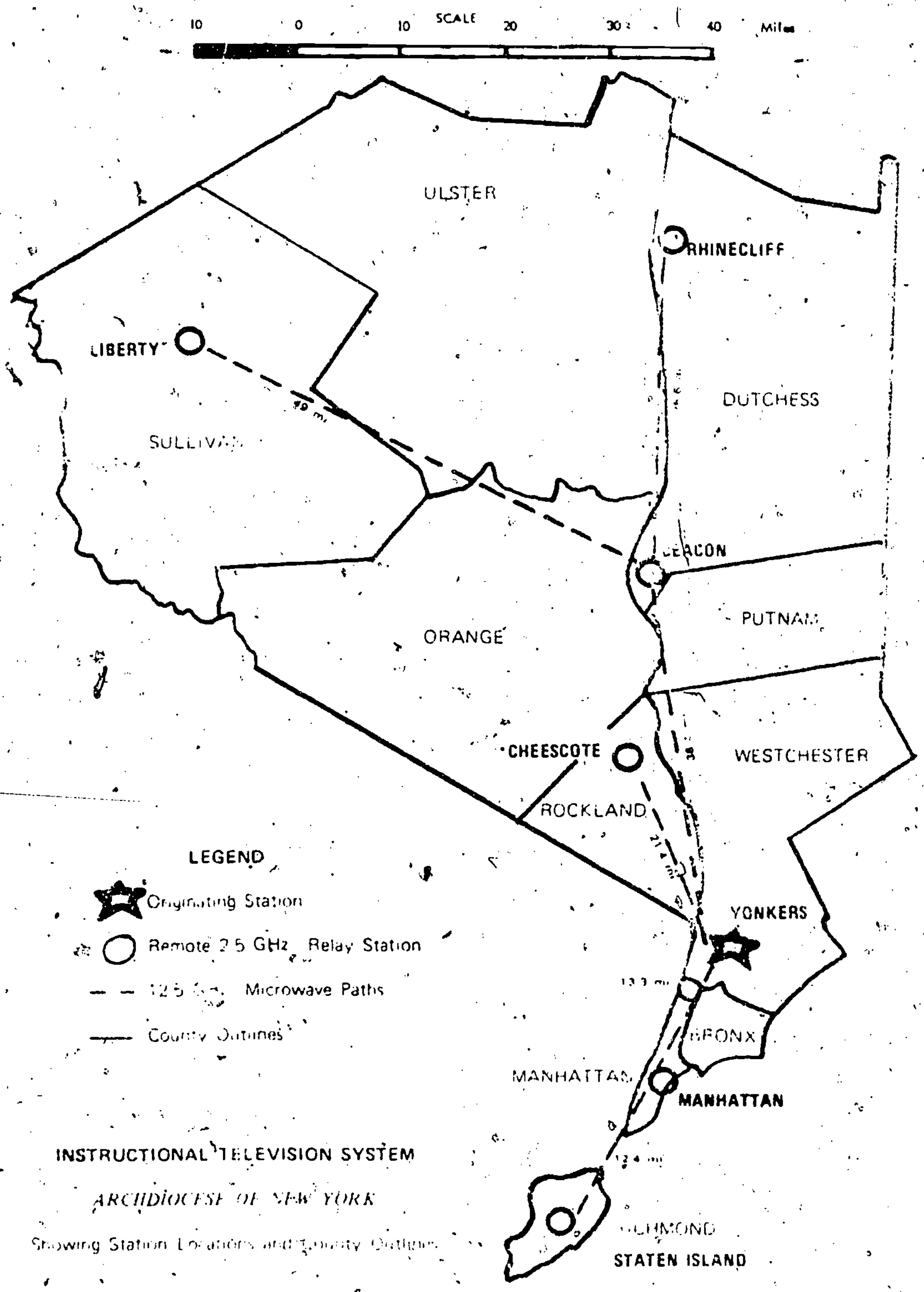
Geographical Features

Since this Archdiocese is composed of ten counties located in a 4,717 square mile expanse, several 300 foot towers were erected to transmit three channels of ITV to more than 230 parish schools and hospitals. The originating signals at the New York Instructional Television Center (ITC) are sent by three high frequency (12 GHz) signals over distances ranging from 14 to 38 miles to three translator transmitters in Manhatten, Cheescot (Rockland County), and Beacon (Dutchess County). The Manhatten signals are retransmitted 12 miles to Staten Island. The Beacon signals are retransmitted 28 miles to Rhinecliff (northern Dutchess County) and 49 miles westward across the Hudson River to Liberty (Sullivan County).

The first broadcast of the New York Archdiocesan Instructional Television Center took place on May 17, 1966. In October 1966, the ITC began a complete broadcast schedule on its three Channels 8, 10, and 12.

One of this system's interesting aspects is that it conveys ITV to both densely and sparsely populated areas within a large region equivalent to one having a radius of nearly 39 miles. The map below describes the geographical configuration of the system.

Detailed cost and technical data on five of the "remote relay stations" are not available since the data were stored away 10 years ago. However, cost and technical information is available for the two most important and expensive stations; the Yonkers origination station and the Beacon relay station.



INSTRUCTIONAL TELEVISION SYSTEM

ARCHDIOCESE OF NEW YORK

Showing Station Locations and County Outlines

This system is complicated by the fact that unidi[illegible] missions to other relay stations occur in the 12.5 GHz directional transmissions to receiving terminals at us[illegible] the 2.5 GHz band. This means, for instance, that the [illegible] on top of the Empire State building has three 12.5 GHz channels coming from Yonkers, three 12.5 GHz transmitt[illegible] going to Staten Island, and three omnidirectional 2.5 [illegible] for three channels going to user receiving terminals i[illegible] area.

The whole transmission system was built in one pi[illegible] origination station in Yonkers cost $177,000 (1966 dol[illegible] Beacon Station cost $235,000 (1966 dollars). The chie[illegible] for the transmitters ($75,000) and the 300 foot tower ($99,000). The Beacon Station's costs were identical Yonkers Station except for an additional $60,000 for l[illegible] We may estimate that the other stations cost approxima[illegible] $786,000, for a total transmission system cost in 1966 (not including costs at user sites for microwave recep[illegible] equipment).

The entire transmission system cost $254 per squa[illegible] coverage area and $5,357 per average site (elementary However, these figures mask the great disparities betw[illegible] to transmit to the average remote site in the sparsely and what it cost to transmit to the average site in th[illegible] regions. The table below displays these and other dis[illegible] not include four colleges and nine hospitals.)*

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*The individual costs of all the transmitters but are uncertain, so the amounts in No. 10 through No. 1[illegible] the subsystem columns.

TABLE I-A[b]

SUMMARY DATA:
INSTRUCTIONAL TELEVISION CENTER, ARCHDIOCESE OF NEW YORK

	Sparsely[a] Populated Regions	Densely[b] Populated Regions	Whole System
1. Area (square miles)	4,162	555	4,417
2. Student population	14,900	83,104	98,004
3. Number of reception sites	39	185	224
4. Number of ITV classrooms	525	2,535	3,060
5. Number of rooms per school	15	14	14
6. Number of students per school	382	449	438
7. Number of schools per square mile	.01	.33	.05
8. Number of students per square mile	3.6	150	20.8
9. Number of rooms per square mile	.13	4.6	.65
10. Transmission system capital costs[c] (approximate, in 1966 dollars)	$687,000	$513,000	$1,200,000
11. No. 10 per square mile	$ 165	$ 924	$ 254
12. No. 10 per school	$ 17,615	$ 2,773	$ 5,357
13. No. 10 per classroom	$ 1,310	$ 202	$ 392
14. No. 10 per student	$ 46	$ 6	$ 12

[a]Rockland, Putnam, Orange, Sullivan, and Ulster Counties.

[b]Westchester (Yonkers), Bronx, Manhatten, and Richmond (Staten Island) Counties.

[c]These are absolute costs that have not been amortized over the subsequent 10 to 15 years. Since this equipment is expected to last until 1981 or after, No. 14 is highly misleading and the costs there should be amortized and distributed over all students from 1966 to 1981.

A fourth ITV channel is presently being added to the existing three channel system to provide medical programming to 11 hospitals. The existing three ITV channels will be used in the hospitals by young patients, but channel space is needed for special professional medical programming for hospital staff without crowding the existing capacity that has always been reserved for elementary and secondary ITV. The fourth channel will probably only be received by the hospitals.

The capital cost (in 1976 dollars) for adding the extra channel to the whole system is $304,000. This includes $110,000 for 12 GHz equipment and $156,000 for 2.5 GHz equipment. Amortizing this capital cost over 15 years yields a per annum figure of $20,000.

The per site cost of this transmission equipment is high (almost $2,00(per site per annum) considering that it buys only a single channel. The per site annual share of the amortized cost for the original three-channel ITV transmission system is only about 357 (1966 dollars) per school per annum. However, the Archdiocese believes that the ITFS system can grow into the chief multi-functional communication hub for the whole area, thereby enhancing community bonds and links throughout the Archdiocese.

Capacity and Capacity Allocation

A) ITV Supply and Potential Consumption. The volume of services provided to this system's consumers can be measured, but no data exists on actual consumption of ITV in the classroom. The New York ITC's program evaluation survey instruments ask teachers about which programs they liked or did not like and about which programs they would like to have repeated the following year, but they do not ask teachers for the number of hours their TV sets are turned on nor for viewer attendance numbers.

It is therefore impossible to determine the total 1975-6 consumption of ITV in the New York system in terms of actual student-contact-hours. Nevertheless, the "volume of service" and the "potential classroom consumption" can be estimated.

In 1975-6 the New York ITC conveyed (transmitted) the equivalent of 1750 continuous hours of ITV to the elementary schools in the Archdiocese and the equivalent of 250 continuous hours of ITV to the secondary schools for a total K-12 transmission volume of 2,000 hours. Since there are 3060 elementary classrooms and 530 secondary classrooms that are wired for ITFS reception, the 1975-6 K-12 "volume of service"* was 7,180,000 potential classroom contact hours (pcch). The "potential classroom consumption"* volume was 3,201,000 pcch.

New York ITC can transmit to students for about seven hours per day 169 days per school year. This gives the system a K-12 ITV capacity of 3550 continuous hours per year over its three ITFS channels. However, it actually transmitted only about 2000 continuous hours of programs during 1975-6 for a capacity utilization rate of 57 percent.

It should not be inferred from this that the system could compress all of its transmission into two channels. If 15 minutes of each hour are reserved for recess, changing classes, etc., then the utilization rate rises to 76 percent. Scheduling flexibility is an equally important factor. It is usually the case that all three channels are in simultaneous use and that, for instance, two channels are needed when one 15 minute program has to begin before another 20 minute program is finished.

The extra margin of capacity in this system can be regarded as providing the traffic schedule flexibility needed to ensure that the timing of ITV transmissions can be determined according to criteria of educational excellence and user preference instead of according to criteria of traffic compatability imposed by technological constraints. The Center was rarely forced to reject an important program having valuable educational content just because its length did not match existing gaps in the schedule.

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*For a discussion of these concepts, see the Introduction to the Cost-Service Study.

On the other hand, the 57 percent (perhaps more realistically, 76 percent)* capacity-utilization rate may say something about _ad hoc_ short lead-time transmissions in response to individual telephone "special requests." Gaps did exist in 1975-6 schedule and could have been filled if users had chosen to receive transmissions at those times.

There are several possible explanations of why users did not try to take advantage of these schedule gaps. The most plausible explanation is that the popular high quality programs were already aired so often that extra repeated transmissions of them were unnecessary. The Archdiocese has been unable to purchase a large library of high-quality elementary programs to supplement the programs already included in the formal schedule. So an individual request for a special _ad hoc_ transmission of a program during a gap in the schedule is usually a request for a transmission of the program that is additional to the five repetitions of that program that have already been scheduled. This may suggest that the Center needs, not less capacity, but greater financial support to acquire supplementary high-quality programs aimed at serving individual needs for a wider range of diverse programs (not a wider range of viewing-time opportunities). It also suggests that five repetitions per program are sufficient to meet individual user needs for scheduling flexibility and convenience.

B) _Mass Scheduling and Individualization_. The ITV Center reserves about six hours per day, or 30 percent of its absolute capacity, for responses to individual requests for transmissions of programs on a "call-in" basis. This service is called "Dial-a-Lesson." The rest of the absolute capacity is reserved in the more conventional mass-scheduling way for transmissions that are scheduled well in advance of their transmission dates on a system-wide mass popularity basis. The utilization rate for mass-scheduled transmission is fairly high at 69 percent (90 percent).

*The "76 percent" in parentheses is a reminder that the 56 percent is absolute and does not take into account the fact that students are not really able to view ITV for more than about 75 percent of the 60-minute hour.

TABLE I-B

SYSTEM UTILIZATION: INSTRUCTIONAL TELEVISION CENTER, ARCHDIOCESE OF NEW YORK

	Total Number of Hours	Utilization's (% of)	Scheduled Original's (% of)	Scheduled Repetitions (% of)	Unscheduled Transmissions (% of)
A: 1975-76 Actual ITV Capacity in Continuous Hours	3,550	57% --	10% --	39% --	8% --
B: 1975-76 Actual ITV Utilization	2,000	100%	80% --	20% +	14% --
C: Scheduled Original ITV Transmissions	344	--	100%	--	n.a.
D: Scheduled Repetitions	1,376	--	--	100%	n.a.
E: Unscheduled Transmissions	280	--	--	--	100%

Estimated Potential Volume of Services:

Volume of Services: 7,180,000 per classroom contact hour

Potential Classroom Consumption: 3,201,000 per classroom contact hour

So the lower 57 percent (76 percent) overall utilization rate noted in the preceding section is obviously due more to the under-utilization of the individualization capacity than it is due to the under-utilization of the mass-scheduling capacity.

Both elementary and high schools in the Archdiocese can take advantage of "Dial-a-Lesson." But the ITV Center conveys secondary level ITV to secondary schools in the Archdiocese <u>only</u> on an individual "special request" basis. Here is how the Center presents this program to the teachers:

> Realizing that the use of television at the secondary school level requires a different approach from the one used successfully with the elementary grades, ITV will offer high school programs on a call-in basis.
>
> To use <u>Dial-a-Lesson</u>, the teacher surveys the contents of the Broadcast Manual and selects the programs from particular series that he or she wishes to use for student instruction. Having selected the lesson, the teacher then writes or telephones the ITV studio and makes known the request stipulating the desired day and time of broadcast.
>
> Priorities, of course, must be established by selecting for telecast those programs receiving the most requests and for special programs that must be broadcast.
>
> It is hoped that high school teachers will view <u>Dial-a-Lesson</u> with its request feature as being more useful than the rigidly scheduled broadcast of a regular ITV series and an easy method for obtaining lessons on a "what-I-want-when-I-want-it" basis.

The New York ITC possesses 27 series of programs for secondary students in 11 subject areas with an average of 16.5 programs per series. Since the average length of each program is 25 minutes, this library collection contains nearly 190 continuous hours of programming tailored to the secondary classroom. To this must be added 31 hours of other special programs that are not arranged in series and are targeted at secondary, college, and adult viewers. Altogether, "Dial-a-Lesson" contains 220 continuous hours of programming.

As promising and progressive as this program appears to be, it is less well utilized than one might expect. The New York ITC reserves almost 31 1/2 hours of its total weekly transmission capacity for "Dial-a-Lesson." This means that a total of more than 1,000 continuous hours of capacity are reserved for "Dial-a-Lesson" during the 169 day school year. Yet the Center reports that only the equivalent of about 280 continuous hours were actually transmitted on this basis during 1975-6. This represents a utilization rate of about 28 percent (37 percent) of total reserved capacity.

There is no question that the prime target of the overall system is the elementary school child. It is therefore understandable that priorities for formal scheduling favor program popularity rankings by elementary school teachers. That the utilization rate for "Dial-a-Lesson" is only 28 percent, may indicate that "call-in" individualized scheduling of single programs is suited to one set of teachers while mass-popularity scheduling of semester-long ITV series is suited to a different set of teachers. On this hypothesis, "Dial-a-Lesson" would seem to attract the teacher who wants both the control and the responsibility for the organization of his/her course. It might tend to discourage the teacher who appreciates the outside help in structuring his/her course afforded by textbooks, departmental exams, and semester-long rigidly scheduled ITV courses.

C) <u>ITV Utilization in the Schools</u>. In 1975-6, the New York ITC devoted about 9 percent ($25,000) of its operating budget to providing ITV utilization support to the schools. This component appears to be vigorous, well-planned, and highly cost-effective (especially given that one-third of the utilization-support budget went to printed teacher support materials for the ITV programs).

Utilization-support services fall into two categories: "Teacher Education" and "Services." Teacher education activities include visits to most of the schools each year to discuss programming and ITV utilization programs with teachers and to provide information to school faculty meetings.

The purpose of these visits is both to give and receive information. Currently, the ITV staff is recommending the division of each ITV class into groups in order that one group (equipped with individual headsets) can watch program transmissions at the same time that other groups are receiving face-to-face instruction from the classroom teacher. The ITV staff is also trying to persuade teachers to overcome semantic prejudices by recognizing that programs labeled for certain specific subject areas can be effectively used in other subject areas. Finally, the ITV staff is constantly trying to gather information from the school staffs about their needs, the quality of the programs, and scheduling problems. The ITV staff hopes to be able to use profiles of teachers and students to increase interest and support for ITV in those who have been unenthusiastic in the past.

The second "Services" category of activities includes (1) an ITV newsletter and the sale of guidebooks and schedules, (2) sale and installation of headsets for individualized student use, and (3) the collective coordination of service contracts for maintaining and repairing receiving equipment in the schools.

In early 1976, the utilization staff (Suzanne Rothenberg aided by Suzanne Berard) designed and implemented a survey instrument to serve the needs of the Archdiocese. The results of this survey appeared in the New York ITC's "Study to Determine the Teacher Attitudes and Utilization of Television in the Classroom." The general goals of the study were to determine "(1) the frequency of viewing according to subject area in grades four through eight, and (2) the correlation, if any, of specific teacher attitudes and experience to the frequency of viewing." (p. 1) the focus of the analysis was on detecting positive correlations between frequency of teacher use and responses to statements/questions about factors that were suspected of being causally connected to frequency. Over 700 teachers responded to the survey.

The statement/question in the survey that is of most interest here was No. 13: "Scheduling is a major problem in using ITV." Teacher responses showed that in only 47 percent of the cases were frequent users of ITV correlated with schedule complaints or infrequent users of ITV correlated with no schedule complaints. So, there was only a slight positive correlation between frequency of use and scheduling complaints. This is exactly what one would expect if the system is doing an adequate, but not a superlative, job in getting programs to users when they want them.

D) Courseware. Nothing will be said here (or in any of the other case studies), about the quality of programming that is delivered by the ITC to the schools in the New York Archdiocese. Something should be said, however, about the sources of the courseware since the cost of the courseware is one of the three factors that makes this system's operations budget so remarkably low.

The ITV Center's two principal sources of programming are the New York State Department of Education and the Catholic Television Network (CTN). The New York State Department of Education considers the ITC as simply a resident purchaser of its programs on a par with any New York State school, school district, or New York State citizen. The State buys and leases programs from the major vendors either on its own or as a member of buyer-consortia. It then makes these available in most cases to any resident of New York State for only a small business operation fee plus the costs of dubbing the programs on the buyer's tapes. (The buyer can do his own dubbing and not pay the State for this.) In any event, the buyer must supply the tapes. No fewer than 20 full elementary school ITV courses were acquired from the State in 1975-76 on this basis.

The New York Archdiocese also joins with some or all of the other members of CTN to purchase programs on an ad hoc consortium basis. Different vendors have different cost-per-member schedules. Generally,

if all ten members of CTN agree to join together in a temporary <u>ad hoc</u> consortium to buy a certain ITV course, the price of the course for each member will be anywhere from 20 percent to 75 percent lower than the price the member would have had to pay if it had purchased the course separately. This per-consortium-member price reduction shrinks as fewer CTN members are involved in buying the course.

<u>Costs</u>

A) <u>Capital Expenditures</u>. In order to compare this ITFS system both to other ITFS systems and to ITV delivery systems based on other kinds of conveyance technologies, the costs for building the microwave transmission/reception system are separated from capital and other expenditures which would be incurred by any ITV delivery system.

This ITFS system's principal capital expenditure was for the construction of the microwave transmission system. A large initial expenditure was required because (1) the system as a whole has a relatively low student population density thereby requiring multiple translator-transmitters to achieve adequate coverage, and (2) the Manhatten area has many tall buildings, thereby requiring an extra translator-transmitter perched on top of the Empire State Building.

The transmission system start-up capital expenditure came to $1.2 million (1966 dollars) for one main transmitter and six translator-transmitters. Given that most of this equipment will last for 15 years (1966-81), and since the average annual enrollment in the system is around 100,000, the <u>annualized per student</u> cost of this basic <u>transmission</u> equipment is $1,200,000 ÷ (15 x 100,000) = 80 cents per student per year. If the annual potential consumption (I-S) is 3,201,000 pcch, then the <u>annualized per potential classroom-contact-hour</u> cost of this transmission equipment is 2.5 cents.

By comparison, total reception equipment costs came to around $600,000 (1966 dollars), half the size of the capital cost of the transmission side.

The entire conveyance system (transmission and reception combined) cost a total of $1,800,000 to construct. For purposes of comparison to other kinds of ITV conveyance systems, this cost amounts to $8,036 per school and less than 4 cents per annualized potential classroom contact hour.

These figures do not include the cost of building the main production studios and the control rooms at the Yonkers facility which come to a total of around $2 million. Thus, the total initial capital investment in this ITV distribution system came to $3.8 million ($2.53 per student per year, 7.9 cents per pcch). However, since most of this money was spent in 1966-67, this estimate may be considered misleadingly low since it does not reflect the effect of inflation. To state capital costs in terms of 1976 dollars, the estimate can be multiplied by an inflation factor of 1.65 to yield the corrected estimate of $6,270,000.

Although this number is technically superior to the 1966 figure, it may actually be more misleading in certain respects since the ITV electronic equipment needed for both conveyance and program production was, in constant dollars, far more expensive in 1966 than it is for a comparable facility today. The Archdiocese of Chicago, for example, needed only $2.3 million to equip a very sophisticated modern facility for program production and control room functions, and $1.7 million for a conveyance system that is roughly comparable to New York's. So it seems that technological progress in this area has kept pace with inflation.

The New York ITC reports that no significant capital expenditures were made between 1966 and 1975 when $700,000 was (and is still being) spent on converting transmissions from black and white to color. So, (excluding the $300,000 cost for adding on the fourth channel) we can

estimate that the grand total capital outlay for this ITFS system is in the neighborhood of $4,500,000 (unadjusted dollars) or $7,000,000 million (1976 dollars) over the 11 year period from 1966 through 1977.

B) Operating Expenditures. On the face of it, the most remarkable feature of this system is that its annual operating budget for 1975-6 was only $288,000 ($2.90 per student, 9 cents per pcch). The primary reason for this low figure is the extremely small portion of the budget that is devoted to program acquisition and production: $36,500. One might have expected a figure an order of magnitude greater. Secondary explanations for this low figure are (a) the absence of salaries for the chief administrators of the system who are members of the Archdiocesan Sisterhood, and (b) the dedicated and self-sacrificing support from the staff and the Archdiocesan community. This programming expenditure accounted for only 12 percent of the total operating budget which compares to 14 percent ($39,000) for equipment maintenance and repairs and 16 percent ($46,000) for building rentals and utilities.

Three hundred thirty-six hours of elementary programs, and 120 hours of high school programs were acquired "out-of-house" (mainly from the State of New York) for $12,475 and $2,100, respectively. To this must be added approximately $6,000 that the ITC paid for dubbing its own copies. Also acquired "out-of-house" were approximately 200 hours ($2,000) of college programs and 100 hours ($1,500) of teacher in-service programs. Seventy-one hours of elementary programs, and 68 hours of high school programs, were produced "in-house" for $2,500 and $12,000, respectively.

TABLE I-C

EXPENDITURES: INSTRUCTIONAL TELEVISION CENTER, ARCHDIOCESE OF NEW YORK

	Gross Amount	Per Year Amortized Over 15[a]	Per Year Per Student[b]	Per Year Per PCCH of Supply[b]	Per Year Per PCCH of Consumption[b]	Percent of Capital Costs[b]	Percent of Operating Costs	Percent of Total System Costs[b]
I. CAPITAL EXPENDITURES								
A. 1966 Start-Up Expenditures								
1. Transmission System	$1,200,000	$ 80,[illegible]	$ .80	1.1c	2.5c	31.6%		13.6%
2. Reception System	$ 600,000	$ 40,000	$ .40	.6c	1.3c	15.8%		6.8%
3. Central Facilities	$2,000,000	$133,000	$1.33	1.9c	4.[illegible]	52.6%		22.7%
B. Recent Capital Outlays								
1. Color Conversion	$ 700,000	$ 47,000	$ .47	.7c	1.5c	10.[illegible]		8.0%
TOTAL CAPITAL OUTLAYS	$4,500,000	$300,000	$3.00	4.2c	9.4	100		51 %
(Adjusted Total)[a]	($7,000,000)	($467,000)	($4.67)	(6.5c)	(14.6c)			
II. OPERATING EXPENDITURES (1975-76)								
1. Courseware	$ 36,000		$ [illegible]	.5c	1.1c		[illegible]7%	6.2%
2. ITFS Operation	$ 141,500		$1.42	1.9c	4.4c		49.1%	24.1%
3. Rents/Utilities	$ 46,000		$ .46	.6c	1.4c		16.0%	7.8%
4. Maintenance	$ 39,000		$ .39	.5c	1.2c		13.5%	6.6%
5. Utilization	$ 25,000		$ .25	.4c	.8c		8.7%	4.3%
TOTAL OPERATING	$ 288,000		$2.88	4.0c	9.0c		100.0%	49.0%
TOTAL ANNUAL SYSTEM COSTS	$ 588,000		$5.88	8.2c	18.5c			100.0%
(Adjusted Total)[a]	($ 755,000)		($7.55)	(10.5c)	(23.6c)			

[a] See section on capital expenditures for explanation.

[b] Calculated for 1966 dollars, not for adjusted 1976 dollars except where indicated by parentheses.

CASE STUDY II

THE CATHOLIC TELEVISION NETWORK OF CHICAGO

Overview

The Catholic Television Network of Chicago (CTN/C) began serving the Archdiocese of Chicago with ITV and other televised services in 1975-76. This ITFS system is discussed for two reasons: (1) it provides 1975 information about the initial capital costs needed to launch a large ITFS distribution system, and (2) it illustrates the potential of this multiple-channel technology for dispensing closed-circuit services to meet the needs of a wide and diversified range of audiences.

Geographic and Technical Features of the Conveyance System*

The CTN/C and the Archdiocese of Chicago are coterminous with Cook and Lake counties and have an area of 1,411 square miles; the ITFS transmissions actually extend beyond the perimeters of these counties to cover a potential viewing area of 2,520 square miles. Since metropolitan Chicago has a population of 5.9 million persons, the density of the area is 4,200 /person per square mile.

In 1975-76 the Archdiocese enrolled approximately 140,000 elementary and junior high school students at 363 parish schools giving the CTN/C system a student population density of about 100 students per square mile. The average parish school has 17 classrooms that are wired for ITV reception for a total of 6,170 ITV rooms in the whole system. This gives the system a high potential classroom consumption density of about 4.4 ITV reception rooms per square mile. Given the high aggregation level of 17 rooms per reception site, the Archdiocese is ideal for ITFS ITV distribution at least as far as the demographic distribution of ITV consumers is concerned.

*These features are summarized in tabular form at the end of the narrative.

The Chicago area, however, does contain enough microwave signal obstacles to require sophisticated transmission facilities. The main transmission tower (WAC-262) is perched on top of the Sears Building in Chicago's "Loop" district and reaches an above-ground height of 1,460 feet. Four channels are transmitted to the Sears Tower at 12 GHz from the main studios a quarter mile away. The Sears transmitter broadcasts ITFS C-group frequency signals to parish reception sites in a 44 mile radius. The Sears transmitter cost about $150,000.

A second transmitter (Schaumberg) is located 24 miles to the north of the Sears transmitter from which it receives 12 GHz signals. These signals are translated to ITFS F-group broadcast signals that are picked up by parish receivers within a 35 mile radius. The Schaumberg signal is also picked up 9 miles away by another transmitter (Mondaline) which translates the F-group signals to C-group broadcast signals that are received within a 14 mile radius. The Schaumberg transmitter cost about $145,00 and the Mondaline about $95,000.

Finally, a transmitter south of the Sears Tower in Orland Park picks up C-group signals from the Sears transmitter and translates them to F-group signals for broadcasts to parish receivers within a 14 mile radius. This transmitter cost about $120,000; the extra costs being for a 490 foot tower and associated installation fees.

Altogether, the entire transmission component of the CTN/C ITFS conveyance system cost about $500,000.

Turning now to the ITFS reception component of the conveyance system, there are a total of 419 sites altogether, 363 of which are parishes with schools. The reception apparatus at the average site cost around $1,600 broken out as follows: mast ($350), antenna ($240), down-converter ($325), amplifier an J-S converter ($190), and installation ($500).

Internal closed-circuit distribution wiring costs in the parishes with schools averaged close to $1,400 for wiring 17 rooms and 22 outlets. Hence, the reception costs at the average school site totaled approximately $3,000 or $176 per viewing room. If the costs for the system's transmission component are distributed among just the parish schools, then they come to $81 per classroom. So the cost for the whole conveyance system was only $257 per room, including internal wiring costs. The start-up capital reception costs for all the 363 parish schools totaled $1,090,000.

The other 56 non-school sites include 28 parishes without schools, 16 parish rectories, 2 colleges, a hospital with 125 wired rooms, and a cable headend serving two outlying school sites. Since wiring costs were less for these non-school sites, the average per site capital cost for reception was about $2,100 for a non-school system total of $118,000. This brings the total capital costs for the reception side of this conveyance system up to a little more than $1,200,000, almost 2.5 times the cost of the transmission side of the conveyance system.

Defining the "ITFS conveyance system" as all the hardware between the signal origination control room and the TV sets/monitors in the classrooms and other viewing rooms, the CTN/C system's total capital expenditure for the ITFS conveyance system amounted to approximately $1.7 million. This figure averages out to about $4,100 per receiving site.

For a system this large, one might conjecture that the conveyance system costs would constitute at least half of the total capital costs for building the system. However, the whole CTN/C sysrem actually required a start-up capital expenditure of around $4 million. Forty-three percent of this went toward the construction of the conveyance system. The other $2.3 million, or 58 percent, went toward building sophisticated program production studios and broadcast control room equipment and facilities. If this cost is distributed among just the schools in the system, it comes to $373 per classroom. Combined with the $257 per room cost of the conveyance system, the total system cost was $630 per classroom.

Capacity and Capacity Allocation

CTN/C reports that 58 K-8 series (ITV courses) were scheduled and aired during 1975-76. The average series had 30 programs or installments. The average program was about 18 minutes long and aired 3.5 times. Multiplying these factors by one another to determine the total amount of actual ITV service to the parish schools, we find that the equivalent of about 1,800 continuous hours of programming were scheduled and delivered to consumers over three channels (8, 10, and 12).

Since transmissions can occur from 8:45 to 3:05 p.m. every school day for 169 days per school year, the portion of the ITFS system devoted to grade-school-level ITV service had a capacity of about 3,200 continuous hours.

Therefore, the CTN/C's utilization rate for scheduled K-8 ITV service in 1975-76 was 56 percent (1800 ÷ 3200).

To this must be added those transmissions of programs that occurred on a special request individual "call-in" basis. CTN/C reports that there were 570 transmissions of this type during the year which is equivalent to 170 continuous hours or 5 percent of the 3,200 hour capacity. This plus all other K-8 ITV services raises the 56 percent utilization rate to a grand total of 62 percent. This implies that CNT/C's "potential consumption" can be calculated to be: 1980 hours x 6170 rooms x $\frac{.33}{.62}$ = 6.5 million potential classroom contact hours. This utilization rate has been calculated on the assumption that the system has only a three-channel capacity. Actually, CTN/C can transmit over 4 channels; it simply did not use the fourth channel during 1975-76 for K-8 ITV services. If the fourth channel is added into the calculation of CTN/C's total capacity, then the total utilization rate of K-8 ITV drops to 46.5 percent. This underutilization is predictable for the first year of operation, and it may be that the total utilization rate will climb into the 60 percent range when teachers get used to ITV and become better acquainted with individual "call-in" special-request possibilities. It may be that there will be opportunities for other Chicago based non-profit

educational organizations such as Chicago TV College to lease portions of the fourth ITFS channel.

During this first year of operation, the CTN/C concentrated its energies on organizing and consolidating its services for the ITV consumer group whose needs were best known and most urgent: the parish schools. From 1976 onward, the CTN/C plans to devote much more of its attention to the improvement and expansion of services to other groups.

The most important of these is the group of lay adult parishioners. It is hoped that ITFS will be able to provide this group with access to adult education at parish sites which might be more accessible than other existing institutions. The CTN/C plans to devote much of its resources in the future to the development and production of TV programs for this audience. It is expected that these can be best made available on an individual request basis to parish meetings and study groups that would occur whether the ITFS system existed or not. The equivalent of about 630 continuous hours of programs were aired in 1975-76 for this audience.

Another important group that the CTN/C thinks can benefit from the ITFS system is the Archdiocese's instructional staff. The CTN/C furnished teachers with the equivalent of about 230 continuous hours of in-service programs during 1975-76.

Outside the parish reception sites, CTN/C also serves two colleges and a hospital. The latter consumes programs intended for the audiences that have already been mentioned. But the colleges in 1975-76 did receive two college courses over the ITFS system or the equivalent of 50 continuous hours of programs. Five courses are planned for 1976-77.

Altogether, these non-K-8 groups were furnished with the equivalent of about 1,080 continuous hours of televised programs over CTN/C's ITFS system. When combined with the 1,992 hours intended for the K-8 audience, the system's total supply of televised services to all groups amounted to the

equivalent of over 3,000 continuous hours of programs in 1975-76 (see Table II.C)

Support Services for the Schools. The CTN/C provides substantial utilization and other services to the schools. Four staff members are assigned to inform teachers about programs and about how they can be best used in the classrooms. This utilization staff also acts as a conduit from schools to the CTN/C for information about classroom utilization problems and needs. It is estimated that the average cost of CTN/C staff consultations in the schools averages $19 per school.

Equipment maintenance and technical consultation support are also provided to the schools on a request basis. CTN/C's total expenditure for this kind of support in 1975-76 amounted to $18,728.

Finally, the CTN/C makes program guides and materials available to teachers for all 57 ITV series. The schools pay for these on a cost-plus-handling-charge basis. Beyond making these printed program support materials available to schools, the CTN/C expended $8,000 in 1975-76 for program schedules, TV coordinator bulletins and preview information, and program evaluation materials.

ITFS Programming. It is CTN/C's belief that the educational goal of individualized instruction can best be served in the ITFS ITV structure by stressing the delivery of mini-series instead of one or two semester long ITV courses. It is also expected that this stress will make it possible for the ITFS system to serve a far broader range of classes than could be served if only semester-long courses were aired.

Of the operations budget funds that went for programming, most were spent on programs that were acquired "out-of-house." These costs were kept low because of CTN/C's affiliation with the national Catholic Television Network, the confederation of 10 ITFS systems described in Case Study I. CTN-originated programs tend to be less expensive than the national average

because the costs for the ITV talent are often nominal or non-existent. More importantly (because most programs are acquired from non-Catholic vendors), programs are made available to CTN/C by the national ITV vending libraries (AIT, GPN, PTL, and so on), at reduced per copy rates when CTN/C joins with other CTN members into purchasing consortia.

Altogether, the costs in 1975-76 for the ITFS programming for all groups totaled around $41,000 or about $100 per receiving site for the 419 sites.

Total start-up capital expenditures are summarized in Table II.D.

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TABLE II.A

GEOGRAPHICAL FEATURES: CTN/C

1.	Area (square miles)	1,411 (2,500)
2.	Student population	140,000
3.	Number of reception sites (schools only)	363
4.	Number of ITV classrooms	6,170
5.	Number of rooms per school	17
6.	Number of students per school	386
7.	Number of schools per square mile	.26
8.	Number of students per square mile	99
9.	Number of rooms per square mile	4.4

TABLE II.B

COST DATA: CTN/C[a]

	Amount in 1975 Dollars	Amount per Square Miles[b]	Amount per School	Amount per Classroom
Transmission System	$ 500,000	($200.00) $ 354.36	$ 1,377	$ 81
Reception System	$1,090,000	($436.00) $ 722.50	$ 3,000	$177
Total Conveyance System	$1,590,000	($636.00) $ 1,126.86	$ 4,377	$258
Central Studies and Control Room Capital Costs	$2,300,000	($920.00) $ 1,630.05	$ 6,336	$373
Total System Capital Costs	$3,890.00	($1,556.00) $ 2,756.91	$10,716	$631

a. The costs here are calculated in such a way as to tell the reader what the system and its components would have cost if it had contained only the 363 parishes with schools. The other 56 sites have been ignored in these calculations as have the costs for their reception equipment.

b. Figured on both the area in which the Archdiocesan receiving parish sites are located (1,411 square miles), and, in parentheses, the total area reached by the ITFS signals: 2,500 square miles.

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TABLE II.C

CAPACITY AND CAPACITY ALLOCATION: CTN/C

	Total Number of Hours	Utilizations % of	Scheduled Originals % of	Scheduled Repetition's % of	Unscheduled Repetition's % of
1975-76 Actual ITV Capacity in Continuous Hours (3 channels)	3,200	62%	16%	40%	6%
1975-76 Actual ITV Utilization	1,992	100%	26%	65%	10%
Scheduled Original ITV Transmissions	514	-	100%	n.a.	n.a.
Scheduled Repetitions	1,286	-	-	100%	n.a.
Unscheduled Transmissions	192	-	-	-	100%

Estimated Potential of Service Volume

Volume of Services: 12,291,000 per classroom contact hours

Potential Classroom Consumption: 6,542,000 per classroom contact hours

Supplies of Programming to Groups other than K-8 Students

1.	Adult Education	630 continuous hours
2.	Teacher In-Service	230 " "
3.	College	50 " "
4.	Others	170 " "
	TOTAL Other Groups	1,080 continuous hours

TOTAL TRANSMISSIONS SUPPLIED TO ALL GROUPS: 3,072 continuous hours

TABLE II.D

START-UP CAPITAL EXPENDITURES: CTN/C

	Gross Amount	Per Year, Amortized Over 15 Years	Per Year Per Student	Per Year Per PCCH Supply	Per Year Per PCCH Consumption	Percentage of Total Start-Up Capital Costs
1. Transmission System	$ 500,000	$ 33,333	$ .24	.3¢	.5¢	13%
2. Reception System	$1,090,000	$ 72,667	$ .52	.6¢	1.1¢	28%
TOTAL CONVEYANCE SYSTEM	$1,590,000	$106,000	$ .76	.9¢	1.6¢	41%
3. Central Facility	$2,300,000	$153,000	$1.09	1.3¢	2.3¢	59%
TOTAL CAPITAL OUTLAY	$3,890,000	$259,000	$1.85	2.1¢	4.0¢	100%

CASE STUDY III

BROWARD COUNTY, FLORIDA

Overview

The Broward County ITV conveyance system is a classical a instructional television fixed service (ITFS) technology that omnidirectional over-the-air transmissions of microwave video county's terrain, high population density, and relatively weal combine to provide ideal conditions for ITFS.

The system also illustrates (as well as any case in this extent to which ITFS can be used to individualize the mass-mec to achieve a balance between the delivery of mass-appeal progı delivery of specialized programming to serve individual needs also illustrates the fact that ITV distribution systems which their broadcast schedules to school and classroom schedules ı more conveyance capacity than they absolutely have available.

This system promotes individualized ad hoc transmission ı system studied here, yet there is much less user demand for t than is made available. This suggests that centralized distr much less convenient and flexible for users than off-air VTR offset the latter's greater costs. (The implication of this that systems should allocate their resources to centralized I only for the purpose of delivering popular mass-appeal progra 4 times per week and that additional resources should be inve controlled by the ITV consumers at the schools.).

Geographical Features

Broward County has an elongated shape along the southeas coast with rough dimensions of approximately 11 miles by 23 m miles total area). The ITV delivery system accordingly uses transmitter to reach half of the County and one slave transla

TABLE III.A

SUMMARY DATA: BROWARD COUNTY, FLORIDA

GEOGRAPHICAL FEATURES

1.	Location:	Southeast Florida
2.	Area :	250 Square Miles
3.	Shape:	1 x 2 Rectangle
4.	Population:	887,500 Persons
5.	Population Density:	3600/Square Mile
6.	Student Population:	140,000 Students
7.	Student Population Density:	560/Square Mile
8.	% of Students in the Population:	16%
9.	Number of Reception Sites:	148 Schools
10.	Average Number of Students per Site:	946
11.	Total Number of Rooms wired for TV:	2716
12.	ITV Reception Site Density (#9 ÷ #2):	.6 Sites/Square Mile
13.	Reception Room Density (#11 ÷ #2):	11 Rooms/Square Mile
14.	Classroom Aggregation (Average Number of Rooms Wired for ITV per Site:	18 Rooms per Site
15.	Transmission System Costs:	$120,000
	a. per square mile	$ 480
	b. per school	$ 811
	c. per classroom	$ 44
	d. per student	$ .87
16.	Reception system costs per school (average):	$6,420

other half. The population density in the area is high (about 3600 persons per square mile), as is also the density of schools (about one elementary school for every 2.5 square miles and about one high/middle school for every 5 square miles). This high density combines with a fairly flat terrain to make Broward County ideal for ITV distribution via the multipoint microwave transmission technology used by ITFS systems.

The level of ITV reception-classroom aggregation in the system's schools is also comparatively high, with an average aggregation of 20 reception-rooms, per elementary school and 15 reception-rooms, per high/middle school.

Capacity and Capacity Allocation

Since 1968, the Instructional Television Center of Broward County has provided ITV to all the 148 schools in the county via its 4 ITFS channels. The Center also provides a videotape dubbing service for those of its schools that are too new to have been fitted with ITFS reception equipment or that have school-wide scheduling problems that cannot accomodate the Center's ITFS schedule.

About 90 percent of this system's transmission capacity is directed at students in all grades K-12 for instructional purposes. The remaining 10 percent of the capacity is used for in-service teacher training for all locations throughout the school year, and for administrative and personnel service purposes.

The system's comparatively large transmission capacity is illustrative of what makes ITFS so different from typical single-channel public television broadcasting systems. The Center transmits from 8:00 a.m. in the morning to 3:30 p.m. every school day throughout the 175 day school year. This gives the system a total transmission capacity of about 5,250 hours per school year over its four ITFS channels.

The system does not use all of its capacity. To understand just how much of its capacity the County does need and use requires a brief discussion of the Center's transmission capabilities.

TABLE III.B

CAPACITY, AND CAPACITY ALLOCATION

	Total # of hours	B's % of	C's % of	D's % of	E's % of	F's % of	G's % of
A: 1979-80 Absolute Capacity in Continuous Hours	5,250	67%	50%	45%	33%	25%	11%
B: 1975-6 Actual Capacity in Continuous Hours	3,500	100%	75%	67%	50%	38%	17%
C: 1975-6 Actual Utilization in Continuous Hours	2,611	X	100%	90%	67%	50%	23%
D: 1975-6 Actual ITV Utilization in Continuous Hours	2,350	X	X	100%	75%	56%	26%
E: 1975-6 Scheduled ITV Transmissions in Cont. Hours	1,750	X	X	X	100%	1:3	N/A
F: Scheduled Repetitions of Scheduled Programs in Continuous Hours	1,313	X	X	X	X	100%	N/A
G: 1975-6 Unscheduled ITV Transmissions in Continuous Hours	600	X	X	X	X	X	100%

VOLUME OF SERVICE (ND POTENTIAL CONSUMPTION): 6,383,000 pech

POTENTIAL CLASSROOM CONSUMPTION (I-S POTENTIAL CONSUMPTION): 1,240,000 pech

TOTAL 1975-76 ESTIMATED UTILIZATION: 3,500,000 Student-Contact-Hours

In the case of Broward County, the limited number of expensive 2" videotape recorders (VTR's) the Center can use requires that the machines used in a play-back mode for transmission must also be used for rewinding transmitted tapes, before they (the machines) can again be used for playback-transmission of new tapes. In practice, this means that one-third of every transmission hour must be spent on rewinding videotapes.

This situation will gradually change from 1977 to 1980 since the 2" machines are being replaced by a larger number of chapter 3/4" VTR's. The greater quantity of VTR's will permit full utilization of the time periods available for transmission.

For the present, however, although the absolute transmission capacity during 1975-6 was 5,250 continuous hours, the actual capacity was only two-thirds of this amount or 3,500 continuous hours. To simplify matters in the rest of this case study, the continuous hour will be the standard unit used for comparison purposes. The 1975-6 levels of utilization of capacity will be figured as percentages of both actual 1975-6 capacity and absolute 1979-80 capacity. The reader should keep in mind that the 50 percent increase in capacity between 1975 "actual" and 1980 "absolute" levels will be created solely by the replacement of a few 2" VTR's with a larger number of 3/4" VTR's.

Broward County did not fully utilize its actual capacity in 1975-6. The County's total actual utilization of ITV was only 67 percent of its actual capacity (and therefore only 44 percent of its 1980 absolute capacity).

The Center allocates the capacity it does utilize to three different kinds of functions: (1) original transmissions of distinct programs in distinct series, (2) repeated transmissions of those original transmissions, and (3) transmissions on an ad hoc individual request basis of either unscheduled programs or scheduled programs in unscheduled time-slots.

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The first two of these functions involve the transmissions of programs scheduled well in advance of their transmission dates. Choices of program and series titles and choices of transmission time-slots are determined from pre-season surveys on a county-wide popularity basis.

The ratio between original transmissions and repetitions is significant because, to some extent, it reflects a policy choice between increasing selection in the program menu and increasing selection in the access-time menu. The ratio in Broward County is three repetitions for each original transmission (or four transmissions for each program title).

Equally important is the ratio between scheduled transmissions and unscheduled transmissions because scheduled transmissions are determined on a mass-popularity basis while unscheduled transmissions are determined on an individual-request basis. The Center reports that its policy has been to allocate 50 percent of its capacity to scheduled transmissions and 50 percent to unscheduled individualized transmissions. In 1975-6, exactly 50 percent of actual capacity was indeed devoted to scheduled transmissions, but only 17 percent of actual capacity was used by consumers for unscheduled transmissions. So, although the Center's policy and goal is to divide the ITFS system's large capacity equally between mass-determined and individually-determined access to ITV, the educational consumers have in fact changed the ratio to three to one in favor of mass access.

The demand for individualized transmissions had been 26 percent in 1974-5. The Center hopes to reverse the decline from 26 percent to 17 percent by promoting the use of actual capacity for individualized transmissions above the 26 percent level. The Center's administrators suspect that the explanation for the decline in use is that local schools have recently acquired 1/2" or 3/4" VTR's for off-air recordings of programs they can play back at their own convenience.

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Data on user request patterns would have been very valuable since it is possible that the scheduling flexibility provided by four telecasts of each program is the only kind of flexibility that is both feasible for delivery systems and desired by educational users. It may be that other conveniences desired by users cannot be feasibly provided by the delivery systems, but only by the schools' possession of their own videotape copies. This might imply that the more desirable way of using ITV transmission is in a textbook mode with users being given the chance to create local ephemeral or long-term videocassette libraries as they please.

In Case Study I (ITV Center, Archdiocese of New York), the concept of "volume of service" was equated to the concept of "potential consumption." Measurement or potential consumption was defined in terms of "potential classroom-contact-hour (pcch)." For this study, the Broward County ITFS system in 1975-6 had a potential classroom consumption volume of 1,240,000 pcch (based on 1296 continuous hours of ITV for 1933 elementary classrooms and 1054 continuous hours of ITV for 783 secondary classrooms).

The recourse to the concept of "potential classroom consumption" was taken in the first two case studies in part because there was no data on actual student contact (viewing) hours. However, data on ITV utilization volume does exist for the Broward County ITFS system and provides a welcome complement to the foregoing potential consumption measure.

The Center has rough student consumption data for 1975-6 but none for previous years, so it is not known whether the level of ITV consumption is increasing or decreasing. In 1975-6, estimated consumption was substantial: 3.5 million student-contact-hours (7 million program-contact-hours). This estimate is based on the testimony of teachers who have been known occasionally to treat the Center's questionnaires rather carelessly. Nevertheless, the "3.5 million" figure is the best number available.

Turning to the courseware used in the system, the Center transmitted 48 series of programs during 1975-76. Of these, two-thirds were produced by the

Center and the other 16 series were acquired from the State of Florida. There is no doubt that this ITFS system is in a distinctive position relative to the rest of the ITV distributions and consumers in the State because of its exceptionally large transmission capacity. The State uses its resources to purchase those programs that are popular throughout the State, so the Center is forced to rely mainly on its own resources for new programming that will meet the broader needs of its own constituency.

Costs

In order to compare this ITFS system to ITV distribution systems based on other kinds of conveyance technologies, the costs for building the microwave transmission/reception system are kept separate from capital expenditures which are also incurred by other kinds of delivery systems.

The capital expenditure for the microwave transmission system came to $120,000 for one main transmitter and for a translator to bring the signals to the lower half of the County. Given that this equipment will not have to be completely replaced for 15 years (1968-83), and since the average annual enrollment in the County is 140,000, the annual per student cost of this basic conveyance equipment is, $120,000 ÷ (15 x 140,000) = 5.7 cents.

The ITFS system's principal start-up capital cost was the construction of 148 microwave receiving terminals at the 148 schools in the County. The Center reports that, on the average, each of these terminals cost approximately $5,500 for a total of $950,000 for the whole system. Based on the assumption above, the annual per student cost of this reception equipment is 45 cents, and the annual per student-contact-hour cost is 1.8 cents or nearly 8 times the cost of the transmission equipment.

Beyond these start-up capital costs, it is estimated that the total capital outlay during the 1969-83 period is about $2 million. This number is hard to deal with in a cross-system comparison analysis since some of the new equipment will be used for program production and videotape dubbing purposes as well

TABLE III.C

EXPENDITURES FOR BROWARD COUNTY, FLORIDA

		Amortized Over 15 Year Period	Annual Stude. Cost	Per Stud. Cont. Hour	Per PCCH Supply	Per PCCH Consumption	% of Total Capital Costs	% of Total Operat. Costs	% of Total System Costs
I. RELEVANT CAPITAL EXPENDITURES									
A. 1968 Start-Up Capital Expenditures									
1. Transmission Equipment	$ 120,000	$ 8,000	$ .05	.2¢	.1¢	.6¢	3%		1%
2. Reception Equipment	$ 950,000	$ 63,000	$ .45	1.8¢	1.0¢	5.1¢	27%		6%
3. Center Facility Equipment	$ 500,000	$ 33,000	$ .24	1.0¢	.5¢	2.7¢	14%		3%
TOTAL	$1,570,000	$104,000	$ .75	3.0¢	1.6¢	8.4¢	44%		11%
B. Total 1969-83 Capital Expenditures									
1. Strict	$1,250,000	$ 83,000	$ .59	2.4¢	1.3¢	6.7¢			
2. Loose	$2,000,000	$133,000	$ .95	3.8¢	2.1¢	10.8¢	56%		14%
TOTAL CAPITAL EXPENDITURES									
STRICT	$2,320,000	$154,000	$1.10	4.4¢	2.4¢	12.4¢			
LOOSE	$3,670,000	$245,000	$1.70	6.8¢	3.8¢	19.8¢	100%		25%
II. OPERATING EXPENDITURES (1975-6-7 averaged)									
1. Courseware development and prod.	$ 510,000		$3.64	4.6¢	8.0¢	41.1¢		68%	52%
2. Maintenance in schools	$ 110,000		$ .79	3.1¢	1.7¢	8.9¢		15%	11%
3. ITFS Operation	$ 50,000		$ .36	1.4¢	.8¢	4.0¢		7%	5%
4. School Utilization	$ 44,000		$ .31	1.3¢	.7¢	3.6¢		6%	4%
5. Dubbing Service	$ 25,000		$ .18	.7¢	.4¢	2.0¢		4%	3%
TOTAL	$ 750,000		$5.36	21.4¢	11.8¢	60.5¢		100%	76%
TOTAL ANNUAL SYSTEM EXPENDITURE (LOOSE)	$ 995,000		$7.03	28.0¢	15.4¢	79.4¢			100%

as for ITFS transmission. On the other hand, an ad hoc choice of a sizable percentage of this cost to represent percentage of non-ITFS uses might not be justified since it is plain that the ITFS system's great capacity drives all other costs in the system.

We have decided to present both "strict" and "loose" estimations. Strictly, we will say that 62.5%, or $1.25 million, of this total outlay is attributable to the ITFS system. Loosely, we will say that 100%, or $2 million, of this total outlay is attributable to the ITFS system. The sum total of capital expenditures over 15 years yields a total annual per student cost of from $1.10 (strict) to $1.46 (loose). The total annual per student-contact-hour cost is from 4.4 cents (strict) to 5.8 cents (loose). Finally, the total annual per potential classroom-contact-hour cost is from 4 cents (strict) to 11 cents (loose).

It was impossible to ascertain the exact start-up costs for the control-room and below-roof transmission equipment at the Center. An estimate of $500,000 may be considered reasonable. If this investment is attributed to the ITFS system (as it should be if the strict post-start-up costs are so attributed), then the total annual per student costs increase to $1.34 (strict) and $1.70 (loose), the total annual per student-contact-hour costs increase to 5.4 cents (strict) and 6.8 cents (loose), and the total annual per potential classroom-contact-hour costs increase to 9 cents (strict) and 13 cents (loose).

All of the foregoing remarks about capital costs establish the following as the ranges of capital costs that can be attributed to the Broward ITFS system:

1)	total annual per student costs:	$1.10 to $1.70
2)	total annual per student-contact-hour costs:	4.4 cents to 6.8 cen
3)	total annual per potential classroom consumption costs:	7 cents to 13 cents

CASE STUDY IV

WVIZ, CLEVELAND, OHIO*

Overview

The most striking aspect of this system is that despite the availability of many repetitions of each school's ITV programs on both the UHF and ITFS channels, over-the-air telecasts are used much more for recording copies of programs on videotapes than for direct viewing in classrooms.

The second major source of ITV for classroom viewing is WVIZ's service for dubbing copies of programs and videotapes which are then shipped to schools. These two sources (off-the-air recorded copies and shipped dubbed copies) are so effective that suburban schools hitherto unreached by ITFS have now requested the building of new outlying translator/repeater stations to extend ITFS signals out to them.

Geographical Features and Capacity Allocations

WVIZ, public television channel 25, Cleveland, Ohio, is the most complex of the mediated instruction distribution systems studied here. It serves many of the video and film needs of the area's public elementary, junior high, and high schools, and acts as an ITV conduit for a major medical center's broadcasts and those of a university to outlying industry-based adult students. In serving all these diverse groups, WVIZ utilizes a diversity of conveyance modes including (1) single-channel UHF broadcasting for viewing, (2) multiple-channel ITFS telecasts for viewing, (3) UHF/ITFS telecasts for recording programs off-the-air in schools for classroom playback, (4) shipments to schools of copies of programs dubbed at WVIZ on both videotape and videocassette, and (5) shipments to schools of film materials.

*The EPRC wishes to express special appreciation to Dr. Alan Stephenson of WVIZ, who supplied the data-base for this report and who spent many hours reviewing drafts and offering invaluable advice.

From its inception, WVIZ's mandate has been to meet the educational needs of the Cleveland metropolitan area. It has striven to accomplish this by acting as the coordination hub of most of the mediated instruction distribution in the area, starting in the middle 1960s. In 1966, a number of independent educational organizations in the area developed separate plans for their own autonomous ITFS systems. WVIZ coalesced these plans into a single plan in which it would act as the ITFS operator for all users. ITFS broadcasting began in 1970.

The terrain of the Cleveland area is ideal for inexpensive ITFS transmission. Not only is the land generally flat, but the elevation gradually and concentrically falls off as one moves away from the transmitter's locale. For instance, the elevation six miles distant from the transmitter is in some places as much as 1,000 feet lower than is the ground at the ITFS transmission station. For this reason, it was possible to mount the omnidirectional ITFS antennas on a 300 foot tower owned by another organization but released for WVIZ use on a <u>quid pro quo</u> basis. Because of this arrangement and because there was no need to build special repeater/translator ITFS stations inside the 20-mile radius coverage area, the start-up capital costs for transmission in this system were comparatively lower than were those of the systems described in case studies I, II and III. (See Table IV. A.)

The demographic character of this area is also ideally suited to ITFS. Not only does the central location of the transmitter permit it to serve the most densely populated portion of metropolitan Cleveland, but schools in this sector (the "inner city") are less willing and/or less able than are the suburban schools to acquire expensive non-ITFS equipment such as videotape recorders that can make copies off-the-air of UHF telecasts. So the ITFS coverage area both maximizes this technology's effectiveness in reaching the largest number of schools reachable by a single transmitter and makes this form of ITV distribution available to those whose need is the greatest.

TABLE IV.A

GEOGRAPHICAL FEATURES

	UHF BROADCAST	ITFS	DUBBING SERVICE
1. Location	Greater Cleveland	Cleveland	Greater Cleveland
2. Area (in square miles)	4,405	1,257	4,405
3. Total Population	2,500,000	?	2,500,000
4. Population Density (persons per square mile)	568	?	568
5. Number of Schools	697	138	156
6. Number of Reception Rooms (wired classrooms)	5,070	815 (est.)	?
7. Total Number of Students in the Area	487,087	120,000 (est.)	?
8. Student Population Density (per square mile)	111	96	?
9. Number of Students exposed to any ITV	305,564	36,700 (est.)[a]	?
10. Average Number of Students per School	700	870	?
11. Number of Schools per Square Mile	.16	.11	.04

[a]Students who directly view ITFS telecasts and students who indirectly view ITFS telecasts via videotaped copies of those telecasts recorded off-the-air.

Only one ITFS channel, A-3, has been reserved for ITV distribution to public schools. However, since WVIZ broadcasts during the day to these schools over UHF Channel 25, A-3 acts as a supplement to Channel 25 making this system equivalent to a two-channel ITFS system. WVIZ has the legal authority and capability of broadcasting ITV over two other channels, A-2 and A-4, but there has not been enough demand to initiate their utilization.

Two other active ITFS channels, C-1 and C-2, [illegible] been reserved for telecasts of continuing professional education programming from Case Western University to working engineers and other professionals who receive the ITV in industries in the Cleveland area. This system is very similar to the Stanford system described in Case Study No. IX. WVIZ acts as the source of programming for channels 25 and A-3, but it acts only as a conduit for signals on C-1 and C-2.

A fourth active ITFS channel, C-4, is used by a local medical center for distribution of medical training and information programs to hospitals in the area.

The non-school users of ITFS in Cleveland were not asked to respond to the data-gathering instruments that we sent to WVIZ. All attention has been focused on WVIZ's public school ITV system.

WVIZ serves 524 elementary schools and 173 junior high and high schools in metropolitan Cleveland within an area of 4,405 square miles. Before 1970, WVIZ dispensed ITV to these 700 schools only via its UHF Channel 25. As the single channel capacity was too limited to meet the diverse needs of its heterogeneous consumer base, the ITFS channel, A-3, was added to meet the special needs of one sector of that base: the 103 junior high and high schools that lie in the most populous part of the region. The

be reached by the signals from the 300 foot ITFS tower which cover only a 1,257 square mile area having the equivalent of a 20-mile radius.

The UHF channel complements Channel A-3 by broadcasting programming to the 524 elementary schools in the entire 4,405 square mile area. A-3's elementary grade telecasts are received by only the 35 elementary schools which have decided to buy the special ITFS reception equipment. Consequently, only 35 percent of the ITFS telecasts contain programming that is explicitly intended for elementary classrooms. All of these elementary ITFS programs are also broadcast over the UHF channel, but each is re-telecast on A-3 an average of four times compared to an average of two broadcasts per program on the UHF channel. Additionally, all ITFS schools can call in special individual requests for re-telecasts of missed programs at unusual unscheduled times, something that is not possible on the congested UHF channel.

Nevertheless, the ITFS system's main function is to serve the junior high and high schools in and around the City of Cleveland. As in the case of the elementary programs, all junior high/high school programs are also broadcast on the UHF channel since so many junior highs and high schools lie outside the ITFS telecast area. But, on Channel 25, they are transmitted largely on a one-time-only no-repeat basis. A-3 carried 85 percent of these Channel 25, 6-12 grade programs, but they are re-telecast an average of four times per program on A-3. These repetitions are believed to be essential for distribution to junior highs and high schools since they have a greater need for schedule flexibility than do the elementary schools (whose teachers can more easily adjust their classroom schedules to WVIZ's broadcast schedule).

As already stated, ITFS serves only the populous part of the metropolitan Cleveland area which has a school population density of one junior high/

of the junior/high schools) where the school population density is one school every 45 square miles.

WVIZ did, at one time, consider the possibility of building translator transmission stations in the outlying areas to relay ITFS signals to schools that could only receive one telecast per program on the UHF channel. However, at that time these suburban schools were already beginning to solve their schedule flexibility problems on their own by purchasing one-half inch videotape recorders (VTRs) for off-the-air copying of programs broadcast over the UHF channel. WVIZ aided many schools in this effort by purchasing VTRs in lots and transferring the bulk-rate cost savings to the schools. The demand for the multiple telecasts of each program on A-3 never really developed to a degree large enough to justify building outlying relay stations.

This raises the most interesting issue surrounding ITFS's potential as an ITV distribution vehicle. Its economic virtue is reputed to be that it is less expensive than UHF, off-the-air videotaping, and videotape shipping to VTR-owning schools, despite ITFS's high reception equipment costs. Its educational virtue is reputed to be that multiple telecasts of each program provide the scheduling flexibility that would be educationally desirable but uneconomical in an expensive UHF system.

ITFS' chief competitors are the off-the-air videotaping and the shipped-videotaped-copies distribution modes which are obviously superior to ITFS as far as scheduling flexibility and convenience go. However, the latter two modes are expensive since off-the-air recording requires at least three VTRs at each site (for record, playback and back-up functions) and the shipment of videotaped copies requires at least two VTRs (for playback and back-up functions) plus centralized dubbing and shipping costs.

Are these cost disadvantages of VTRs offset by their educational advantages?

WVIZ reports that educational opinion in its area answers this question in the affirmative for junior high/high school ITV consumption, except for the larger inner city schools that are perennially faced with relatively greater financial problems and with higher theft and vandalism rates. The inner city schools want VTRs and are not satisfied with the four telecasts-per-program ITFS service; they just cannot afford to do anything about this situation. The suburban schools have tended to opt for VTRs without hesitation.

The 524 elementary schools served by WVIZ <u>may</u> need flexibility less than do the junior high/high schools since only 9 percent (49) of them own VTRs; however, this low percentage may reflect only a financial resource difference, not an educational need difference. Fully 62 percent (107) of the junior high/high schools in the whole system had a per school average of 4.8 VTRs in 1975-76.

Only about 60 percent of the videotaped copies used by the VTR-owning schools are copied off-the-air by the schools themselves. About 40 percent are copied (dubbed) by WVIZ at the schools' requests, most often on the schools' own one-half inch tapes or three-fourths inch cassettes which are sent to WVIZ with the requests.

WVIZ's centralized dubbing service offers three advantages over off-the-air recording to the schools. First, schools need to purchase VTRs for recording purposes; in fact, off-the-air copying requires, besides one machine for playback, at least two playback-plus-record machines (for record and minimal backup functions) whereas WVIZ's centralized dubbing minimally requires only two playback-only machines (for playback and back-
up) which are 20 percent cheaper than machines having the additional re-

The second advantage is that off-the-air recording in the school ties up a person for operating the VTR during the recording period which is not always convenient or inexpensive. The third and final advantage of WVIZ's centralized dubbing service is that every program in WVIZ's large ITV library is available at no penalty at any time in the school year. Off-the-air recording requires that the copy be used in the same portion of the school year that it is telecast on Channel 25; otherwise, the tape must be stored for a long period of time for eventual classrom consumption. If the school has a limited stock of blank tapes for recording purposes, then long-run storage will exhaust this stock at some point, and some programs will have to be sacrificed that would otherwise have been available via WVIZ's centralized dubbing service which requires no long-term storage in the schoo.

However, a school's exclusive reliance on WVIZ's dubbing service has two important drawbacks. First there is an average turn-around time of 14 days between the time at which the school submits its request for a copy of WVIZ and the time it actually receives the copy. The school must therefore know in advance that it wants a particular program and when it wants to be able to use it. In some cases, this will entail considerable planning. In the off-the-air recording mode, an evaluation of the program can occur at the same time it is being recorded; if the evaluation is negative, the tape can simply be treated as a blank tape to be used again immediately for another off-the-air recording.

Second, a school that commits itself to the centralized dubbing service and accordingly does not buy machines with recording capabilities thereby deprives itself of acquiring a teacher-student program production capability for the cost of only a small TV camera. Such a capability could result in substantial cost-savings if, for example, an expensive or dangerous laboratory experiment could be conducted just once and videotaped for later viewing by other classes instead of being conducted in every one of many

In 1975-76, WVIZ made approximately 8,000 videotaped copies of programs for shipment to schools for an average of 51 dubbed copies per VTR-owning school. Schools kept the copies an average of 21 days. WVIZ has no data on the number of these copies that were, in turn, copied onto other copies for use at later times, in other classes, or in other schools.

WVIZ surveyed the junior high and high schools to determine the ratio between:

1. Student viewings of playbacks of videotape copies of programs recorded off-the-air in the school.
2. Student viewings of playbacks of centrally dubbed copies shipped to schools from WVIZ.
3. Student viewings of ITFS telecasts over Channel A-3.
4. Student viewings of UHF telecasts over Channel 25.

Perhaps most significantly, the survey results reveal the difference between student viewings of playbacks of videotaped copies (No. 1 plus No. 2) and student viewings of ITFS and UHF telecasts (No. 3 plus No. 4). Here in Table IV.B are the composite proportions that are derived from the survey results for all junior high/high schools in the UHF coverage area including both schools that do own VTRs and those that do not own VTRs.

TABLE IV.B
"STUDENT VIEWINGS" SURVEY RESULTS

Student Viewings Of:	Percentage of All Viewings
1. Playbacks of videotaped copies of programs recorded off-the-air in the school	53%
2. Playbacks of centrally dubbed copies shipped to schools from WVIZ	35%

In brief, survey responses from virtually all the schools indicated that fully 88 percent of all viewings were not direct off-the-air viewings of either UHF or ITFS telecasts but were instead viewings of playbacks of dubbed videotape copies.

It seems clear then, that telecasts were used primarily for making videotape recordings for playback at other times. Direct viewing of telecasts occurred chiefly in inner city schools that do not possess VTRs. The remarkable fact is, however, that only 12 percent of all viewings were of telecasts even though 38 percent of the schools have no VTRs. This is partial evidence that school control of ITV materials increases ITV consumption. However, the low 12 percent off-the-air viewing rate is partially due to the fact that inner city schools have few TV sets because they are stolen or vandalized so frequently.

Telecasts were indeed used chiefly for direct off-the-air viewing in the 524 elementary schools in WVIZ's service area, but this audience receives only UHF Channel 25 (with the 35 exceptions noted earlier). This elementary school audience is also the biggest consumer of ITV in the area: 78 percent of all student viewings were of elementary programs.

Consequently, for the public school system as a whole, less than 22 percent of all ITV consumption took the form of direct ITFS viewing (6 percent of junior high/high school consumption plus 22 percent of total consumption).

The conveyance capacity of each of the two channels may be assumed to be around 1,350 continuous hours per school year (169 days x 8 hours per day). Both channels are utilized at virtually 100 percent capacity (over 1,2[illegible] hours on A-3). The total supply of ITV over Channels 25 and [illegible] follows:

TABLE IV. C

SURVEY OF PROGRAM VIEWING

	CHANNEL 25		CHANNEL A-3	
	No. of Hours	Percent of Total	No. of Hours	Percent of Total
Elementary Programming:				
1. Scheduled Multi-Program Series	942	78%	320	27%
2. Scheduled Single-Program Specials	5.5	.5%	0	0%
3. Unscheduled Special-Request Telecasts	5.5	.5%	47	4%
TOTAL ELEMENTARY PROGRAMMING	953	79%	367	31%
Junior/High School Programming				
1. Scheduled Multi-Program Series	244	20%	662	55%
2. Scheduled Single-Program Specials	12	1%	38	3%
3. Unscheduled Special-Request Telecasts	3	-	135	11%
TOTAL JUNIOR/HIGH SCHOOL PROGRAMMING	259	21%	835	69%
GRAND TOTAL	1,212	100%	1,202	100%

Some aggregations based on the above table:

1.	Total Elementary telecasts (both channels):	1,320 hours	55% of total
2.	Total Junior/High School telecasts (both channels):	1,094 hours	45% of total
3.	Total Both Types of Programming (both channels):	2,414 hours	100% of total

1.	Total Scheduled Multi-Program Series	2,168 hours	90% of total
2	Total Scheduled Single-Program Specials	56 hours	2% of total

Repeated Telecasts of Programs:

1.	Channel 25:	430 hours	36% of all Channel 25 Telecasts
2.	Channel A-3:	607 hours	51% of all Channel A-3 Telecasts
3.	Both Channels:	1,037 hours	43% of all Telecasts, both channels

WVIZ's survey instrument registers quantities of ITV utilization for each of the courses it telecasts. Of the 487,087 K-12 students in the 697 schools served by WVIZ, 63 percent or 305,564 were reported to have viewed at least one of WVIZ's programs at least once during the school year (Table IV.C

The viewing-attendance questions in the survey were not articulated in such a way that the total number of student-contact hours (student-viewing-hours) can be calculated. The average elementary series contained 20 individual programs of approximately 20-25 minutes in length. The average junior high/high school series contain 14.6 programs of approximately 20 minutes in length. But the survey asked only for "the total number of students who have viewed at least one program in the WVIZ series listed... children viewing several series should be counted again for each series." But, clearly, viewing at least one program in a series does not entail viewing all of the series' 14.6 to 20 component programs.

The composite results of this survey for 1975-76 are contained in Table IV.D.

TABLE IV. D
COMPOSITE SURVEY RESULTS

1.	Per series elementary program:	660,222 viewers
2.	Per series junior/high program:	258,490 viewers
	a. Off-the-air, A-3:	15,369 viewers
	b. Off-the-air, 25:	16,244 viewers
	c. Copy taped by school:	137,252 viewers
	d. Copy taped by WVIZ:	89,625 viewers
GRAND TOTAL:		918,712 viewers

If each viewer of a series viewed exactly one and only one program in each of the series for which he was counted as a viewer, then the numbers in Table IV. D would represent the total number of students' viewings or student-contact-programs from which the total number of student-contact-hours, 340,000, can be easily deduced. If, on the other hand, each of the viewers that have been counted once for each series did, in fact, view every program in the series he is correlated with, then the total number of student viewings would be as in Table IV. E [with equivalent student-contact-hours (sch) in parentheses]:

TABLE IV. E

POTENTIAL STUDENT CONSUMPTION

1. Elementary program viewings:	13,204,440 viewings	(4,886,000 sch)
2. Junior/High School program viewings:	3,773,954 viewings	(1,396,000 sch)
a. Off-the-air, A-B:	224,387 viewings	(83,000 sch)
b. Off-the-air, 25:	237,162 viewings	(88,000 sch)
c. Copy taped by school:	2,003,879 viewings	(741,000 sch)
d. Copy taped by WVIZ:	1,308,525 viewings	(484,000 sch)
GRAND TOTAL:	16,978,394 viewings	(6,282,000 sch)

WVIZ has since conducted another survey of teachers to determine what percentages of the average series different classes of students are exposed to. Eight hundred ninety-six teachers were surveyed with the following results:

1. 565 said their classes watched 90 percent or more of the programs in the average series.

2. 117 said their classes watched 75-85 percent of the programs in the average series.

3. 123 said their classes watched 50-74 percent of the programs in the average series.

4. 91 said their classes watched 0-49 percent of the programs in the average series

On the basis of these results, it is calculated that the average viewer watched 82 percent of the programs in an average series. To get actual, and not just potential, student viewings and student contact hours, the numbers in Table IV. E are multiplied by .82 to yield the measurements in Table IV. F.

TABLE IV. F

ACTUAL STUDENT CONSUMPTION

	Student Viewings	Student Contact Hours
1. Elementary programs	10,827,640	4,006,520
2. Junior High/High School programs	3,094,642	1,144,720
a. Off-the-Air, A-3:	183,997	68,060
b. Off-the-Air, Channel 25:	194,473	72,160
c. Viewings of Copies Taped by Schools:	1,643,181	607,620
d. Viewings of Copies Taped by WVIZ:	1,072,991	396,880
GRAND TOTAL	13,922,283	5,151,240

It should be noted that these results do not agree with WVIZ's own results which were 39 percent greater than those presented here. However, WVIZ did not supply a new data-base from which to derive the larger figures, so Table IV. F's estimates must be taken as the best available. WVIZ and EPRC agree about Table IV. D figures, so the basic discrepancy in the data-base for the two calculations must concern the figures in Table IV. C, even though WVIZ management was the original source of Table IV. C.

Table IV. F's five million sch actual consumption/utilization quantity compares with a supply measure of 12,240,000 potential classroom contact hours (pcch). The largeness of this latter number is because there are 5,000 TVs in Greater Cleveland's public schools. The potential consumption volume is 4,454,000 pcch and is high again for the same reason.

This profile of WVIZ's distribution system has concentrated on the services it telecommunicates throughout its UHF broadcast area. Not included in the profile is the extension of the broadcasts via several outlying cable systems which bring ITV to 30 elementary schools and 12 junior high/high schools that are beyond the reach of the broadcasts. Little is known in detail about these schools so they were ignored in the analysis.

Of greater significance is the fact that the ITV supply and consumption profile has not included either the supply information about WVIZ's dubbing service or both consumption and supply information about WVIZ's distribution of films to many of the schools in the UHF broadcast area.

WVIZ dubbed 3,672 elementary programs and 4,072 junior/high programs on videotapes in 1975-76 for a total of 7,744 dubbed copies. Approximately 88 percent of these were dubbed on one-half inch videotapes while the rest were dubbed on three-quarter's inch videocasettes.

These remarks apply equally to WVIZ's film distribution component. It reports that it lends reel-to-reel films to 425 of the 524 elementary schools and to 100 of the 173 junior high/high schools in its service area In 1975-76, WVIZ delivered 3,245 titles to the elementary schools meeting 77 percent of their requests and 4,304 titles to the junior high/high schools also meeting 77 percent of their requests. These schools generally received their requested films within seven days of the request dates and were allowed to keep the films an average of five days. It is WVIZ's belief that its general mediated instruction services will increasingly emphasize film distribution because of the popularity of film's large screen and because a wider spectrum of courseware is available on film than is permitted for broadcasting.

It is noteworthy that approximately equal numbers (7.5 thousand) of films and dubbed videotapes were delivered to the schools. Unfortunately, the obstacles that prevented educated speculation about the supply and

potential classroom consumption levels of the dubbed videotapes also prevents educated speculation about supply and potential classroom consumption of the films. Unquestionably, these levels are less than half the levels that have been assigned to ITV telecasts, but more accurate estimates are not within our grasp.

Start-Up Capital Costs: ITFS

WVIZ's ITFS system perfectly exemplifies the advantages of adding microwave technology onto an existing transmission system. The 300 foot tower, usually an expensive component of the transmission system, was made available for WVIZ use on a cost-free quid pro quo basis. The multiple-channel antenna installed on this tower costs $16,000. It received four ITFS signals (E-1, E-2, E-3, and E-4) from WVIZ's studio 3.3 miles away and they are converted to A-3, C-1, C-2, and C-4. The four down-converters cost $2,500 and the transmission lines also cost $2,500. The transmitters constituted the chief cost: $80,000 ($20,000 per channel). The final expenditure at this station was $10,000 for the installation of the foregoing equipment. All together, these costs for adding-on the ITFS transmission equipment at this station totaled $111,000.

The other start-up capital costs for the ITFS system were incurred at WVIZ's Channel 25 central facility. These costs came to about $80,000 for an ITFS transmission system. The grand total for start-up capital expenditures was $190,000.

The reception equipment at the 103 junior high/high schools and 35 elementary schools averaged $1,500 including classroom wiring costs. This number is low because only 2.5 rooms were wired on the average; this is consistent with the facts that (a) wealthier ITFS schools intended to use it mainly for off-the-air recording purposes, and (b) the inner city schools strove to keep their costs down to a bare minimum. So the reception side of the add-on ITFS system cost about as much as the transmission side, namely $207,000.

The combined transmission and reception start-up ca
for public school ITFS came to $400,000, or about $2,900
If this cost is amortized over 15 years, it amounts to $
per year.

These and other important proportional amortized co
capital investment in the ITFS conveyance system are sum
(Table IV. G).

TABLE IV. G

ITFS: START-UP CAPITAL COSTS

	Transmission Costs[a] Amortized Over 15 Years	Recept Cost: Amorti: Over 15 Yea
1. Per year amount	$12,667	$14,00[illegible]
2. Per student (120,000 students)	$ .11	$ .1[illegible]
3. Per ITV Viewing Student (36,700 in 815 wired classrooms)	$ .35	$ .3
4. Per school (138 ITFS sites)	$ 92.	$ 10
5. Per student contact hour (600,000 sch)	$ .02	$ .0
6. Per supply potential classroom consumption hour (980,000 pcch)	$ .01	$ .0
7. Per potential consumption pcch (550,000 pcch)	$ .02	$ .0

[a]No discount rate has been taken account of in these cal

The numbers in parentheses in Table IV. G are based
jectured data as on hard data since WVIZ has supplied th
only system-wide composite answers to its survey and sin

ment costs. Its educational virtue is

asts of each program provide the scheduling flexil

lucationally desirable but uneconomical in an expe

ITFS' chief competitors are the off-the-air video

ed-videotaped-copies distribution modes which are

TFS as far as scheduling flexibility and convenien

latter two modes are expensive since off-the-air r

east three VTRs at each site (for record, playback

the shipment of videotaped copies requires at leas

back and back-up functions) plus centralized dubbi

exibili.y that would
xpensive UHF system.

deotaping and the
are obviously superior
iience go. However,
ir recording requires
back and back-up functions
least two VTRs (for
ubbing and shipping costs.

does not ask respondents to indicate how many of the school's classrooms are wired for ITFS reception nor how many students in wired rooms view each ITFS telecast. Comparison of Table IV. G to Tables IV. E and IV. F shows that very generous assumptions are made for Table IV. G in figuring numerical levels for Rows 3 and 5-7; this was done to take into account students who view ITFS telecasts indirectly via tapes dubbed on the school's premises.

[illegible] adopted a "loss-leader" strategy when building the ITFS system. [illegible] for both the microwave receiver apparatus at each school and for [illegible] wiring of one or two classrooms. The poorer inner-city districts were [illegible] to pay for this initial capital outlay, but [illegible] hoped that [illegible] would be inspired by their experience with the ITFS service in these few classrooms to pay themselves for the wiring of additional rooms. Some districts did do this but apparently many did not. [illegible]'s best guess is that an average of five rooms per school are now wired for ITFS reception.

[illegible]

[illegible] spent $[illegible],800 on mediated instruction courseware in 1975-76. [illegible], [illegible] percent went to ITV programs and 24 percent went to film [illegible]. [illegible] the [illegible] percent, or $227,800 allocated for ITV courseware, a very high percentage, 95 percent, went for the in-house production of new programs; only 5 percent went for the acquisition of programs produced "out-of-house" by non-[illegible] organizations. Below is the full [illegible] of these expenditures. As is obvious, very few of the programs [illegible] during 1975-76 were paid for during that year by [illegible].

	Grades K-6	Grades 7-12
1. Produced In-house	24 hours, $210,[illegible]	[illegible] hours, $[illegible]
2. Acquired Out-of-house	26 hours, $ [illegible]	[illegible] hours, $11,[illegible]50
3. Film	[illegible] titles, $[illegible]	[illegible] titles, $[illegible]

Altogether, these programs account for only 18 percent of WVIZ's telecasts during the school year. We have obtained detailed program-by-program information about only the junior high/high school programs WVIZ aired, but this information may be transferable to grades K-6 as well.

Much of the acquired-out-of-house series were made available to WVIZ at no charge from the Ohio State Department of Education. Only three series were leased directly from commercial vendors for a total of $1,470.

Besides the State Department of Education, the second major source of programs was WVIZ's own past productions. Since these are completely paid for out of the budgets for the year in which they were produced, their costs are not included in the 1975-76 budget.

Utilization Costs

WVIZ employs five persons for the purpose of providing ITV utilization services to the Greater Cleveland schools. Their tasks include visiting schools every year to gather information about program popularity and about the advantages and drawbacks of the different conveyance modes and to inform school staffs about new courseware possibilities and offerings. Altogether, WVIZ spent about $125,000 on these utilization activities. Of this amount, $55,000 went for staff salaries and $53,000 went for printed support materials for the ITV programs that were telecast.

Total Operating Costs: 1975-76

WVIZ's budget is exceedingly difficult to analyze since most of its line items identify costs shared by both UHF and ITFS services. Table IV. 4 breaks out WVIZ's budget as it was reported to us.

This sum is $813,471, or about 39 percent of WVIZ's total operational budget of $2.1 million. The 61 percent not accounted for here is attributed to WVIZ's evening public television broadcasting to homes in Greater Cleveland.

TABLE IV.-H

1975-76 TOTAL EDUCATION OPERATIONS EXPENDITURES

	Amount	Per Student	Per ITV Student	Per Student Contact Hour[a]	Per PCCH Supply[a]	Per PCCH Consumption[a]	Percent of Total
1. Courseware	$299,800	$0.62	$0.98	$0.058	$0.025	$0.067	37%
2. Engineering	$172,890	$0.35	$0.56	$0.034	$0.02	$0.038	21%
3. Utilization Salaries	$ 55,000	$0.11	$0.18	$0.011	$0.005	$0.012	7%
4. Printed Materials	$ 30,240	$0.06	$0.10	$0.006	$0.003	$0.007	4%
5. Other	$255,541	$0.53	$0.85	$0.050	$0.02	$0.06	31%
TOTAL	$813,471	$1.67	$2.66	$0.16	$0.066	$0.18	100%

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[a]Total potential supply (Potential Classroom Consumption): 12,240,000 pcch

Total potential consumption (Potential Classroom Consumption): 4,454,000 pcch

Total Actual Consumption: 5,151,240 sch

Since, as we saw before, expenditures for courseware amounted to $299,800, they accounted for 37 percent of this mediated instruction outlay. The next largest item (21 percent) is the $172,890 attributed to "engineering."

The final significant quantity in this WVIZ educational budget is the 50 percent of the "management" and "general and administrative" boxes which come to $100,153 or 17 percent of the educational operations budget.

One final remark about a special operational cost, WVIZ's dubbing service. In 1971, WVIZ tried out the Cadavers Telemetry System which enabled WVIZ engineers to remotely signal and activate special VTRs in schools for recording copies on tape between 12 a.m. and 8 a.m. over Channel 25. Consumers liked the fact that their special requests could be met within 24 hours on VTRs they leased from WVIZ for $200 per year.

However, WVIZ found that it had to pay for three highly trained and high cost engineers to operate the expensive and complicated telemetry system. The system's volume capacity was inadequate for the demand for the service and the engineers had to work overtime (and be paid for it) on weekends. Because of the high salary costs, WVIZ decided it would either have to charge schools for this service or have to move to a centralized dubbing and mailing system. The schools decided that the advantage of immediate delivery was not worth the cost. The dubbing system was built in 1972-73 at a capital cost of $30,000, less than the price for the engineers for one year.

At present, a staff of two relatively unskilled persons operates the dubbing equipment in a small room at WVIZ at a labor cost of only $10,000. Output is around 8,000 dubbings per school year (three per hour on each of three machines operated by two persons) so the labor cost for the service, which is the main cost, is only $1.25 per dubbing. If the $30,000 capital

investment is amortized over 10 years, then it amounts to about $0.40 per dubbing. So the total cost per dubbing is under $2.00 and probably close to $1.50.

CASE STUDY V

INSTRUCTIONAL RESOURCE CENTER

SCHOOL BOARD OF WASHINGTON COUNTY, MARYLAND

HAGERSTOWN, MARYLAND

Overview

After 20 years of experience with intensively used ITV, the Hagerstown system has radically altered its educational philosophy. It has shifted away from a centrally-controlled mass-instruction approach that to a large extent tended to replace student and teacher instruction in the classroom. It has instead embraced the concept of classroom-controlled individualized learning.

Centralized, cabled, and intensive ITV is giving way to (1) dubbed-videotapes bicycled from school to school, and (2) reel-to-reel films, film-strips, slides, overhead-projector transparencies, and other venerable but more individualized modes of mediated instruction.

In sum, Hagerstown is opting for school-controlled mediated instruction that teachers and students can get their hands on, and against centrally controlled ITV distribution (see Table V.A).

Foreword

Since its inception some 18 years ago, much has been written about Hagerstown as a model of the intensive use of instructional television, on a multi-school region-wide basis. These studies have plotted this system's historical development, analyzed its educational impacts on resident students, scrutinized its costs, estimated the costs and benefits of intensive ITV, and extrapolated recommendations to benefit future intensive ITV systems.

This case study does not recapitulate these studies, nor does it purport to examine comprehensively the range of factors examined by those studies. As indicated in the introduction to this study, only a narrow range of

Table V.A

Instructional Resource Center

FIVE YEAR TELEVISION DISTRIBUTION PROPOSAL

Year	CaP Cable Costs	CaP Distribution Reduction	Channel Reduction	Actual CaP Costs	CaP Savings Costs	Internal Distributions	Color Costs	Total Realloca-tion Costs	Total System Costs	System Differ-ential
1975-76	183,877.00	--	--	--	--	--	--	--	183,877.00	--
1976-77 Phase I	183,877.00	60,028.50	10,732.00	113,116.50	70,760.50	14,800.00	48,000.00	62,800.00	175,916.50	7,960.00
1977-78	183,877.00	26,680.00	--	86,436.50	97,440.50	13,300.00	48,000.00	61,300.00	147,736.50	36,140.50
1978-79	183,877.00	37,120.00	--	49,316.50	134,560.50	28,100.00	48,000.00	76,100.00	125,416.50	58,460.50
1979-80	183,877.00	16,456.00	--	32,860.50	151,016.50	17,000.00	48,000.00	65,000.00	97,860.50	86,016.50
1980-81	183,877.00	7,953.00	--	24,907.50	158,969.50	9,600.00	48,000.00	57,600.00	82,507.50	101,369.50
1981-82	183,877.00	--	--	24,907.50	158,969.50	--	48,000.00	--	24,907.50	158,969.50

phenomena are focused on, including system costs and conveyance technology.

Geographical Features

The shape of Washington County bears a striking resemblance to that of the State of Maryland itself. It has an area of 468 square miles and a population of 104,00 persons. The student population in the county's school system is about 21,500, with a student density of 46 students per square mile. Below is a map which displays the development of the system.

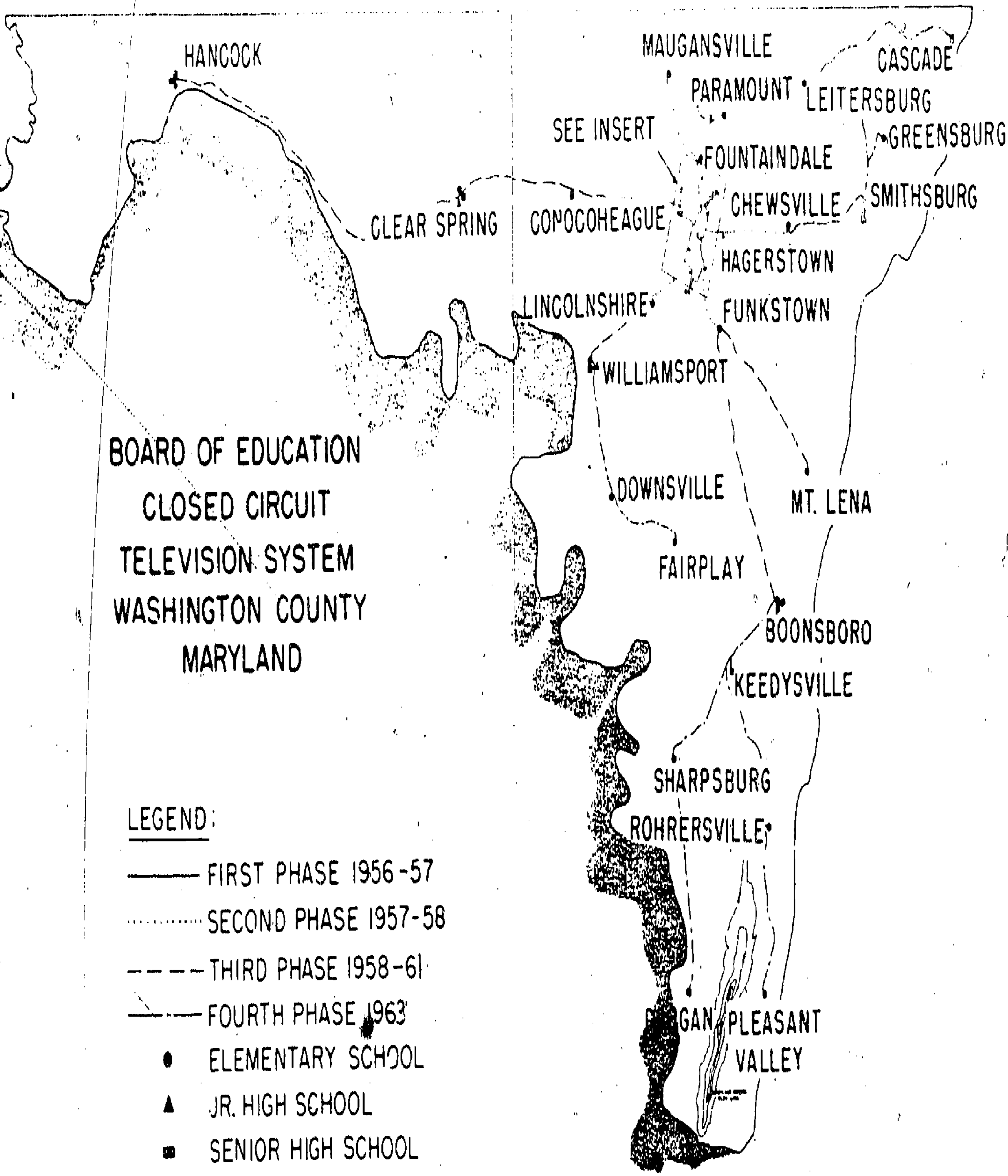
The "Hagerstown" system serves 37 elementary schools and 15 middle and high schools in the County, for a total of 52 ITV receiving sites. The number of elementary ITV classrooms is 519, while the number of middle and high school rooms is 710, yielding classroom densities of 1.1 elementary rooms per square mile and 1.5 secondary rooms per square mile. ITV rooms per square mile over-all number is 2.6. Classroom aggregation levels for the system are 14 per elementary school, 47 per middle/high school, and 24 per school over-all.

Table V.B summarizes the geographical features of Washington Coun

Capacity and Capacity Allocation

The ITV conveyance system that has been used since 1956 is unique among all the systems looked at in this study. It consists of more than 115 miles of simplified coaxial cable developed by the Chesapeake and Potomac Telephone Company (C&P), with technical advice from Bell Laboratories. Up until 1976-77, the cable has carried 6 channels solely for ITV purposes; two of these will henceforth be eliminated.

The hub of the system is the Instructional Resources Center (IRC) in Hagerstown, which, in 1975-76, transmitted to elementary schools over channels 2, 4, and 6; to middle schools over 2, 4, 6, and 7, and to high schools over 2, 6, 9, and 11. The IRC has a two-way link with the Maryland



WASHINGTON COUNTY

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TABLE V.B

GEOGRAPHICAL FEATURES

1.	Area (square miles)	468
2.	Student population	21,500
3.	Number of reception sites	52
4.	Number of ITV classrooms	1,229
5.	Number of rooms per school	24
6.	Number of students per school	413
7.	Number of schools per square mile	.1
8.	Number of students per square mile	46
9.	Number of rooms per square mile	2.6
10.	Lease costs for transmission/reception system, 1975-76	$183,877
	a. per square mile	$ 393
	b. per school	$ 3,536
	c. per classroom	$ 150
	d. per student	$ 9

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State Department of Education (MDOE) via the Maryland Center for Public Broadcasting in Owings Mills from which the IRC receives and retransmits about 15 hours of ITV per week. Although these programs are broadcast over the Hagerstown Public TV UHF station, the hilly terrain in the County prevents the latter from reaching the outlying schools; hence, the need to retransmit the MDOE's programs over cable. The IRC is capable of transmitting downstate into the state-wide Maryland network and does occasionally broadcast community-oriented programs over the Hagerstown Public TV station.

In regard to total ITV transmission capacity, the IRC's typical telecast school day lasts from 8:00 a.m. to almost 3:00 p.m. Assuming a 34 week school year, the system's 6-channel capacity is therefore (7 hrs. x 170 days x 6 channels) = 7,140 continuous hours.

The IRC reports that, in 1975-76, it telecast 15 elementary series having an average of 45 programs per series. Each program was cablecast in four different time-slots on the average. Since the average program lasted approximately 20 minutes, elementary school transmissions equalled the equivalent of 900 continuous hours for the whole school year.

In 1975-76, the IRC telecast 12 middle/high school series having an average of 36 programs per series, each of which was retransmitted an average of 3 times. Since the average program lasted approximately 30 minutes, middle/high school transmissions also totaled about 900 continuous hours for the whole school year.

So all scheduled transmissions together totaled 1800 continuous hours, for only 26% of the 7,000 hour capacity.

The "potential classroom contact hour" volume was slightly more than 1,100,000 (elementary: 900 hours x 519 rooms, + middle/high: 900 hours x 710 rooms).

Table V.C summarizes the Hagerstown ITV capacity and capacity allocation.

TABLE V.C

CAPACITY AND CAPACITY ALLOCATION: ITV

	Total Number of Hours	B: Utilization as % of	C: Scheduled Originals as % of	D: Scheduled Repeti. as % of	E: Unscheduled Transm. as % of
A: 1975-76 Actual ITV Capacity in continuous hours	7,000	27%	6%	19%	1%
B: 1975-76 Actual ITV Utilization	1,870	100%	24%	72%	4%
C: Scheduled Original ITV Transmissions	450	X	100%	n.a.	n.a.
D: Scheduled Repititions of Original Transmissions	1,350	X	X	100%	n.a.
E: Unscheduled Transmissions	70	X	X	X	100%

VOLUME OF SERVICE (CD Potential Consumption): 2,298,000 pech

POTENTIAL CLASSROOM CONSUMPTION: (I-S Potential Consumption): 1,064,000 pech

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Given Hagerstown's reputation as the classical case of intensive ITV distribution and use, this low ITV transmission capacity utilization rate is both remarkable and unexpected. It has no doubt been one of the reasons for the elmination of 2 channels (9 and 11), after 1976.

This shift from centrally-controlled distribution has resulted in a reduction of the number of hours per week of ITV exposure, for those students who receive any ITV at all. (This does not necesarily mean that the total number of student contact hours in the whole system has diminished since some students may now be exposed to ITV who would not have been under the traditional philosophy.)

The shift has also resulted in a move toward the bicycling of videotapes and videocassettes whose playbacks can be controlled inside the school. (For instance, the teacher can not only control the time during the day and the time during the class-period at which the tape is played, but can also interrupt, skip over, or re-order the sequence or portions of the program in a way that more closely resembles student classroom exposure to a textbook.)

And finally, the shift in philosophical stance has also resulted in a move away from ITV in general, to the more venerable audio-visual technologies that are less modern and sophisticated but are also more easily used and controlled by students and teachers; technologies such as 16mm reel-to-reel film, Super-8 film, film-strips, slides, and various transparency technologies. The IRC reports that the move to smaller classroom technology has been inspired as much by teacher-student demand, as by economy drives by the County School Board.

The IRC's view is that each kind of technology should be used to do what it does best and that no technology can substitute for active student participation in the learning process through interactions with the teacher and other students. TV and other media are more sharply defined as learning enhancers that are not genuinely essential to adequate learning.

The only exceptions to this policy are cases in which ITV is much more cost-effective than paying for classroom talent. One exception is using highly specialized ITV talent, plus classroom teachers who can teach in more than one subject area, instead of highly specialized art and music teachers for each of the schools in the system.

The IRC has launched a project that will almost completely transform the County's ITV conveyance system by replacing coaxial cable transmissions with shipments to schools of dubbed videocassettes. Different segments of the County's cable system will be sequentially phased out until only Hagerstown itself will be distributing ITV via cable. Each school in a segment being phased out will be simultaneously equipped with facilities for playing videocassettes over its own internal closed-circuit system that reaches every classroom in the school.

This plan will be implemented in five stages from 1976 to 1981. Equipping the schools for videocassette playback mode will be financed from savings from reductions of the cable lease with C&P. The savings will be reallocated to cover costs for (1) a gradual conversion from black and white to color, and (2) the installation of videocassette recorders and other headend hardware in each school's ITV center.

The 15 middle/high schools are already outfitted for dubbed videocassette reception and, in 1975-76, were shipped over 1,000 dubbed copies of programs that were also concurrently telecast over the cable system. The IRC plans to bicycle 2,160 dubbed cassettes to certain recently equipped elementary schools during 1976-77. A total of 1,350 blank tapes are currently in use for this purpose, a quantity IRC believes to be adequate for future needs.

Film materials of all types and transparency technology have the advantage over even the internal school distribution of ITV of being autonomously usable in the classroom by teachers and students. As it is unlikely that

the IRC will be able to afford a videocassette recorder for every ITV classroom, this advantage of non-ITV materials should continue into the foreseeable future. But perhaps the greatest advantage of non-ITV over ITV forms of mediated instruction is that many programs on film are prevented from being delivered via ITV video by royalty right restrictions. If there were enough copies of each film title on hand in this system, there is no question that film would be overwhelmingly preferred to ITV if only because of the expansive selection of programs afforded in the film format.

The IRC met over 5200 requests for film materials in 1975-76 (2576 from elementary schools, 2655 from middle/high schools). The IRC's reel-to-reel film library possesses about 1000 elementary level titles and the film-strip library about 600 elementary level titles; it also possesses about 500 of each type for middle/high school students. The IRC expects to expand this collection from 20 to 50 percent in the very near future.

Consumption and Service Volume

In other case studies, it was noted that rarely have the systems studied been able to supply any data on ITV consumption and utilization in their schools. Hagerstown is no exception.

There are, however, indications of a shift in teacher and student media demand. For instance, the IRC has had to move its graphics department's activities away from fabricating film and other materials for use in ITV productions to meeting requests from teachers for these items for direct use in their classrooms. Previously, 90% of this department's output went for ITV production support. Presently, 75% of the output is used in classrooms.

A comparable uncertainty surrounds the available indicators of non-ITV media service volume. In the case of ITV it is known how many hours of programming are aired annually and how many classrooms could receive and consume ITV if their TV sets were turned on. Roughly analogous data are

available for film but not in a form that lends itself to developing a meaningful measure of "potential classroom contact hour" volume.

The IRC shipped and loaned about 6,000 film items to schools in 1975-76. It estimates that the typical item was shown an average of three times during each loan period for a total actual consumption estimate of 18,000 actual classroom-contact-hours. But the IRC has no hard evidence on which to base this 3.1 ratio between showings and loans. It is even less clear how the potential consumption rate of film materials should be estimated since the items are loaned to each school for a period long enough for each loaned item to be shown 24 or more times per loan period. This would provide an annual potential consumption estimate of, say, 250,000 potential-classroom-contact-hours to compare with the ITV potential consumption estimate, but it is not obvious whether such a comparison could be very meaningful or useful.

Perhaps these problems can be ignored since the most important aspects of the Hagerstown system are the sweeping changes it is now undergoing that are transforming it into a radically new type of system. Not only has the IRC eliminated two of its six transmission channels, but it is also reducing the number of courses that are produced in-house every year and is increasing the proportion of its transmissions that are originated by the Maryland State Department of Education.

In the 1960's, the IRC telecast only "live" classroom-like programs, all of which were produced "in-house" using outstanding resident teachers. For 1976-77, there are no "live" telecasts and, except for art and music programs designed for different grade levels telecast from 2 to 8 times a month, the IRC is telecasting only 6 series that have been produced "in-house." Its major production goal now is to reproduce older black and white programs in color. The rest of the schedule is filled with 22 series/mini-series originating from the MDOE. So, except mainly for art and music, the transmission component of this system is becoming largely an ITV redistribution

arm of the Maryland Public TV Network. It should be noted, however, that the IRC reschedules and repeats most of the State programs, so it is not merely an extension of the State system.

Costs

Of greatest interest to many readers are the changes in the system's financial picture brought about by the policy changes that have been discussed. Some cost data have been unobtainable either because they were video costs, but not isolated as such in the IRC budget, or because they were more general media costs, but not isolated as such in the Washington County School Board budget.

Building rentals, costs for telephone and other communications, and costs for utilities are examples of the latter since the IRC shares its physical plant with other School Board departments. Similarly, salary and personnel compensation data were not clearly attributable to the ITV component of the IRC operations since most of the IRC staff perform functions related to the acquisition, production, storage, or distribution of film and other media materials as well as of ITV. Where possible, we have estimated the proportions of these costs that can be attributed to the ITV component.

The data that have been acquired are interesting in their own right even though they do not together provide an exhaustively complete picture. Table V.A outlines the IRC's 5-year plan to transform the traditional conveyance system from transmission to shipments of dubbed tapes. The second column in Table V.A concerns ITV distribution costs and indicates cates what IRC did pay in 1976, and would have paid in each succeeding year from 1977-82, to Chesapeake and Potomac Telephone Company for leasing its cable lines. The second row of the fourth column represents savings earned from eliminating channels 9 and 11, reducing the total number of transmission channels from 6 to 4. The Phase V $24,907.05 in the fifth column, is the lease fee for the remaining cable lines used only in Hagerstown itself. The

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seventh column indicates annual expenditures for equipping schools with head-ends for their autonomous internal closed-circuit distribution systems that will playback tapes shipped to them from the IRC. The eighth column indicates the $240,000 expenditure for converting the system from black-and-white to color.

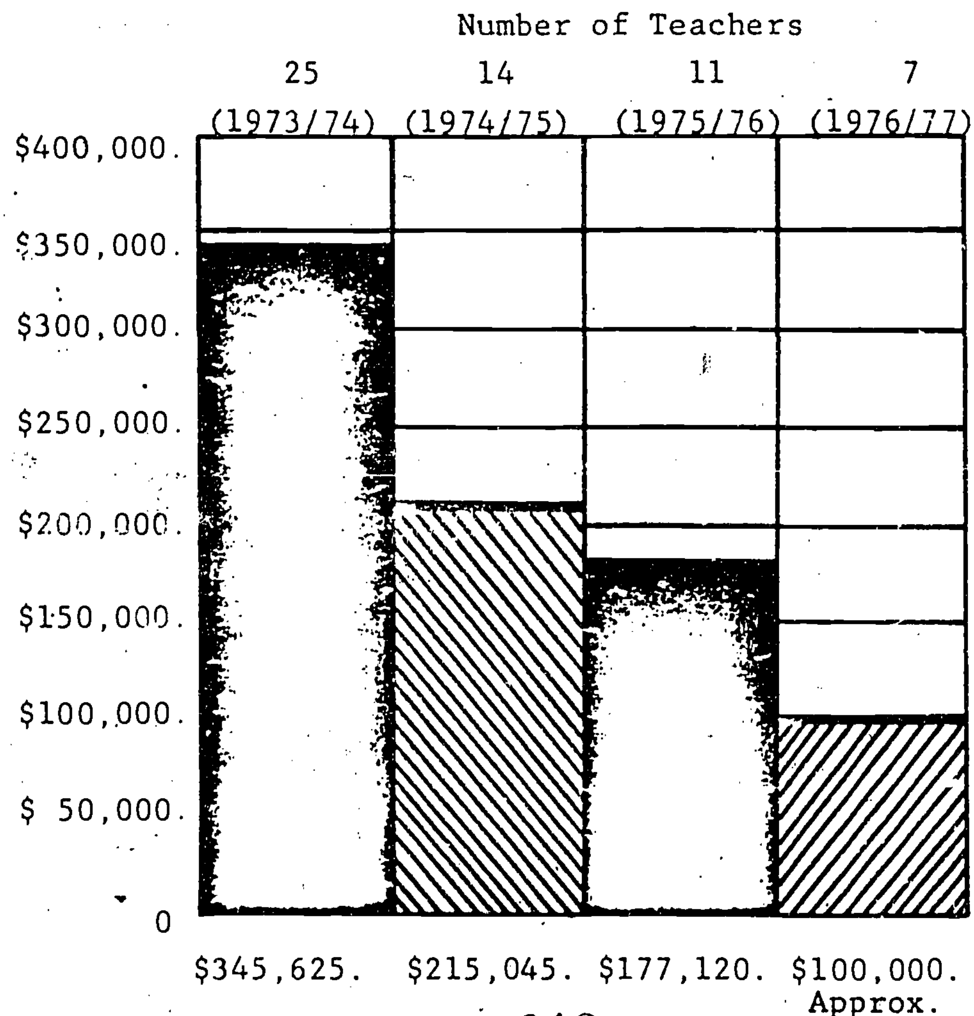
Missing from Table V.A are expenditures for the equipment, tapes, labor, and shipping/bicycling charges to be incurred by the new dubbed-tape shipment system that will replace cable delivery in most of the county. The IRC expects that these will not be countable as extra add-on costs to the whole system, as the tapes and dubbing equipment were already in use in the transmission system and the increase in dubbing-shipping labor will be matched by decreases in transmission-related labor.

The most salient and remarkable feature of this plan is that, simply by reducing long-line transmission charges, the Hagerstown system will be able to pay for both (1) the conversion from black-and-white to color, and (2) the installation of all internal distribution equipment at all the schools to be served by the new dubbed-tape bicycling system.

Figure A depicts the reductions in expenditures for programming talent from 1973 to 1977. It is expected that this trend will level off after 1977. The IRC believes now that repeated uses of taped high-quality programs are more educationally worthwhile than single-use "live" programs. Interviewed production staff say that it now takes only one year to generate a semester course that has "all the bugs worked out of it."

Figure A

TELEVISION TEACHER'S SALARIES



The total "IRC Capital Outlays Budget" came to $59,000. It will be assumed here that this 1976-77 total is ~7% larger than the 1975-76 total for the same items making the latter about $55,000. ITV's share would then be around $14,000.

The IRC's "Instructional Resources Center Budget" for 1976-76 totaled $125,741. This expenditure was for the materials, not the capital equipment, needed for producing and distributing ITV, A-V, and printed products. ITV's share of this expenditure is estimated by this writer to have been $52,500.

Other costs reported by the IRC but not included in either of the above budgets are summarized in Table V.D.

TABLE V.D

EXPENDITURES

The original capital expenditures for the conveyance system in the county twenty years ago were quite high largely because large-scale closed-circuit ITV was a technological novelty. Since these capital outlays could have only historical interest and could not be meaningfully compared to the other systems studied here, they are ommitted.

The only capital expenditure over the past few years that should be mentioned here is the IRC film library's purchase of $433,000 worth of reel-to-reel films, film-strips, and slides. All other expenditures included in this table occurred in 1975-76.

		Cost per Student	Cost per PCCH Supply	Cost per PCCH Consumption	Percentage of Total 1975-76 Costs
I. COSTS ASSOCIATED WITH THE CONVEYANCE SYSTEM					
1. C&P Cable Lease	$183,000	$ 8.55	8¢	17¢	28%
2. ITV Engineering Personnel Salaries	63,600	2.96	3¢	6¢	10%
3. ITV's Share of the IRC Capital Outlays	14,000	.65	___	2¢	2%
TOTAL CONVEYANCE-RELATED	$260,600	$12.12	11¢	25¢	40%
II. COSTS ASSOCIATED WITH PRODUCTION					
1. TV Teacher Salaries	$177,120	$ 8.24	8¢	17¢	27%
2. TV Directors and other Personnel Salaries	$115,649	5.38	5¢	11¢	18%
3. ITV's Share of the IRC Materials Outlays	$ 52,550	2.44	2¢	5¢	8%
TOTAL PRODUCTION-RELATED	$345,319	$16.06	15¢	33¢	53%
III. COSTS ASSOCIATED WITH OTHER ITEMS					
1. ITV Administration Salaries	$ 35,478	$ 1.65	2¢	3¢	5%
2. Printing and Publications	5,000	.23			.7%
3. Travel	3,500	.17			.5%
4. Library(non-print)	2,000	.09	___	___	.3%
TOTAL OTHER	$ 45,978	$ 2.14	2¢	4¢	7%
TOTAL OPERATIONS COSTS	$653,000	$30.37	28¢	61¢	100%

CASE STUDY VI

THE INSTRUCTIONAL MATERIALS SERVICE
INTERMEDIATE UNIT #14

BERKS COUNTY, PENNSYLVANIA

Overview

During the late 1960's, the Instructional Materials Service (IMS) experienced increasing difficulty in meeting the request for films from its constituent school districts. The IMS film library contained more than 5,000 film prints. But, as the ratio of copies to titles was 4:1, demands for programs often exceeded the supply. The demands themselves were rarely spread out evenly over the school year but rather displayed an up and down character.

For instance, requests for films about Daniel Boone (who was born in the Berks County area) tended to inundate the IMS around November 2 (Boone's birthdate) but would then taper off to a trickle at most of the other times in the year. Teachers frequently had to wait weeks or months for their requests to be fulfilled and would consequently be forced to use the films at untimely points in their courses or not use them at all. Film technology was clearly not appropriate for the large-scale distribution desired by teachers and students.

Since 1970, the IMS' "Operation Cooperation" has striven to overcome these distribution problems by resorting to the mass-distribution video technologies of cablecasting and the dubbing of films on multiple videotapes for shipment to schools with VTRs. Teachers and students are now able to view indirectly films via video simulations when they want and need them.

The success of "Operation Cooperation" has been due to the IMS' ability to engage the collaboration and support of both commercial film vendors and local cable companies in the Berks plan to cablecast films at a price per copy

that seldom exceeds the price for the four copies that the IMS traditionally purchases anyway. Most of what follows will concentrate on this unusual experimental arrangement.

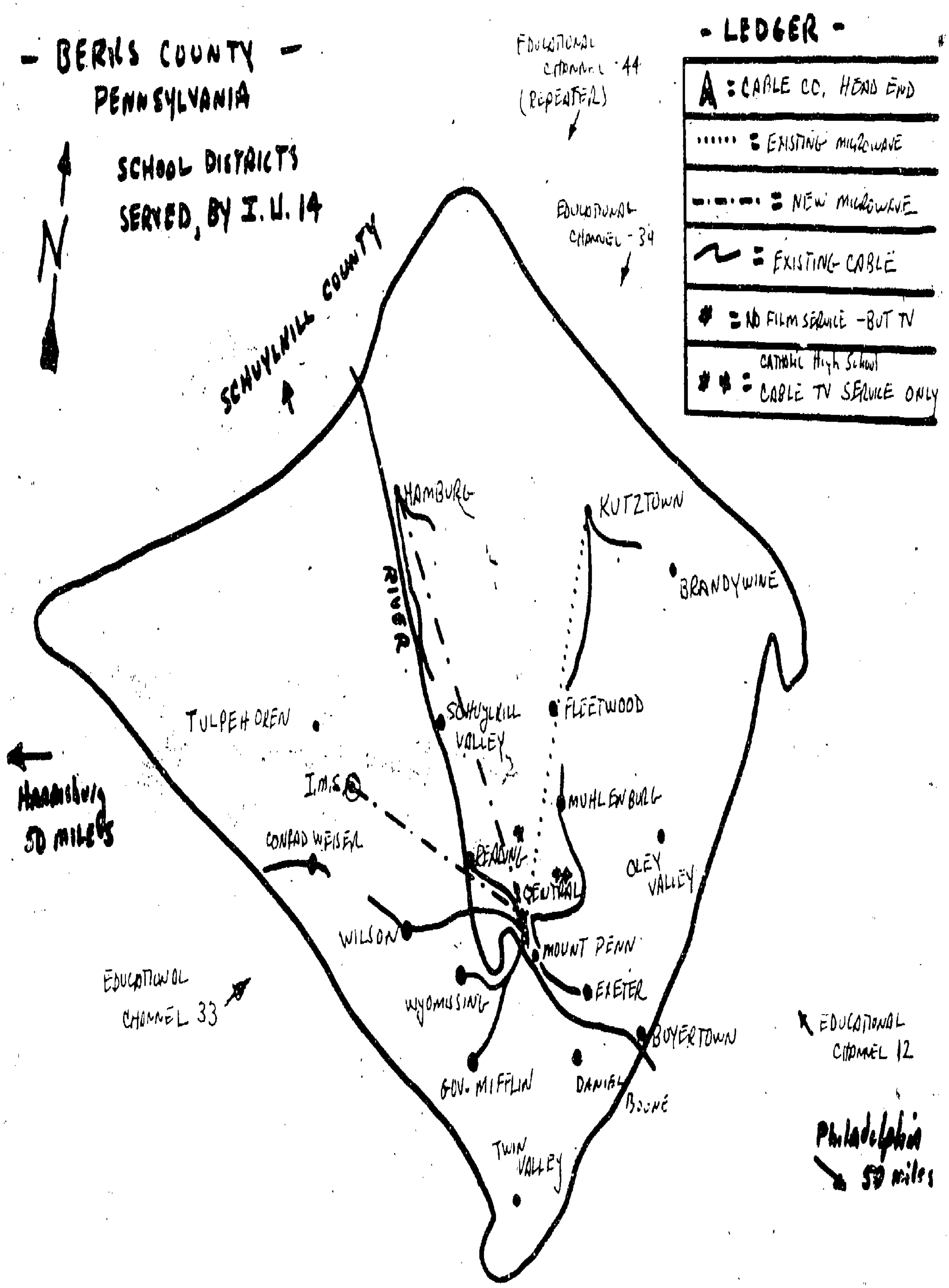
The System

Berks County is a rural-suburban, somewhat hilly area of 1264 square miles in the southeastern quadrant of Pennsylvania. Fifty miles northwest of Philadelphia, its largest city is Reading with a population approaching 100,000. The Berks County Intermediate Unit (BCIU), located a few miles away in Leesport, is one of twenty-nine regional facilities established in 1970 to serve as intermediate agencies between school districts and the Pennsylvania Department of Education. One of the BCIU's major operations is an Instructional Materials Service (IMS) which maintains and distributes a library of approximately $1,000,000 worth of films. The library contains approximately 2,900 film titles and a total of 6,000 prints. The IMS is responsible for serving all of the county's elementary and secondary schools in eighteen school districts with a total of 65,000 students. Just to the northwest of Berks is rural and mountainous Schuylkill County which has eleven school districts and 30,000 students which are also served by the Berks IMS. The IMS is the sole source of educational films for the 3,800 teachers and 95,000 students in these two counties.*

Most of the schools can receive programming from Public Television stations in neighboring counties. Because these stations are located outside the IMS service area, however, their telecasts reflect the curriculum decisions of other school districts. The districts in Berks and Schuylkill Counties have therefore had to rely on the IMS for their own special needs.

The IMS operates in a lending library mode. Holdings are circulated to

*Berks and Schuylkill Counties each have distinct Intermediate Units. Schuylkill, however, does not have an Instructional Materials Service and contracts with Berks' IMS for programming.


- BERKS COUNTY -
PENNSYLVANIA
SCHOOL DISTRICTS
SERVED BY I.U. 14
N
- LEDGER -
A : CABLE CO. HEAD END
: EXISTING MICROWAVE
: NEW MICROWAVE
: EXISTING CABLE
: NO FILM SERVICE - BUT TV
: CATHOLIC High School
CABLE TV SERVICE ONLY
EDUCATIONAL CHANNEL 44 (REPEATER)
EDUCATIONAL CHANNEL - 34
SCHUYLKILL COUNTY
HAMBURG
KUTZTOWN
BRANDYWINE
RIVER
TULPEHOCKEN
SCHUYLKILL VALLEY
FLEETWOOD
I.M.C.
MUHLENBURG
Harrisburg 50 miles
CONRAD WEISER
READING
OLEY VALLEY
CENTRAL
WILSON
MOUNT PENN
EDUCATIONAL CHANNEL 33
WYOMISSING
EXETER
BOYERTOWN
EDUCATIONAL CHANNEL 12
GOV. MIFFLIN
DANIEL BOONE
TWIN VALLEY
Philadelphia 50 miles

213

users on a request basis. But before 1975, the IMS was unable to adequately meet teachers' needs. Seasonal films were the biggest problem. The scarcest with respect to peak demand were films appropriate for use on days surrounding Washington's Birthday, Columbus Day, Thanksgiving and so forth. During these periods, a host of teachers would request the same film at the same time. However, the IMS has traditionally had no more than four or five copies of any one title available for distribution, and the purchase of additional copies was not cost-effective because these films are expensive and are not used throughout the rest of the year. So the BCIU sought cost-effective ways to make its library holdings more available at the times when they were needed.

Since 1971, four separate entities have collaborated in planning efforts aimed at solving these problems: the BCIU, the local school districts, the Berks County Educational Television (ETV) Committee and Berks and Suburban cable television companies. The ETV committee acted to improve media utilization countywide by calling on school districts to purchase standardized videotape equipment to ensure county-wide compatability and by recommending the joint purchase of equipment, tapes, and other materials to reduce costs. The joint purchase of materials and equipment and the purchase of compatible equipment may have other implications than savings in cost, time and effort. It may insure a continued cooperative relationship as institutions must work together to coordinate their efforts in order to maintain a successfully functioning system.

The ETV Committee also began negotiations with the Berks and suburban cable companies and with vendors of educational films in order to add on to its bicycled film system a telecommunicated-film system and a bicycled videotape system. The negotiations resulted in the following experimental arrangement. The BCIU contracts with the vendor of a film for either the rights to make duplicate copies on videotape or the rights to cablecast this film to schools that have a cable hook-up, or both duplication and cablecast rights.

public service. The BCIU is thereby able to provide access to high demand films in three distinct ways for little additional cost: (1) original 16 mm film prints for those schools which do not receive cable TV, do not have videotape players or simply want the program on film, (2) videotape copies (on reel-to-reel tape or videocassette) for schools not on the cable, and (3) cable distribution of films for the ever increasing number of schools able to receive this medium.

The Relationship Between the BCIU and Media Distributors

The agreements worked out with several film distributors are interesting because they represent a step toward a more favorable utilization policy for educational media. It must be emphasized that only a few vendors have entered into this arrangement. Coronet Films, BFA Educational Media, Benchmark Films, and a few others have agreed to experimental contracts whereby the BCIU can make videotape copies of particular films or transmit them via cable television on a closed-circuit channel. The 'closed-circuit' designation is critically important because most vendors do not themselves have the authority to grant rights for the distribution of their programs in modes which can be received by the general public. Vendors must respect contracts with the producers of the films they sell, and these producers in turn have contracts with the actors appearing in the films which require payments of royalties to the actors for every open-circuit showing to the general public. BFA Educational Media, for example, cannot give the BCIU the rights to open-circuit distribution of the Dr. Seuss films. In fact, Dr. Suess films are regularly leased to commercial television networks by Walt Disney Productions for open-air broadcast. (Royalty fees are paid in this case as with all other broadcast programs.) Obviously, periodic transmissions by organizations like the BCIU to the general public would seriously diminish network revenues for Disney.

The ability to duplicate films and to transmit via a closed-circuit cable

willing to try these experimental arrangements to find out how they may affect their sales. The BCIU continues to purchase four prints of each title contracte in the arrangement. The vendor knows that the BCIU can buy no additional copies so there is no sales revenue to be gained beyond the original four. The vendors have been persuaded that they will not lose money by granting distribution or duplication rights and have therefore temporarily given them to the BCIU gratis or for a small annual fee.

There is a difference between distribution and duplication rights. Both kinds of rights are not necessarily available for each particular title just as neither of these rights is available for some titles as mentioned earlier. At the present time, the BCIU must negotiate each separately. The BCIU can be faced with various possibilities when considering the acquisition of rights to a film.

1) The rights may not be available, in which case nothing can be done to obtain them.

2) The rights may be available but may be so expensive as to preclude their purchase by the BCIU.

3) The rights may be purchased for a nominal fee or one within the range of the BCIU.

4) The rights may be given free for a year to the BCIU on an experimental basis.

The designation "experimental" is used frequently by the parties involved in this arrangement. The reason for this caution is that the vendors are unwilling to leave the impression that these rights are obtainable by any agency similar to the BCIU, or are perpetually available to the BCIU itself. While similar organizations are invited to negotiate for the rights, the vendoı reserve the privilege of refusing rights to those whom they feel may abuse them.

At the time of this writing, the BCIU has acquired the duplication and distribution rights to 100 films. Of these films, the rights to about twenty

State of Pennsylvania, and forty or fifty came automatically with the purchase of the films. These are total figures covering both distribution and duplication rights. While an exact breakdown is not available, more rights have been obtained for cable TV distribution than for videotape duplication.

The Relationship between the BCIU and Cable Television Companies

At the present time, three cable companies have agreed to transmit the BCIU's programming. Six more companies are expected to follow soon. The cable companies involved have provided the BCIU with sole access to a channel which can only be received by those persons equipped with a channel converter. The cable companies have supplied these converters to each school within a close proximity to the trunk cables which run the length of the streets on which their customers live. The channel converters have been supplied only to schools; they are not provided to regular cable subscribers. Although some established cable systems are designed with channel converters in every home, many others throughout the country are similar to the Pennsylvania systems just described. In these similar cases, there exists the possibility of cooperative efforts like those found in Berks County. The companies have also connected these schools to the cable at no charge, with one exception. In one case it was necessary to install wire in many rooms in one building which was not previously wired for television. The cable company involved charged a nominal fee of forty dollars per room; this charge included the cost of the wire used.

The BCIU uses the cable channel to transmit only those programs for which it has obtained distribution rights. A master copy of each film thus cleared is made on a videocassette. (The film itself is then free to circulate directly to schools.) Programs are transmitted according to schedule on a videocassette player supplied by the cable company at its transmission facilities called the cable "headend." A BCIU staff member works at the cable headend where he or she does the actual running of the machine and changing of the tapes. Programs are scheduled and transmitted six hours a day four days

a week, Monday through Thursday. On the fifth day the BCIU staff member works at the IMS production facilities transferring films to tape and generally preparing for the next week's programming.

It is important to point out that the cable companies involved in this operation were not required by law or charter to go as far as they have in meeting the needs of the schools. They have provided this service as a measure of good will. One must not be so naive as to think that the companies are not benefitting from providing this service. All cable systems are expected to, and frequently charged with, serving the public. By providing Berks County schools with a free exclusive television channel they are enhancing their image in the community. Maintaining good public relations is sound business practice. One would suspect that similar arrangements can be worked out between educational organizations and cable companies throughout the country based on these principles.

How Programming Decisions Are Made

The Berks County Educational Television Committee is an active group of concerned individuals. This group includes curriculum and media specialists as well as representatives from all levels of the educational community, civic organizations and businesses such as the cable companies discussed above. The committee meets monthly to determine which programs will be shown the following month and on what days and what times of day each program may be seen. In arriving at these decisions, the committee solicits and considers scheduling requests from each of the school districts. Typically, a teacher will receive from his/her district a "feedback form" on which are listed the programs to be shown the following month. The teacher may list the times when each appropriate film would be most conveniently viewed by his/her class. These opinions are synthesized at the school district level and forwarded to the ETV committees. A schedule for the month is printed and distributed to all teachers.

Also included on the schedule are times when new films may be previewed by teachers. These films may be under consideration for purchase or for acquisition of distribution and/or duplication rights. Teachers are encouraged to submit their recommendations regarding these decisions.

At this time teachers do not formally have input into which programs will be shown each month, only when they will be shown. The reason is that the selection of films from which to choose is relatively small. Certain seasonal films and continuing programs in a series are essentially self-scheduling. The others are decided upon by the ETV committee. As the number of programs for which transmissions rights are obtained grows, a mechanism for teacher input into program selection will be necessary.

A New Wrinkle: A Microwave Link

As of this writing, the BCIU was awaiting installation of a point-to-point microwave transmission system which would permit the IMS to originate programming at its own production studios for transmission to a school district in the northern part of the county (see map). The signal will be picked up there by a cable company and re-distributed to area schools.

This is of particular interest in this study since it is only because the microwave is point-to-point and not omnidirectional (as is ITFS) that the new transmissions will not jeopardize the "closed-circuit" designation deemed mandatory by vendors in suspending royalty requirements. The single microwave beam is awarded the same status as a single cable-line.

Apparently, vendors stress <u>how</u> the signal is conveyed from place to place (single narrow beam versus 360° wave-front) and not how many sites are equipped to receive the signal. Thus, many ITFS systems are denied the "closed-circuit" designation even though special equipment is needed to receive the super-high frequency low-powered signal.

The most interesting aspect of this new step is that it is a harbinger of

what BCIU hopes will be a complete two-county microwave network. As more and more cable companies must join the existing system to extend coverage to all schools, the project may well become cumbersome and unmanageable. The necessity to have BCIU staff persons at each cable headend may be unfeasible. It is unlikely, however, that a "pure" microwave network will emerge, unless costs can be minimized. (The first system being installed costs approximately $56,000.) What is more likely is some combination of microwave network and the existing cable structure which is serving so well at the present time.

Capacity and Allocation

In regard to the IMS' cable cast mode of ITV conveyance, the single channel system has an absolute capacity of 6 3/4 hours per day, 33 3/4 hours per week, and 1140 3/4 hours per school year. However, since the channel is dark on Fridays as previously explained, these capacity values should be reduced to 27 hours per week and 912.6 hours per school year.

Actual transmission schedules vary from week to week, but a typical weekly value (April 5-8, 1976) measured by our staff was 17 hours 22 minutes for a capacity utilization rate of 64%. Nearly 1/3 of these cablecasts were previews of the new programs or of candidate programs that the IMS was considering purchasing.

Little can be said about the supply and consumption sides of this system because the IMS does not tabulate disaggregated data about the ultimate potential consumers, the teachers and students.

The IMS acts chiefly in a brokerage capacity between the school districts on one hand and the Pennsylvania Department of Education, the local cable companies and the vendors of film on the other hand. Film utilization on the school district level amounted to over 80,000 prints in 1975-76. However, the IMS has no idea how many schools, classrooms, teachers and students used each print on the average, so this has little utility for cross-system compari-

Few other less disaggregated data have been made available by the IMS. What information has been obtained is summarized below.

Of the 95,000 students in the 1,264 square mile area, about 35% or 33,000 received ITV in 1975-76 either via cablecasts or via dubbed videotapes that were shipped to them. Films, on the other hand, continued to be sent to all districts in the area. Presumably, this means that films were distributed to all schools. However, the IMS does not know what happens to the prints after they are received at the school district offices which have complete control over how IMS materials are redistributed to schools.

A total of 125 schools are hooked into the main Berks cable system covering a 200 square mile area. Another 25 schools are served by the suburban system covering an 85 square mile area. The IMS expects that 6 cable systems will eventually collaborate in this IMS program. But it is interesting that the two cable systems just mentioned together reach only 16% of the total area over which films are distributed.

The total IMS budget for 1975-76 came to $261,700. $55,000 of this went to the construction of the point-to-point microwave link that has already been mentioned. So the operating expenditures totaled $206,700 or $2.18 per student for the 1975-76 school year.

The IMS reports that a surprisingly small portion of this total, namely $8,600 (4% of the total), constituted ITV costs and that the rest were film-related expenditures. It is probable that the $8,600 was restricted to dubbed-videotape costs and that the costs associated with cablecasting (e.g., salaries for IMS staff at the cable head-ends) were absorbed under the "film" heading.

46% of all expenditures ($95,000) were spent on the acquisition of new films. However, this was paid for ultimately by the Pennsylvania Department of Education and not the school districts.

CASE STUDY VII

THE CLARION MANOR SYSTEM

Overview

The Clarion Manor, Pennsylvania, system makes televised media available to the classroom teacher upon request through the use of videocassette recordings of films. Based on the Clarion Manor idea a system of locally maintained libraries of videocassette materials can be envisioned. Such a videotape library could be a part of a school district's library, thus making available televised instructional materials to each classroom teacher--and to each student--much like ordinary library books.

The primary difficulty encountered within such a system would be the copyright laws presently governing duplication of films. Under present law, fees paid to film producers to duplicate their films, as well as restrictions on longevity of use of tapes, may make the concept of local videocassette libraries prohibitively expensive. However, the success of the Clarion Manor system indicates the possibility of solving this problem. The long term advantages which would accrue to the film industry if such a system were widespread might make changes in the copyright laws practical.

Clarion Manor Instructional Materials Services distributes a variety of educational materials throughout 17 school districts in six western Pennsylvania counties. This 3,000 square mile area has more than 45,000 public school students. Prior to the beginning of an experimental project using a videocassette library system to stimulate utilization of instructional materials, a teacher who requested a film from the regional materials library had only a 50 percent chance of receiving it. Consequently, many teachers became discouraged. The result was that far fewer requests were being made for films than were actually desired. Even so only about half of all requests could be satisfied. Despite having 2,300 titles in its film library, the regional material library had to deny requests for films 26,000 times a year because of the logistics of film usage.

Wayne Goss, the director of the Clarion Manor Intermediate Unit, Instructional Materials Services, and Michael Vereb, who is in charge of Special Projects for the unit, developed the idea of replacing the central library of film reels with 17 videotape libraries, one for each school district. Continuing the central system of film titles and prints to meet a growing demand posed insurmountable difficulties in booking, scheduling, delivering, retrieving and maintaining films. The more convenient videotape system offered a solution.

The plan that was developed envisioned each of the 17 district videotape libraries being supplied with 1,000 identical titles on videocassettes. In time, it was anticipated, the local libraries would become customized to meet special local needs and philosophies--a flexibility impossible for a regional facility.

The regional instructional materials service provides coordination and development services under the new arrangement. This coordinating service includes acquiring new titles for the master film library, making videotape masters from which videocassettes can be dubbed as needed, and maintaining dubbing and repair facilities for the district.

The start-up costs of the new system, at about $500,000 (or about $11 per student served), were met when previously impounded federal funds were released. With funding approved in December, 1973, the logistical work began. One thousand titles were to be duplicated on videocassettes and cataloged so that teachers could use the new district videotape library the following September. Formal agreements with the producers of the first 1,000 film titles had to be reached in order to get permission to duplicate their copyrighted works.

The Clarion Manor system requested permission from the producers to duplicate specific titles, 17 copies each, at an annual per title fee, and to handle the duplication and distribution themselves at no cost to the copyright holders.

Currently, controversy surrounds the duplication of legally protected works by schools, libraries, and other non-profit institutions. Some publishers and producers are wary of permitting any kind of copying, preferring to supply film prints or videocassettes themselves. However, the Clarion Manor proposal's advantages were appreciated by the producers of educational materials. The film producers realized the potential benefits that would accrue to them with greater utilization and availability of their products, so they elected to keep their duplication fees reasonably low--$7 per title annually up to a flat 10 percent of the film's list price, plus the purchase of one copy of the film to serve as the videocassette master. This arrangement both increases use and availability of the material to the classroom and increases profit to the film producer. The fee structure will be reviewed by Clarion Manor and the producers in two or three years in order to see if the agreements should remain as negotiated or adjusted in some way. But it is already clear that the Clarion Manor plan could become a model for other educational systems.

Film Transfer Technology

The Clarion Manor region was fortunate to have locally available quality duplicating facilities with the capability to undertake major communications projects from conception to completion. Such a capability reduces logistical problems and consequently reduces the costs of quality videocassette duplicating. The availability of such a full service quality production company facilitated the smooth development of the experimental and pioneering Clarion Manor system. Especially during the start-up phase, ongoing cooperation between the regional materials library and the local commercial quality duplication house was essential. However, this duplication could also be accomplished at somewhat greater cost for regional school programs not located near such duplicating facilities.

The technology involved in the film transfer and final post production of videocassettes for the Clarion Manor system links Bauer 16mm and Magnatec

35mm film projectors with individual interlock systems in order to project the material throu a Rank Cintel film chain. This process actually results in an improvement in the images being transferred to the tape and includes color correction and masking. The master tape is then dubbed into videocassettes via Sony's DPR-100 duplication system. The finished cassette is of equal or better quality than the original film.

Several films of 10, 20 or 30 minutes are combined on one 60-minute videocassette for economy. Sixty minutes of programming on one videocassette cost about one third as much as six 10-minute cassettes. When possible a 10-minute film, a 20-minute film and a 30-minute film of related content are combined on one 60-minute videocassette. The originally projected 1,000 film titles are contained on 250 videocassettes. During the academic year of 1974-1975, the first year of operation of the local video library system, the master library added another 300 titles.

At the beginning only 14 of the 17 districts chose to participate. Some districts tested the idea in one school, others implemented the system in each school in the district. Between 125 and 130 videocassette players, recorders, TV sets and projection stands were originally purchased for the cooperating schools. This number doubled during the second year of operation. Using the local school district's videocassette library and in-room equipment, teachers now have quick and sure access to many titles.

Utilization Results

The immediate result of the local library of videocassettes was the greatly increased availability of film titles to the classroom. The establishment of locally maintained videocassette libraries has meant that 95 percent of teachers' requests for materials are now fulfilled. During 1975-1975 twice as many requests were fulfilled under the new system as could have ben fulfilled under the regional film reel library system. More importantly, teacher satisfaction with instructional aids was enormously increased. The more

convenient and easier use of the videocassette system encourages the teachers to utilize their district's cassette library.

Discussion and Comments

The Clarion Manor regional facility created 17 district videocassette libraries from one program collection. Precise cost data are not available but improved material availability and the related advantages of the Clarion Manor system are obvious. Multiplying libraries of educational materials via videotape presents an autonomous, locally controlled program of instructional aids that can be selectively utilized by individual classroom teachers.

User access on demand is the obvious functional advantage a system of locally maintained videocassette libraries has over the technologies previou discussed in this report. In this sytem of videocassette libraries there is no necessity for central decision making regarding what is to be programmed. Indeed, videocassettes can be made as available to teachers and students as a book or microfilm in the school library. This technology is easy enough to operate that students can be assigned homework films, or even follow their own interest in a broad range of directions. Video library systems are limited only by the availability of videocassettes and equipment. A local library system also allows the flexibility for local interests to be served.

The flexibility of programming, ease of use, and user access on demand coupled with a relatively low-cost makes it easy to envision the Clarion Manor system being used as a model nationwide. A system can be imagined which ties each local district into a national library service of videocassette instructional materials. Local school districts could order videocassettes directly from a central (regional, state or federal) library, thus selectively serving local needs and interests with quality instructional materials.

Accurate cost data are unfortunately unavailable for the Clarion Manor system. But even if the instructional costs per-student hour of use were greater than that of the other systems previously discussed in this report, the functional advantages of a system of local videocassette libraries are compelling. User access on demand coupled with the immediate availability of self-selected materials results in a system which can be tailored to local education requirements--a flexibility missing from the centrally programmed systems previously discussed. At the very least adequate cost data should be obtained for a Clarion Manor type of system of instructional aids before a decision is made to implement any of the technologies discussed in this report.

CASE STUDY VIII

THE STANFORD ITV NETWORK

The Stanford ITV Network is an ITFS system designed to provide advanced technical courses to a special audience--professionals in Bay Area industries with limited time to devote to school work. Unlike the preceding seven cases, almost all programming is provided live (by professors at Stanford's School of Engineering).

The system was the first to install microwave audio uplinks to allow students to interact with professors "in real-time."

Background

The Honors Cooperative Program at Stanford University was begun in the mid 1950s to allow full-time employees of companies in the San Francisco Bay area to earn graduate degrees in the School of Engineering. By bringing the instruction to the students via broadcast television instead of bringing students to the instruction, the Stanford program has sought to substitute communication for transportation for students whose professional time is expensive.

The program was attractive to the companies because it allowed employees to enhance their professional capabilities (and credentials) while staying on the job. Stanford was interested in attracting professionals to its courses who are not releasable from their jobs for long periods. It saw that this market promised continued growth as the number of Bay area industries which use large numbers of engineering personnel was increasing exponentially.

Prior to the creation of the TV system, companies were usually willing to allow an employee to commute to the University to take a course--or even two if one followed the other--three days a week. But if the desired courses were separated by an hour or so, an employee could easily be absent from his

job 12 or 14 hours each week. The need for a cooperative graduate engineering program and the need to minimize time away from the job were the major considerations which resulted in the creation of the Stanford ITFS system.

The system's planners studied the ITV systems at the University of Florida and the TAGER system in the Dallas-Fort Worth area. A feasibility study indicated that, in addition to paying for in-house equipment necessary to receive and display ITV, the companies participating in the Program would also be willing to help defray Stanford's initial capital investment and operating costs.

The graduate faculty was amenable to participating in televised instruction, but with two important provisios. First, they insisted that a classroom atmosphere be maintained--that is, that they continue to teach "live" students in a classroom which is only incidentally a studio. Second, they insisted that remote students in the TV audience have the opportunity to interact with the professor and all other members of the class in real time.[*] This proviso resulted in a study to determine the most cost-effective option for providing the requisite feedback; microwave FM or telephone line rental. It was estimated that telephone rental scheme would cost more than a million dollars over a ten year period and that the microwave option would cost only half that much.[**] Accordingly, Stanford petitioned the FCC to permit the installation of FM talk-back transmitters at each ITV receiving terminal. The FCC responded favorably by granting the right to use a portion

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[*] Although this rule was adopted by the faculty as a necessary condition for receiving credit from Stanford, it has lately been relaxed when special conditions obtain. For example, at the present writing there are four companies participating in the Honors Cooperative Program which are outside the range of Stanford's transmitter, and thus receive 1/2 inch cassette recordings of the day's lecture. Ninety-five percent of instruction, however, continues to be live and interactive.

[**] See Martin-Veque, et al (1971; Reference 1). All references are listed at the end of this appendix. In fact, Stanford has recently retrofitted its network with a "time-sharing" talk back system (described in the following section) which is even more cost effective.

of the ITFS spectrum at the high end of the band for FM talk-back. This set the stage for Stanford to develop the first ITFS system with a microwave interactive capability.

Engineering Features

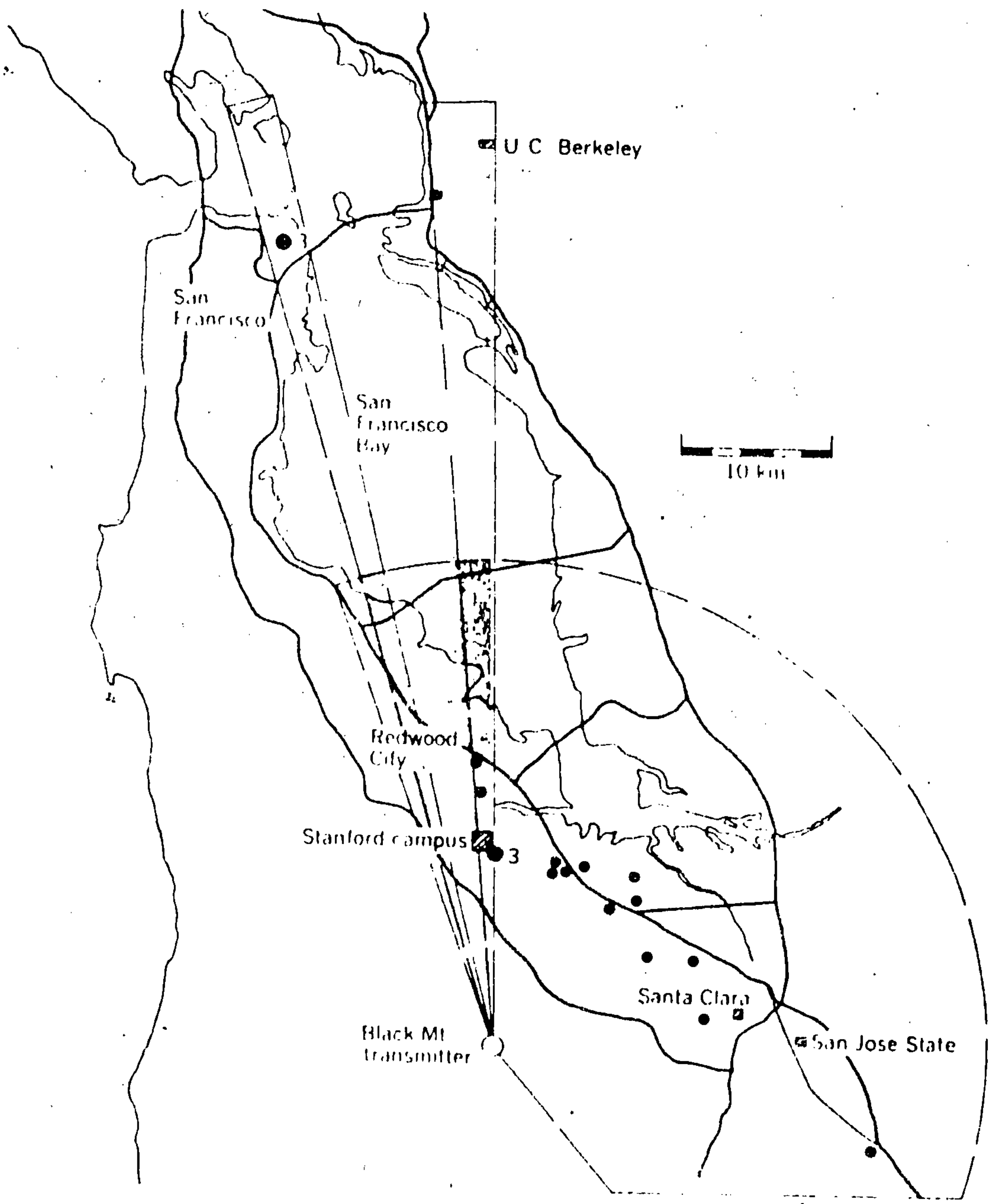
The Stanford system was engineered with a great deal of ingenuity and attention to detail. Instruction can originate from any of four 50 seat classrooms or a 200 seat auditorium. A room with monitors is associated with each TV classroom to accomodate overflow or for closed circuit TV lectures. Each classroom is equipped with an overhead camera which can zoom in on objects as small as transistors on the instructor's desk. A second camera is mounted in a wall in the back of the classroom. The cameras are not obtrusive and yet are fully functional; since they both have remote-controlled tilt, pan, and zoom capabilities, a single student technician can handle the entire production. A professional engineer works in the master control room from where he can supervise all four classroom productions simultaneously.

Each classroom has 25 TV monitors, one for every two students. University of California investigators report that even in-class students tend to make extensive use of the electronic medium, especially for detailed note taking.[2] A Stanford student can address both classroom and remote students by pressing a button on the monitor and speaking normally; his remarks are heard on speakers on either side of the room in the front of the class, and from speakers associated with remote TV receivers rooms throughout the network. The situation is virtually identical for students in remote company classrooms with two exceptions. First, in order to cure a feedback problem, it was found necessary to disenable the speaker system in the company classroom for the period of time the talk-back microphone was in use. Unduely lengthy remarks on the part of a vociferous student in the television audience can be thwarted by appropriate gestures from the podium. Second, with time-shared uplink transmitters at each company in the network, it is possible that two students at a given company

may want to address their separate classes simultaneously. Since the transmitter must shift carrier frequency as a function of video channel, it can only talk back to one classroom at a time. Hence, a simple device has been installed so that if the system is in use, a red light appears by each microphone in the company to indicate to other potential users that they will have to wait. But since the average total number of students taking courses simultaneously in a given company is only two, this time-sharing arrangement rarely poses problems. Finally, the difference between the price of a talk-back system which uses independent transmitters, antennas, and cables for each of four classrooms and the price of one which employs a time-sharing system is claimed by Jamison et al (1976) to be $12,640 versus $6,520.[3]

Normally, four classes are conducted and broadcast simultaneously throughout the network over four distinct channels. The four composite video and audio signals are run through a master switcher in the control room and then modulate a Lenkurt microwave transmitter at 12 GHz. The signal is received seven miles away at the top of Black Mountain, converted down to the ITFS band, and used to modulate standard Varian 10 watt ITFS transmitters at 2596, 2608, 2620 and 2632 MHz (ITFS Channels E 1-4). These are engineering features which are shared by most ITFS systems. The antennas and their feed structure, however, are different from the standard and represent interesting solutions to several problems of coverage.

The accompanying figure gives a view of the pattern of transmitter radiated power as a function of distance from Black Moutain as the system was originally configured. Seven of the total of ten watts of transmitter power per channel are sent through a horn antenna which has a coverage of 160 degrees of azimuthal arc, enough to cover all network companies within 25 miles. This antenna is tailored to radiate very little above the horizon, and its overall gain is 17 dB. As a result, companies in the area can get very adequate signal strength with moderate sized receiving antennas which range from 1 1/2 to 5 feet in diameter and cost as


U C Berkeley
San Francisco
San Francisco Bay
10 km
Redwood City
Stanford campus
3
Santa Clara
San Jose State
Black Mt transmitter

little as $300. But the system was also designed to reach both San Francisco and Berkeley. Thus, in the case of San Francisco, 33 miles from Black Mountain, a watt of power is used to radiate from a ten foot diameter parabola, with an eight foot antenna at the receiving site. For Berkeley, 38 miles distant, a 6 1/2 foot antenna is driven with two watts of transmitter power to a ten-foot antenna at the receiving site. This results in very adequate (and virtually identical) power received in both San Francisco and Berkeley. Audio uplink signals from the distant sites are received by parabolic antennas on Black Mountain, but their polarization is orthoganal to those carrying downstream video and audio to avoid any possibility of interference.*

There is one other engineering feature of the Stanford system which varies from the norm. Most ITFS systems convert the four received channels down to VHF channels 7, 9, 11, and 13 with a single local oscillator (since all ITFS channels are authorized in groups separated by 6 MHz). However, since strong over the air signals already occupy Channels 7 and 9, conversion to other channels is necessary. For the receiving system at companies in the Stanford network, therefore, a local oscillator frequency is used to mix the signals down to VHF frequencies corresponding to Channels 8, 10, 12, and 168 to 174 MHz. This latter corresponds to the high end of the portion of the VHF spectrum between Channel 6 (82 to 88 MHz) and Channel 7 (174 to 180 MHz). In consequence, a second conversion at VHF is necessary to mix the 168 MHz signal down to a channel which may be selected on a standard television receiver. In this case, Channel 3 (60 to 66 MHz) is used because of its relative freedom from interference. However, the VHF to VHF converter adds an incremental cost to each receiving system of approximately $200.

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*In commenting on an earlier draft of this case study, Kenneth Down indicated that the map and accompanying description of power distribution of the signal from Black Mountain are somewhat out-of-date. There are presently two other antennas which beam approximately 1/2 watt of power apiece in the directions of Richmond and Mount Diablo. The feed structure was modified so that the main horn antenna which serves the mid-penninsula presently radiates 6 1/2 watts and the dish serving Berkeley 1 1/2.

Though using a supplemental converter is not the only option available to solve this particular problem (excellent shielding of the television receiver's front end being another), this problem may be expected to occur with any ITFS system operated in an area of strong VHF signals on any of Channels 7, 9, 11, and 13. Of course, any solution is likely to add to the cost of each receiving site within the system.

Utilization and System Costs

Radically different constraints govern the production of an hour of a graduate engineering course versus an hour of Sesame Street. The professor is at once the source and producer of every program put on the air, and since his salary is paid out of another pocket, the Stanford ITV Network merely pays for a student technician for each classroom plus one engineer to produce four hours of instruction per hour. Even when administrative salaries, maintenance costs and costs for a delivery service are added (a courier goes by each company each day to pick up and deliver notes, homework assignments, and exams), the Stanford ITV network broadcasts 150 engineering courses in 1974-75 at a total operating cost of $173,857 (see Table VIII-A), or the cost of producing two hours of Sesame Street.

TABLE VIII-A

1974-75 OPERATING COSTS OF STANFORD ITV NETWORK

Administrative Salaries	$ 50,374
Engineering Salaries	45,436
Part-time Student Salaries	27,195
Delivery Service and Mailing	21,367
Equipment Maintenance	13,163
Office Supplies and Expenses	8,359
Travel	2,363
Space Rental	600
Videotape	5,000
TOTAL	$173,857

Since underutilized ITV systems have higher per-hour transmission costs than do fully employed systems, Stanford has organized 15 of the network's companies into the "Association for Continuing Education" to fill unused evening hours with a wide variety of special programs. This organization pays Stanford for the use of its facilities for preparing the programming. If these evening courses are accounted for in the system's budget, the courses offered over the network total 230 and operating costs are increased to $221,000. But the number of student contact hours is 135,600 (from 5,400 enrollments) yielding a net cost per student contact hour of $1.63.

These figures, furnished by the Stanford ITV Network for their 1974-75 year of operation, are consistent with those of Jamison, et al (1976; Reference 3). The results of their study of the Stanford ITV costs represent by far the most detailed information available. As Table VIII-B below indicates, all figures are adjusted to 1972 dollars.

Although the table is largely self-explanatory, several items should be signalled. Reception equipment costs, Item 15 in 1968, are for the initial group of approximately 30 companies and average over $10,000 per company. But only $1350 of this covers receiving antenna and mast, down converter, VHF amplifier, power supply and cabling. The rest is for talk-back equipment and TV receivers whose prices increase with the number of in-company classrooms. Second, the authors have included total cost columns that reflect teacher salaries. But instead of prorating professors' salaries to indicate the percentage of their students that are in company TV classrooms versus those who attend at Stanford, a constant $2000 per course to cover teacher salary and benefits is assumed as a cost attributable to the Stanford ITV system. Since on the average less than one-third of the members of an engineering class receive instruction via the ITV Network, it would perhaps be more accurate to attribute only some fraction (e.g., 1/3) of the $2000 teacher salary to the ITV system.*

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*For in-house purposes, the Network routinely adopts what it calls 'anyhow' accounting--since engineering professors are holding classes anyhow, their salaries are not calculated in the Network's budget at all.

Table VIII.B

Costs of the Stanford ITV System in Thousands of 1972 Dollars (from Jamison, et al, Rf. 3)

	1968	1969	1970	1971	1972	1973	1974	1975	1976
Administration[a]									
1. Staff - Stanford		69.5	72.2	74.2	73.7	87.0	104.2	109.5	115.0
2. Office and related - Stanford		8.5	8.7	8.9	9.8	11.5	9.8	10.0	10.0
3. Staff - ACE		21.5	22.4	27.4	27.9	30.9	35.9	37.7	39.6
4. Office and related - ACE		10.3	10.5	12.3	9.4	10.5	9.9	10.0	10.0
Production[b]									
5. Facility	482.2								
6. Equipment	233.3								
7. Maintenance		4.4	5.5	5.6	6.0	6.2	6.3	6.5	6.7
8. Instructors - Stanford		240	296	286	290	300	300	300	300
9. Technicians - Stanford		12.7	15.4	14.6	14.0	18.7	17.0	17.0	17.0
10. Instructors - ACE		48	68	106	120	146	160	170	180
11. Technicians - ACE		2.7	3.8	4.3	5.3	7.2	6.7	7.2	7.6
12. Studio rental - ACE		15.2	21.4	22.9	29.7	29.4	27.7	29.6	31.4
Transmission[c]									
13. Equipment	134								
14. Maintenance		3.3	3.3	3.4	3.2	3.3	4.4	4.8	4.8
Reception[d]									
15. Equipment	337.8				35.4			15.6	15.6
16. Maintenance		8.8	11.0	11.2	12.0	12.4	12.6	1[illegible].0	13.4
TOTAL COST[e]									
17. Stanford (no teachers)	1187.3	107.2	116.1	117.9	154.1	139.5	154.3	176.4	182.1
18. Stanford (teachers)	1187.3	347.2	412.1	403.9	444.1	439.5	454.3	476.4	482.1
19. ACE + Stanford (no teachers)	1187.3	141.7	152.8	159.6	198.6	187.9	206.8	231.3	239.3
20. ACE + Stanford (teachers)	1187.3	429.7	515.8	509.9	564.1	634.1	666.8	701.3	719.3

Footnotes are listed on following page.

Notes for Table VIII.B

[a]Administration. Administrative expenses for Stanford and ACE for years 1969 through 1974 were derived from budgeted expenses for each organization. Office and related expenses include paper, mailings, a courier vehicle for distribution and collection of course-related papers, actual office space rent for ACE and an imputed rent for Stanford. Projections were accomplished by assuming annual increases of 5 per cent in salaries (which may be high as this would be a real increase above inflation rates) and constant streams of $10,000 for office expenses for each organization.

[b]Production. The initial expense for the facility is the amount spent for personnel and construction during the planning and completion of the master control room, and the studio complex. This facility will not need replacement. The equipment includes a specially constructed master control console, cable, control consoles for each of the five classrooms, 10 cameras, and 145 classroom monitors for use by students in the classroom. It is assumed that cameras and monitors will be replaced after 10 years. Maintenance for years 1969 through 1974 is slightly higher than reported amounts and assumed to be equal to $1 per hour for the life of the project. Instructors are assumed to receive a salary of $20,000 per course to cover salary and benefits. This is a reasonable assumption for the Stanford courses as professors at Stanford normally teach five courses per year and have other responsibilities. Technicians are assumed to continue a salary of $3.78 per hour as in 1974. The studio cost to ACE is an internal accounting mechanism between ACE and Stanford whereby ACE has been charged $18 per hour for use of the system (inflation between 1969 and 1974 has caused this figure to be higher in this table for 1969, 1970 and 1971 and lower for 1973 and 1974). Since Stanford pays all technicians this represents a net revenue of $11.70 per hour of ACE broadcast in 1974 and if this were included it would reduce the Stanford cost. If one were calculating costs to ACE the studio cost would be included and the technician, equipment and facility cost excluded.

[c]Transmission. Transmission equipment was purchased in 1968 and is assumed to have a 20-year life. Maintenance is reported amounts for 1969 through 1974 and as the amounts did not vary in this period maintenance is assumed to remain constant for the remainder of the project although at a higher amount.

[d]Reception. Equipment amounts for 1968 and 1972 are estimated amounts based on 1972 equipment costs from Table VIII.3 and the types of equipment purchased by the companies in those years. From 1975 two companies per year are assumed to be added to the system; one with four classrooms and no talk-back and one with four classrooms and time-shared talkback. This may be a slightly high assumption as new companies are often utilizing preexisting facilities at nearby companies and are tending to opt for no talkback if they purchase equipment. However, there is no cost included for arrangement of viewing areas in the companies. It is assumed that conference rooms are used for this purpose. Due to the varying use of the reception equipment, the relative infrequent use of talkback equipment, and the long life of antennas, cables, masts, etc., it is assumed that 25 per cent of the equipment is replaced every 10 years. Maintenance is assumed to be $2 per hour for all reception equipment.

[e]Total cost. Total cost is calculated for the Stanford engineering courses only by assuming all equipment is necessary for Stanford courses and ignoring the possibility of renting facilities to other users when capacity is available. The total for Stanford without teachers is the sum of item 1 + 2 + 5 + 6 + 7 + 9 + 13 + 14 + 15 + 16. When the system is considered as a whole, items 3, 4 and 11 are also added. If one were calculating the costs for ACE only one would use items 3, 4 and 12.

The network collects fees from the companies, part-time graduate students, non-registered but grade seeking TV students, and TV auditors. In addition to their own receiving terminals, the companies pay part of the initial capital development costs as well as a television surcharge (typically $20 per student credit hour). In consequence, the Stanford ITV Network was in the black within two years of going on the air.

Table VIII-C depicts both the growth of the system and the changes in the mix of participants. Kenneth Down, Director of the Stanford Network, has recently reported on the apparent causes of these shifts. In "The Stanford Instructional TV Network: A Survey of Its Students," (Reference 4), Mr. Down traces the development of the rapid increase in demand for refresher courses on the part of engineers. A glance at Table VIII-C reveals that the percentage of Honors Cooperative Program degree seekers has decreased from nearly 85 in the first year of ITV Network

TABLE VIII-C

STANFORD TELEVISED ENGNEERING INSTRUCTION PARTICIPATION DATA
(From Reference 7)

	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75
Honors Coop Program (Degree Seekers)	762	836	546	562	577	685
Non-Registered Option	37	106	66	95	185	374
Television Auditors	102	97	746	1,372	1,246	1,475
Total Registrations	901	1,038	1,358	2,029	2,008	2,534
Number of TV Courses	116	148	143	145	150	148
Average Per Course	7.8	7.0	9.5	14.0	13.4	17.1
Number of Member Companies	23	24	26	30	36	38

nearly 85 in the first year of ITV Network operation to barely 27 in 1974-75. A very substantial increase in auditors occurred in 1971-72--more

in seven times the number in the preceding years. Mr. Down explains that this sudden rise was due to a reduction in the auditor fee from $135 per course to $25. However, since then the fee has gradually increased to an average of approximately $65 for auditors, and the percentage of their enrollment in the total TV student body has held steady.

The tables below, reproduced from the article, present results of a short questionnaire distributed to 650 students taking TV courses in the winter of 1975. The most interesting result is that auditors are 10 years older than the others, take TV courses for professional development, and like them well enough to come back for more.

TABLE VIII-D

QUESTIONNAIRE RESULTS
(From Down, Reference 4)

Questionnaire Distribution and Response.

Student Category	*Distributed*	*Returned*
Honors Coop Program	100	70
Non Registered Option	87	41
Television Auditor	463	201
Totals	650	312

Motivation for Enrolling in a Televised Course.

Student Category	*Degree Seeking*	*Convenience*	*Professional Development*
Honors Coop Program	33	34	11
Non-Registered Option	20	15	18
Television Auditor	2	31	189

Ages of Participants.

Student Category	*Mean*	*Median*	*Range*
Honors Coop Program	27.9	27.0	20-47
Non Registered Option	27.1	27.5	22-36
Television Auditor	38.1	36.5	22-64

Summary. System Features

The Stanford ITV system is a genuine pioneer; other university ITFS systems have been tailored to follow the trail it blazed. An excellent example of a system which learned much from the Stanford ITV experience is the ITV network at the University of Southern California (described in the following case study).

The following is a summary of the main features of the Stanford system which account for its success.*

. NEED — The Honors Cooperative Program was established and running years before the use of television was considered. The companies who sent their engineers to the Stanford program knew the courses were valuable and perceived the program as excellent. When ITV was propose[illegible] from the Graduate School at Stanford University--it immediately captured the imagination of engineers (who are themselves fascinated by well-engineered devices). It was also warmly greeted as an alternative to hours on the freeway commuting from company to class.

. PLANNING — Detailed technical and cost studies of all plausible variations on the theme of the system Stanford finally implemented were conducted. The planning process involved a variety of actors from within the academic community as well as from the outside sources, including participating companies. In consequence the

*The Stanford system, like others chosen for the EPRC's case studies, is sufficiently different from most other systems to have been picked as an interesting case to study in the first place. This simple fact has two important consequences: the description of the system is unlikely to fit any other in any useful detail (though certain generalizations may be pos- [illegible] learned from a given system may well be in-

companies were willing to pay for the Stanford ITV Network in three different ways--capital equipment, operating expenses, and their own TV classroom facilities. But they are integrated into the system more thoroughly by serving as members of the board of directors of the Association for Continuing Education (whose membership from nine companies is elected for staggered two year terms; Stanford appoints a tenth member). In brief, there is a prevailing feeling among companies in the system that they have a piece of the action. When it was decided to petition the FCC to open up a portion of the ITFS spectrum for talk-back, outside legal assistance was sought to ensure that Stanford's views were adequately represented in Washington.

. ENGINEERING

The design of the network is straightforward where it can be, and innovative where it has to be. From the classrooms to the companies and back, the system is marked by soundness of design that makes for special ease in operation and maintenance. It would be a mistake to claim that the system is free from frills, though none interfere with system operation. There are two cameras per classroom (not three): productions can be handled by a single student. Most equipment is solid state and unobstrusive, but when a better alternative to the old audio uplinks appeared feasible it was installed. The Stanford system represents the best engineering job for the money one is likely to find.

. MANAGEMENT

The success of the Network is attributable in large measure to careful and efficient management. The system manages to put on almost 40 hours of ITV per

day more than 300 days of the year. The number of students per class is growing as well, with graduate engineering instruction courses now averaging more than 17 students registered in one option or another. Frills are kept to a minimum; there are no plans to switch color.

In the future the number of member companies, presently 38, will likely be increased to 50. Taping courses for wider distribution has begun and is likely to be expanded. Cooperation with other institutions will no doubt increase, most notably with the University of California at Davis (via a microwave link) and with Carleton University in Canada (via NASA Ames and the Communications Technology Satellite). If patterns of the past continue into the future services will be expanded only after careful planning has assured technical, educational, and economic feasibility.

References

Most of the information for this case study was supplied by Kenneth S. Down, Assistant Dean and Director, Stanford Instructional Television Network. Since the system is the first successful ITFS network to employ microwave talk-back, it has been studied before. A sampling of the literature which has resulted is listed below.

1. Charles A. Martin-Vegue, Jr., et al, "Technical and Economic Factors in University Instructional Televeison Systems, Proceedings of the IEEE, Vol. 59, No. 6, June 1971.

2. Herschel H. Loomis, Jr., and Harry Brandt, "Television as a Tool in Off-Campus Engineering Education, IEEE Transactions on Education, Vol. E-16, No. 2, May 1973.

3. Dean T. Jamison, et al, "The Stanford Instructional Television System," Chapter VIII in Cost Analysis for Educational Planning and Evaluation: Methodology and Application to Instructional Technology, Agency for International Development Studies in Educational Technology, January 1976.

4. Kenneth S. Down, "The Stanford Instructional TV Network: A Survey of Its Students," Engineering Education, April 1976.

5. Joseph M. Pettit and Donald J. Crace, "The Stanford Instructional Television Network, IEEE Spectrum, May 1970.

6. Roger G. Noll, et al, Economic Aspects of Television Regulation, The Brookings Institution, Washington, 1973.

7. "The Stanford Instructional Television Network," Brochure published by Stanford available by request from The Stanford Instructional Television Network, 401 Durand Building, Stanford, California 94305.

CASE STUDY IX

THE UNIVERSITY OF SOUTHERN CALIFORNIA INTERACTIVE INSTRUCTIONAL TELEVISION NETWORK

Introduction

In the fall of 1972, the University of Southern California began operating an Instructional Television Fixed Service system which is organizationally and technically closely akin to the Stanford system discussed in Case Study No. VIII. The Southern California system--like Stanford's--was set up to deliver live video (with interactive audio) engineering courses for graduate credit to a number of companies in the Los Angeles area. Accordingly, this case study will concentrate on those features of the Southern California System which are interestingly different (to the planner) from the Stanford System.

It is convenient to discuss these features under four headings: Regional Classrooms, Special Effects, Repeater and Taping.

Regional Classrooms: In addition to the ITFS classrooms at the participating companies, the USC system has set up two regional classrooms in industrial parks to make the services of the network convenient for continuing education students from companies too small to support reception facilities on their own. Since students from the public at large are also urged to take courses using these regional classrooms, it is possible to study the demand for various TV courses over a broader base of demographic variables than is possible with the Stanford system. The regional classroom concept also represents a potentially important model for more extended continuing education networking.

Special Effects: The USC system utilized a third camera in its classrooms

which pans over the "studio audience;" that is, the in-classroom students. Other special effects such as split screen images are also employed, and the system is equipped to transmit color.

Repeater: Unlike Stanford's Black Mountain transmitting site, the hills in Southern California make it impossible to achieve line-of-site transmission to all users. In consequence, a repeater is used to transmit to several company classrooms which are in a shadow of the main antenna pattern. The overall coverage which results approximates what Stanford achieves with a single transmitting site. This illustrates a simple truth which frustrates attempts to construct universally valid cost analyses: Accurate estimates of received power from a transmitter of known output power and antenna characteristics cannot be obtained for the general case unless the transmitting antenna can be high enough to preclude shadowing effects. Since this is usually the case only when the transmitting antenna is <u>very</u> high (as with a satellite), transmitter configurations for terrestial systems must be designed for the contingencies of each particular situation.

Taping: Much more use of half-inch video tape is made at USC than at Stanford both at the companies and at the system front end. Tapes are used both to alleviate schedule problems on the parts of professors and students alike, and to form the substance of courses offered by specialists who may be far from the USC campus for the academic year.

<u>Operations</u>

The USC Interactive Instructional Television (IITV) System operates on up to four ITFS channels from early morning until 9:30 at night. The system currently broadcasts approximately 90 courses for credit per year. Certain non-credit refresher courses are also offered, and from time to time special lectures and conferences are broadcast. Since [illegible] for the network services are almost exclusively high

technology industries in the Los Angeles area (see Table IX. A), most course offerings are in engineering and mathematics. However, certain short courses are broadcast which cover topics such as "Management by Objectives" and "Communications and Organizational Behavior." Some of these special courses are originated by the Association for Continuing Education and are obtained taped and ready to run. Most offerings, however, are designed to take advantage of the live interactive capability of the Network.

Except where noted in the introduction, the engineering details of the system are not interestingly different from those of the Stanford ITV network, nor are operating procedures. We therefore thought it more important to record the view of a customer of the system than to characterize material which is readily available in brochure form from the School of Engineering at USC. Accordingly, the remainder of this section is based on information furnished by members of the staff of the Aerospace Corporation at El Segundo.

Aerospace Corporation was an original member of the USC-IITV Network and has become one of its largest users. The Company invested in equipment to allow for three classrooms to be wired, but the "classrooms" are in effect auditoriums which can seat from 35 (in the case of the smallest) to over 200 students. Although most classes have but several students, occasionally the large auditorium is needed for special lecturers or, as with a recent course on solar energy, for accommodating over a hundred students.

In the Fall 1976 semester, the Corporation has 48 students taking courses over the USC-IITV System; 21 are taking courses for credit, 25 are enrolled as non-credit attendees, and two are auditors. The Company pays all tuition and fees for successful student completion of both credit and non-credit classes, but auditors must defray the $20 fee themselves if they elect this option. This undoubtedly explains the relatively low number of auditors at Aerospace.

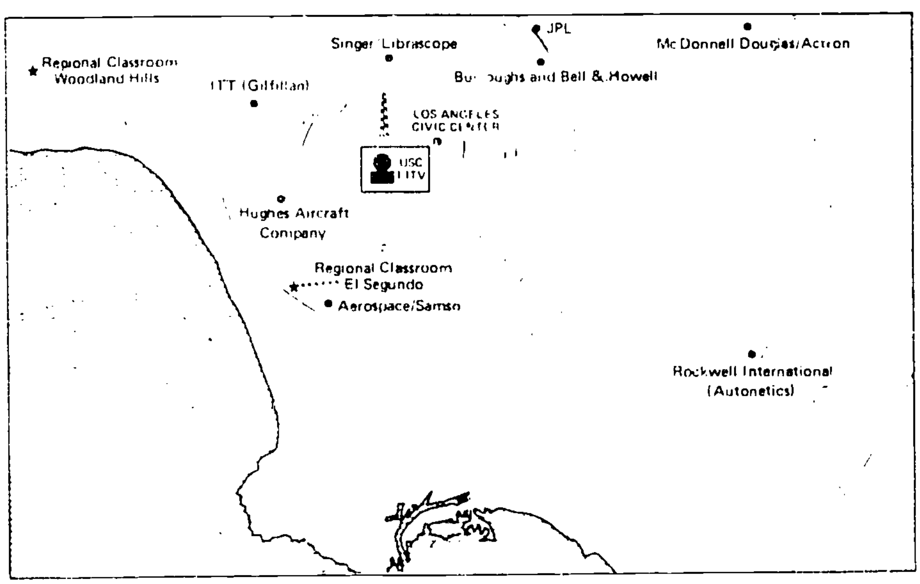
TABLE IX. A

ORGANIZATIONS SERVED BY THE
USC INTERACTIVE INSTRUCTIONAL TELEVISION SYSTEM

Hughes Aircraft Company	Culver City, California
Jet Propulsion Laboratory	Pasadena
Burroughs, Bell & Howell, Xerox	Pasadena
Actron Division of McDonnell/Douglas	Monrovia
Singer - Librascope	Glendale
Honeywell	Covina
International Telephone & Telegraph	Van Nuys
Aerospace Corporation	El Segundo
USC Information Seciences Institute	Marina del Rey
Rockwell International	Anaheim
Magnavox	Torrance
USC Regional Classroom*	El Segundo
USC Regional Classroom*	Woodland Hills

*Regional classrooms have served employees of 45 additional organizations.

COMPANY LOCATIONS (1974)



For regular students taking the courses for credit, the fee is the University tuition of $108 per unit ($324 for a standard 3 unit course) plus a $20 surcharge for being a "television" student. Non-degree students may take courses at a cost of $34 per unit; their papers are collected and exams graded as with the for-credit students, but they are not awarded credits for a degree unless they petition the University at a later date. USC routinely allows for up to four courses to be allowed as "credit" toward advanced degrees if newly matriculated students render the differential fee. Some Aerospace employees who already hold Ph.D. degrees regularly take TV courses, obviously as "non-degree" students.

The Aerospace Corporation pays all fees for degree and non-degree students, and defrays the cost for books as well. In addition, the Corporation pays the USC Network $225 per month as a flat fee for ITV "participation." (USC uses a formula which reflects the number of employees at the company.)

Aerospace Corporation employees tend to travel a great deal, so arrangements have been made with the Corporation to videotape lessons when a student must be absent. The Network allows this with the provision that users erase all videotapes at the end of each semester. Obviously, this option precludes interaction with the professor and the rest of the class, though it is clearly better than being absent altogether. In one case a student elected to take an entire course by tape, but according to Eleanor Anderson, Aerospace Corporation's Manager of Staff Development, he found the course most difficult taken in this fashion and plans to take others "in real time."

Ms. Anderson indicated that the talk back system is frequently used in a quasi-delayed mode--i.e., frequently a student will telephone a colleague at another company after class to see if he is "having problems" on a particular point as well. If he is, then one of them will raise the common question at the beginning of the next class period. The feeling seems to be that valuable class time should be taken up only with questions shared by at

least several students--perhaps a pedagogical advantage of the ITV classroom.

Ms. Anderson also reported on the variations in the quality of instruction: really good teachers do well on the TV; bad ones are very bad. At the urging of students she has occasionally complained to Jack Munushian, Director of the USC Network. "Once in a while," Ms. Anderson reported with an air of surprise, "we actually succeed in getting a bad teacher replaced."

Table IX.B gives a picture of patterns of growth of the USC-IITV system since its inception in 1972. Aerospace Corporation personnel enrollment in USC television courses appears to have reached steady state after an initial period of growth. At current levels of enrollment there is no real need for a fourth classroom to accommodate four sets of students taking four courses simultaneously, and the only time that such a conflict has occurred in the past one Aerospace employee took his course at the regional classroom in El Segundo (which is within easy walking distance of the Corporation).

Ms. Anderson voiced complaints about the high cost of maintaining the service, but she was nonetheless enthusiastic about the advantages of the ITV system. Aerospace employees who have taken courses are less reserved in their praise, perhaps because they are not burdened by having to pay for the service. The most frequently mentioned advantages are a savings in time and miles on the freeway. But when an engineer reports: "In a word, the system is superb!" one suspects that the electronic gadgetry of it all has its charms as well.

Costs

The USC-IITV has provided SRC with detailed information about the capital and operations costs of its system. Although the per student costs of this system are high, they are still low when compared to the other systems in this study. Per-student costs are higher by

TABLE IX. B

ENROLLMENT IN

USC INTERACTIVE INSTRUCTIONAL TELEVISION PROGRAM

ster	Total number of students in regular USC courses (Regular non-degree students and auditors)	Average enrollment per course	Total students/ year in regular USC courses	Total enrollment in non-credit courses
Fall 1972	85	3.4		
Spring 1973	119	4.4		
Summer 1973	21	3.0		
			225	
Fall 1973	182	6.7		
Spring 1974	271	7.5		
Summer 1974	32	4.5		
			485	
Fall 1974	337	8.9		
Spring 1975	309	8.1		125
Summer 1975	33	4.1		
			679	
Fall 1975	300	8.4		
Spring 1976	308	8.5		
			608	604

one order of magnitude than per student costs at the elementary level nationally, and it is clear that the low average per course enrollment of 8.5 is chiefly responsible for the inflated figures. Average system-wide per course enrollment could probably increase to 20 without sacrificing most of the value of the system's live two-way audio interaction feature, and this increase would decrease per student costs by a factor of nearly 2 1/2.

A. Start-Up Capital Expenditures

The following is a direct quotation from the USC Interactive Instructional Television Network's system description supplied to SRC.

> System Investment - The system was constructed with a $825,00 grant from the Olin Foundation. The facility is housed in a renovated 500 square feet stand alone building that was previously an engineering library. Each of the four studio classrooms, as well as an auditorium, is equipped with three black-and-white cameras and a special effects unit. The system also has a color film chain for broadcasting of color sides and movies. Transmitters are atop Mt. Lee 15 miles from the campus and the STL link is by ITFS. Talkback from remote sites is provided by FM radio in the ITFS band. The system also has available a van capable of reception at remote sites. Videotaping is presently done mainly with 1/2" EIAJ machines.

Breakdown of System Investment

Building modification	211,000
Design and engineering	95,000
Studio equipment	253,000
Broadcast equipment	217,000
Remote classroom equipment	20,000
Test equipment	20,000
Vehicles	9,000
	825,000

* * * * *

It should be noted that the above itemized list of outlays does not include the (approximately) $136,000 that was spent by the 10 user companies in the USC Information Sciences Institute for their reception and two-way audio interaction equipment. The list does include $20,000 allocated for two USC-IITN regional classrooms.

Total start-up capital outlays (regardless of the identities of their sources) can be classified in the following way:

1.	Transmission Costs:	$215,000
2.	Other Central Facility Costs:	$559,000
3.	Reception and Interaction Costs:	$156,000
4.	Other Costs	
	a. Test Equipment:	$ 20,000
	b. Vehicles:	$ 9,000
		$959,000

B. 1975-76 Operations Costs[1]

Courseware Acquired Out-of-House	$14,000
Rental Fees (2 Regional Classrooms)	12,500[2]
Rental Fee for USC Central Facility	32,000[3]
Director (part time)	10,000
Technical Staff	40,000
Secretarial	8,000
Student Operators	10,000
Courier	11,000
Printing and Mailing	2,000
Rental of Tower	1,800
Equipment Maintenance	7,000
Vehicle Maintenance	3,000
Office Supplies	750
Cost of Instructor Stipends for Non-credit Courses and Lease of Videotapes	8,500
	$160,550[4,5]

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[1]Income credited to the television program does not include regular tuition even in cases where it is known that a student has enrolled for graduate work only because of the easy availability of the television program.

Television income is derived from a $20/unit surcharge for regular students, a $54/unit fee for non-degree students, a $20/unit fee for auditors and a yearly fee charged to participating companies.

Total income for 1975-76 was $97,000 including $23,000 from participation fees, $44,000 from special TV charges for regular USC courses, $11,000 from non-credit courses and $19,000 from lease of receiving equipment for company classrooms.

[2]This cost is paid for by special NSF grant and is not included in the in the operating budget against which student fees are assessed.

[3]This cost is paid by USC and is not charged to USC-IITN operations.

[4]This does not include a $50,000 depreciation allowance for capital investment. It is not included in this operation budget because capital costs have been kept separate in all preceding case studies.

[5]USC-IITN's own statement of its operations budget registers a total outlay of $102,050. This is the figure that user revenues (student fees) are calculated to match. Not included in USC-IITN's user-assessment budget are (a) the costs explained in footnotes 2 and 3, and (b) the $14,000 for acquired out-of-house course-

It may appear that the foregoing estimate of the USC-IITN's operations costs is significantly incomplete because it omits the substantial price of the actual instruction that is telecommunicated to the remote students. For instance, salaries of the USC instructional staff are not included in the foregoing operations budget even though 68 non-degree enrollees in 1975-76 were charged a $54 per unit ($162 per course) supplemental fee that presumably went for more than just the TV costs.

Any direct unconditional comparisons of the USC-IITV costs to the costs incurred by the systems in case studies 1-6 therefore would seem to be unfair to those systems since their operations budgets do include costs for ITV courseware.

However, the fact is that direct unconditioned comparisons of the foregoing budget to those described in the earlier case studies are quite possible. The systems studied earlier delivered TV instruction that was <u>added onto</u> the face-to-face classroom instruction schools were already providing and paying for. In those systems, the supplemental TV instruction was also a <u>supplemental cost</u> added onto the costs for face-to-face classroom instruction. The TV did not <u>substitute</u> for the classroom teacher, nor did its cost <u>replace</u> the teacher's salary. So, budgetary parity between the USC-IITN and the earlier systems is achieved only if USC-IITN is <u>not</u> charged for the "live" TV instruction.

Thus in all the case studies, ITV courseware costs should be added-on instruction costs and <u>only</u> added-on instruction costs.

C. <u>Total System Costs</u>

Table IX.C displays the total expenditure for 1975-76 as functions of two variables: (1) capital outlays amortized over 10 and 15 year periods, and (2) all costs distributed over (a) all student contact hours in <u>only</u> regular USC courses, and (b) all student contact hours in <u>both</u> regular and non-credit courses.

The student contact hour costs are high. However, the real value of these costs can be appreciated only if their dollar sizes are compared to the costs of the professional time and labor that would have been lost if the professional enrollees had been forced to take the time to drive from their business locations to the USC campus to attend classes.

The average enrollment in a TV course in 1975-76 was 8.5. If educators were to agree that this figure could be increased to 20 per course without a significant decrease in the educational value of "live" two-way audio interaction among remote students and USC professors, then the student contact hour costs could be reduced from the present $5.01 to $11.13 range to a more attractive $2.13 to $4.73 range.

TABLE IX. C

TOTAL ITV EXPENDITURES

	Gross Amount	Per Year Amount Amortized Over 10 Yrs.	15 Yrs.	Per Year Per Student Regular Courses 10 Yrs.	15 Yrs.	Contact Hour All Courses 10 Yrs.	15 Yrs.	Percentage of Total Hours 10 Yrs.	15 Yrs.
I. Start-Up Capital Costs									
1. Transmission System	$215,000	$ 21,500	$ 14,333	$ ..93	$ .62	$ .48	$ .32	8%	6%
2. Central Facility	$559,000	$ 55,900	$ 37,267	$ 2.42	$ 1.62	$ 1.25	$ .83	22%	17%
3. Reception System	$156,000	$ 15,600	$ 10,400	$ .68	$ .45	$ .35	$ .23	6%	5%
4. Other	$ 29,000								
TOTAL CAPITAL	$959,000	$ 95,900	$ 63,933	$ 4.16	$ 2.77	$ 2.14	$1.43	37%	29%
II. Operating Costs 1975-76	$160,550	$160,550	$160,550	$ 6.69	$ 6.69	$ 3.58	$3.58	63%	71%
GRAND TOTAL	-	$256,800	$224,483	$11.13	$ 9.73	$ 5.73	$5.01	100%	100%

III. SUMMARY AND CONCLUSIONS

It is the nature of case study methodology to "suggest," not to 'prove." Case studies sacrifice the statistical security of large numbers in order to provide a more intensive and in-depth analysis of "what is really going on" in a handful of situations. Accordingly, any conclusions offered here must be considered tentative and exploratory.

Such caveats notwithstanding, we were reassured to find that the themes which emerged from the case studies were quite generally supportive of the conclusions drawn from our other analyses. This cannot, of course, be considered as an independent confirmation of such results since there were mutual inputs and interactions along the way. But many of the findings concerning such fundamental factors as land contour, geographical density of receiving sites in the coverage area, and size of the total area covered are clearly independent of such criss-crossing influences.

The following is a brief distillation of the major outcomes of the case studies:

- Costs per student contact hour varied enormously across the nine sites--by factors of ten or more. However, the dominant source of variance was the cost of developing new programming material.

- One source of per-site cost differentials was the fact that prices of major equipment have declined considerably as technological improvements and mass production have far outpaced inflation. Hence, systems which have been developed recently tend to be less expensive than their counterparts which were constructed earlier.

- The patterns of ITV applications and user preferences which emerge from these case studies are less predictable than the findings on cost-related issues. Most systems demonstrate an increasing tendency to use videotapes within a school to achieve scheduling flexibility, even if there are multiple broadcasts over whatever electronic delivery system is used. For example, the Hagerstown system--

long a model of central control over ITV programming and use--is moving rapidly toward a decentralized system for reasons of educational philosophy as well as convenience.

.A number of ITV systems are not fully utilizing their capacity in terms of potential channel hours. In fact, a number of them are only using about half of the capacity.

.There appears to be a rather surprising lack of information on ITV utilization, including such fundamental data as who watches it and who does not watch it and why.

.Different levels of instruction have very different ITV scheduling requirements. Elementary teachers generally require only moderate flexibility in scheduling. Since one teacher usually has responsibility for teaching all subjects to the same set of students all day long, the teacher can adjust the daily schedule to conform to ITV availability. Furthermore, course coverage is more likely to be standardized across a system, and the main source of variation is simple scheduling.

.By contrast, junior high and high school teachers not only have ordinary timing problems but additional ones which arise from variations in classroom style and emphasis. At these levels teachers generally teach one subject to a number of different classes, making scheduling much more difficult. In addition, instructors frequently have more discretion about whether to use all or part of a series or of a single program.

.Somewhat paradoxically, the college-level classes studied appeared to require least flexibility in scheduling. The main reason, of course, is that a fixed time for class is simply taken as a given by participants, just as it would be in a college classroom. Participating students are not, of course, going from one class to another all day long in the manner of public school students. Two of the systems discussed, the University of Southern California and Stanford are quite different from all the others in that they use two-way voice communications between students and instructional staff. Both employ an ITFS system to deliver ITV to area business firms whose employees are enrolled as part-time students.

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.The two-way interactive format, of course, dictates a firm schedule for classes. However, we note that some of the participating companies tape classes upon the request of students whose travel schedules preclude attendance on a given day.

.Two of the systems studied, those in Broward County, Florida and the New York Archdiocese, reserve substantial portions of their broadcast capacity for responding to special requests on a call-in basis. User demand to date has been relatively low. The reasons for this are not clear.

.One trend runs somewhat counter to other generalizations about "flexibility." There is a tendency for ITV programming to be dominated by series formats rather than individual programs. Although using a series requires more advance planning than using a single program, the per-hour costs of series are substantially lower than those of "specials," because vendors' handling, advertising and accounting costs are about the same in either case. There appears to be, however, a decided preference toward series which can be broken into shorter units of a few related installments.

.We also discovered a large amount of continuing experimentation with different patterns of use. There was a general preference for short programs over long ones but no clear preference for greater--or lesser--exposure to ITV as distinct from face-to-face instruction. In fact, as teachers acquire more experience in the use of ITV, some distinctions of this sort begin to break down. Many schools would like to move toward situations where a teacher can work directly with some part of a class while the remainder of the class watches instructional television.

Has there been any trend in increased or decreased use of ITV overall? We have no basis for generalizing on this point. Spokespersons for half the systems contacted said that they favored increased exposure to ITV for the students presently reached by their systems. Only Hagerstown is moving toward a decrease in student exposure, but exposure there has been relatively massive in the past, compared to most systems in the country. Most of the persons with whom we discussed this issue did not give it high priority, possibly because they regarded it as a more appropriate decision for the users, rather than the managers, of a system.

Any future statistical comparative analysis and evaluation of ITV systems will have to be preceded by the creation and implementation of adequate student use measurements. To a large extent the usefulness and feasibility of future research on ITV delivery systems will require coming to grips with the questions of utilization patterns.

The notion of "potential classroom contact hours" is valuable for helping to frame policy questions about the allocation of a school system's resources to the mass-distribution of ITV. In the cases studied, systems often chose to invest resources in "surplus" output for the sake of flexibility. To decide whether this magnitude of "surplus" is cost-effective requires data on how it is actually used when it is available.

In comparing the difference between the New York system and Broward County in their respective gaps between their volume of service and potential consumption values, one might conclude, for instance, either that diverse programming for diverse audiences exacts a high cost-penalty, or, conversely, that achieving cost-effectiveness with ITFS technology exacts a conformity-uniformity penalty.

For many purposes, "potential classroom consumption" is unrealistic. What observers need is a picture of actual student consumption. These data, although absolutely fundamental for authoritative and accurate evaluation, are generally not collected by ITV systems themselves or by anyone else. Only two of the case study systems, Broward County and WVIZ, Cleveland, did collect data of this type.

APPENDICES

APPENDIX A*

COST COMPONENTS

This Appendix provides a guide to the equipment and costs listed under the cost components of the complete and comparative models of Sections II and III. The models are based upon prototype ITV services delivery systems. ITV services are programs which can be viewed in the classroom or elsewhere by students. The emphasis here is upon elementary and secondary schools, not "elsewhere." The delivery or distribution system per se is the means of conveying the ITV signal to the viewing place. The modes of conveyance studied in this report are satellite, cable, instructional television fixed service (ITFS), PTV broadcast and material recorded on videocassettes (films, videotapes, or videodiscs). Utilizing these delivery modes, service distribution systems can be defined for regions using systems based on the different modes. The cost estimates are built up by specifying cost componen' of classes of costs and summing the components to derive total system cost. A listing of the cost components is contained in Table A-1. Some of the components are constant to or common across all delivery modes. These common components are discussed first. The other components are discussed under each delivery mode.

COMMON COMPONENTS

Display Equipment

Display equipment refers to the television monitor/receivers used in the schools. Most schools own TV sets now, which may be mounted in walls in special TV rooms or placed on movable carts so they can be wheeled to different rooms. Classroom-use televisions require large screens of 21% or more and can be either black-and-white or color. Because of special purchase agreements, buying in bulk, and the variety of features television sets can possess, they vary considerably in pri . Basic black-and-white models can start at under $200 while expensive color models can run over $1,000 with prices increasing with screen size. In most of the calculations in this report, $400 is the listed price. Of course, for cost modeling purposes, the initial price is spread over the

* These comm are designed to accompany the cost analysis in Chapter Two.

COST MODEL COMPONENTS BY SYSTEM

Component	Satellite	ITFS	Mailed Materials	PTV Broadcasting	Cable-casting
Satellite Rental	X	–	–	–	–
Uplink Facility and Studio	X				
ITFS Transmission		X			
ITFS Broadcast Studio		X			
Mailing and Dubbing			X		
PTV Broadcast Fee				X	
Cable "Rental"					X
Interconnection		X			X
System Management	X	X	X	X	X
Programming	X	X	X	X	X
Display Equipment	X	X	X	X	X
Videocassette Machines	X	X	X	X	X
Videocassettes	X	X	X	X	X
School Wiring	X	X	X	X	X
School Headend	X	X	X	X	X
School Reception	X	X	X	X	X

An X indicates a probable non-zero value for the component in the given system.

expected life of the set (with heavy use but good care and maintenance--five years). The maintenance and operation of a set is figured at 15% of its annual capital cost. For the cost estimates modes in Section II, it was assumed that each school would possess 8 televisions purchased at the price suggested above. To some individuals, this number may appear too extravagant, to others, far too few. One's opinion of the 8 TVs figure will depend upon the number of classrooms in one school, the expected prevalence of use of ITV within the school, and the local school budget. Clearly, the number of TVs in a school is discretionary and the eight used in this analysis can be treated as an average across all schools served by the delivery system. If this average is changed by one, then the effect on total system cost is $92 times the number of schools in the system.

Videocassette Machines

Videocassette machines for recording and playing programming in schools provide great flexibility in scheduling and give teachers control over the use of ITV. The machines could be located in classrooms, media centers, or school headends to facilitate the transmission of programming over a school's internal distribution system. There are numerous producers of videocassette recorder/players, and the market is highly competitive. Price quotes for the equipment range from $3,000 down to commercial models now marketed for slightly under $1,000. Different models have a variety of featurs including off-the-air recording, slow motion, and automatic timers. The price used in Sections II and III, $1,500, is spread over the five-year expected life of the equipment and may be a little high.

Videocassette machines are a relatively expensive feature of ITV systems with a $300 annual cost each plus $45 maintenance and operation. The number, if any, of machines owned by each school is completely discretionary. Three

was used as the number per school in Section II of Chapter Two, though that number should not be interpreted as a recommendation.

Videocassettes

Each school will require a supply of videocassettes to complement its videocassette machines. The cassettes and the machines have to be compatible and the playing time of cassettes varies (again, they have to be compatible with the machines). The analysis in Section II is based upon cassettes with a one-hour playing time which sell for about $20 and which, conservatively, can be expected to last five years. The number of cassettes each school should possess will depend upon the number of hours of programming telecast per day and upon the need to copy and hold the programming for replaying to accommodate scheduling problems or for special viewings. In the cost estimates of Section II, it is presumed that the schools would prefer to have the capacity of keeping programs for one week.

School Wiring

In order to convey television signals throughout the school, schools require an internal wiring system. The cost of wiring is influenced by factors specific to schools and in the localities. If conduits are already in the schools, the installation of the cables themselves is considerably cheaper. Local labor costs are also an important determinant of the cost of wiring. However, a figure of $120 per room is a reasonable price quoted by both contractors and schools which have recently had such work done. Given a per room price, the number of rooms per school is the major determinant of cost. Our cost model is based upon an average of 20 rooms per school. The 15 year estimate of the life of the wiring may be conservative. At 15 percent of annual capital cost, maintenance and operation cost is also part of this component.

Office Supplies	750
Cost of Instructor Stipends for Non-credit Courses and Lease of Videotapes	8,500
	$160,550[4,5]

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[1]Income credited to the television program does not include regular tuition even in cases where it is known that a student has enrolled for graduate work only because of the easy availability of the television program.

Television income is derived from a $20/unit surcharge for regular students, a $54/unit fee for non-degree students, a $20/unit fee for auditors and a yearly fee charged to participating companies.

Total income for 1975-76 was $97,000 including $23,000 from participation fees, $44,000 from special TV charges for regular USC courses, $11,000 from non-credit courses and $19,000 from lease of receiving equipment for company classrooms.

[2]This cost is paid for by special NSF grant and is not included in the in the operating budget against which student fees are assessed.

[3]This cost is paid by USC and is not charged to USC-IITN operations.

[4]This does not include a $50,000 depreciation allowance for capital investment. It is not included in this operation budget because capital costs have been kept separate in all preceding case studies.

[5]USC-IITN's own statement of its operations budget registers a total outlay of $102,050. This is the figure that user revenues (student fees) are calculated to match. Not included in USC-IITN's user-assessment budget are (a) the costs explained in footnotes 2 and 3, and (b) the $14,000 for acquired out-of-house courseware.

However, the fact is that direct unconditioned comparisons of the foregoing budget to those described in the earlier case studies are quite possible. The systems studied earlier delivered TV instruction that was added onto the face-to-face classroom instruction schools were already providing and paying for. In those systems, the supplemental TV instruction was also a supplemental cost added onto the costs for face-to-face classroom instruction. The TV did not substitute for the classroom teacher, nor did its cost replace the teacher's salary. So, budgetary parity between the USC-IITN and the earlier systems is achieved only if USC-IITN is not charged for the "live" TV instruction.

Thus in all the case studies, ITV courseware costs should be added-on instruction costs and only added-on instruction costs.

C. Total System Costs

Table IX.6 displays the total expenditure for 1975-76 as functions of two variables: (1) capital outlays amortized over 10 and 15 year periods, and (2) all costs distributed over (a) all student contact hours in only regular USC courses, and (b) all student contact hours in both regular and non-credit courses.

$800,000 per channel per year (which, on a 42 per day, 365 day basis is less than $100 per hour) to interconnect member stations who will install receiving terminals costing about $100,000 each. This type of interconnection system is the other extreme from the high-powered direct broadcast system.

Satellite Rental

The $500 per hour satellite rental figure was the same figure used by the STD (see the STD Final Report, p. 294). It is considerably larger than the approximately $100 per hour PBS will be paying for one hour of broadcast. However, ATS-6 is a higher-powered satellite. The crucial assumption is that for a flat $500 per hour fee, educators could rent as much satellite broadcast time over as many channels as they need when they need it. Perhaps common carriers will someday be able to fulfill such requirements, though they cannot at present. Moreover, if educators sponsored the launch of a satellite, any unused time would increase the average cost per hour of broadcast time, raising the rental figure.

One other point is the insensitivity of the rental fee to N, number

while the $200,000 operating expenses for personnel and building rental is based upon ESCD costs. Under some circumstances, educational users might be able to share studio facilities with other groups or institutions, substantially reducing costs. The expected life of the studio, listed at ten years, is probably a somewhat conservative estimate.

School Headend

The signals from the satellite received over the equipment located at the school are sent through an amplifier located at a school headend before being sent through the school wiring system for internal distribution. The amplifier's cost is about $500 and can be expected to last ten years. The headend may also contain videocassette machines and other ITV equipment.

School Reception Equipment

The receive only terminals of the ESCD consisted of a 10-foot parabolic antenna, a preamplifier, and demodulator. The cost of the terminals was approximately $3,000 each. The $6,000 figure used in Sections II and III is a multi-channel receiver version. However, recent rumors suggest that Japanese developers may be able to market receive-only terminals for under $1,000, indicating that the $6,000 figure is pessimistic. An expected life for the terminals of eight years is longer than that suggested in the STD

school year 1974-75 identified 93 systems operating over 252 channels. Among the operating stations, 89 repeaters (reception/transmission stations which boost and repeat the signal) were in use. The reader is referred to the case studies in Chapter Three of this report for descriptions of operating IT[illegible] tems.

ITFS systems are engineered for the [illegible] population and speci[illegible] [illegible]ality they serve. The placement of broadcast towers and studios is dictated by the distribution of the schools or other sites to be served and the [illegible]graphical features of the coverage area. A terrain clear of obstructions and a dense and concentrated user population provides the most propitious circumstances for ITFS, while a scattered user population in a mountainous region or a region with other obstructions inhibits the effective range of the broadcast signal. Trade-offs occur between the cost of the reception and broadcast equipment, especially the broadcast tower and the number of receiving sites. We attempt to quantify the effects of terrain and population distribution by using a variable, t, (the inverse of the quotient, the number of schools N per ITFS broadcast site). The inverse is used so that the product tN yields the number of broadcast sites.

The symbol t can be thought of as an average derived empirically by calculating the simple weighted average of all the t values of all the broadcast sites. Effectively, this makes it impossible to differentiate between a perfectly [illegible] which has highly varying population densities. For

frequency or channel to another if coverage areas of signals overlap. Any system needs at least one broadcast studio or transmission origination site. Signals can be repeated/translated until they deteriorate too badly, three to four repetitions being the limit. It is also possible to use point-to-point microwave relay between origination and other transmission sites. (See Case Study I: The Archdiocese of New York.)

A variable t' is defined for the ITFS cost model with t' equaling the inverse of the number of reception sites, N, per ITFS transmission origination sites. Then the product t'N equals the number of broadcast studios. Also, it is possible to express t' as a function of t, say t'=at where one broadcast studio serves 1/a transmission sites. For example, one origination site with 8 transmission sites would yield t' = 1/8 t.

ITFS Transmission

For either a repeater or broadcast origination transmitter, transmission costs are fairly uniform with a price of $15,000 per transmitter i.e., per channel I. One channel is required for each six hours of broadcast time. However, the most important segment of transmission cost could be the cost of the transmitting tower. The tower cost could range from under $10,000 to over $300,000 depending upon topographical and man-made physical features. This capital equipment has an average expected life of ten or more years.

... costs cannot be understated since they can

the recorded programming. Roughly $50,000 will ensure a good studio which could be located with a school and operated by in-school personnel. If the organization site has to be located elsewhere, studio costs would increase.

Interconnection

As mentioned above, recorded material is used as an origination format in ITFS broadcast studios. Programming can be recorded on videocassettes and sent to the broadcast studios. A four week period would be sufficient to ensure that a day's programming can be copied on cassettes, mailed to studios, played, and returned for re-use. Videocassettes were described earlier. The mailing and dubbing cost for each hour of programming was estimated as $5.00, although this is highly variable. Estimates from different organizations have provided a range of per hour costs from $2.00 to $20. The stock of cassettes each studio requires is (PQ), P, the number of school days in four weeks and Q, the number of program hours per day. P is taken to average 20. If programs are repeated during the week, then the hours of programming on tape will be lower than the number of broadcast hours. Microwave and satellite broadcast can also be used as interconnecting modes though Sections II and III are based upon interconnection by mailed materials.

School Headend

The school headend component for the ITFS system is the same as under

MAILED MATERIALS

A mailed materials systems is similar to the interconnection component described under the ITFS system except each school is its own transmission site. Similar to the case of interconnection, each school needs a stock of videocassettes equal to 20 times the daily number of hours of programming (except for repeat broadcasts, say if every program is repeated twice, then the number of cassettes [20] [1/3] Q). Systems of this sort are in operation in many places, and examples are included in the case studies. New York State provides a similar service with schools having the opportunity to request copies of materials. Many school districts have their own film libraries, mailed materials are not restricted to a cassette format. As mentioned, film is one possibility while a developing technology, videodiscs will be available soon. Videodiscs with players selling for under $500 and discs for under $5.00 could become important.

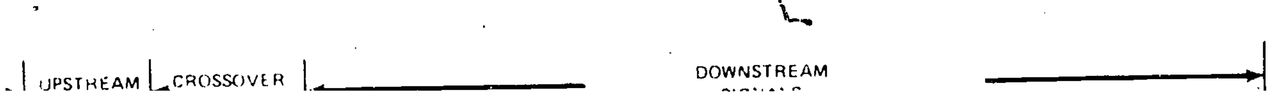
School Headend - School Reception

Besides an amplifier at the school headend, a mailed materials system requires videocassette machines at the headend. Effectively, videocassette machines play a role analogous to reception equipment in systems based on other delivery modes. One videocassette machine is required for every six hours of broadcast time over the school's wiring system. Comments made under the Videocassette Machine component are applicable here.

CABLECASTING

hold converters. The system operator can merely modulate his cable on those frequencies corresponding to ordinary channels 2 through 13, giving a theoretical maximum effective channel capacity into subscribers' homes of 12 channels in the case of a single cable system and 24 in the case of a dual system. In fact, this capacity is optimistic for most installations, for channels occupied by strong over-the-air signals must be left dark to avoid possible interference. (Of course, signals from local VHF stations will be cablecast on other channels.)

We have developed a theory according to which this state of affairs may work to the interest of those interested in delivering ITV to schools. Let us first distinguish two cases which in the interest of simplicity can be called 'new system' and 'old systems', neither incorporating set-top converters at subscribers' houses. New systems will typically be characterized by high quality cable and broadband solid state amplifiers which are essentially linear over 300 MHz. In brief, they will be able to cablecast high quality video over very nearly 300 MHz with high mean time between failures and (owing to amplifier boxes using plug-in modules) with low adjustment and maintenance costs. Old systems seldom share these virtues. The combination of high cable losses and non-linerarites of the trunk amplifiers effectively limits their video signal carrying capacity to a very few more channels than the 6 to 12 they are presently cablecasting. Accordingly, the following remarks will be primarily (though not exclusively) applicable to 'new' systems.



space available. (This figure should be doubled for a dual cable system.) Cablecast signals in the mid-band or superband regions could be received by anyone with a converter while those without converters would experience no interference. This, of course, presents an intriguing possibility for school systems, for with low-cost (approximately $50) converters associated with each TV set (or even fewer if they are installed at the local headends of school distribution systems), one had the potential for receiving a great deal of ITV. Neglecting maintenance, headend costs are on the order of $2,500 per channel for the modulator to cablecast the materials.

Where it exists, cable is part of the communications infrastructure of the local municipality. The laying or stringing of cable headends in a region depends upon the number of independent cable systems. Of course, the number of schools per cable headend is given by the placement of cable systems. For our analysis, the variable h is the inverse of the number of schools, N, per cable headend, and Hn equals the number of headends. All these headends have to be interconnected, and it is presumed that mailed materials will be used.

The key to cable cost is the concessions the cable operator can be convinced to give to the local municipality. Strong bargaining before a local license is granted can ensure schools being hooked-up and that they can have access to channel space either at a nominal cost or no cost at all. Cable operators find that community good will can be acquired by making excess channel space available.

Cable Rental

Rental fee for cables can be expected to be highly variable. One channel

Interconnection

Interconnection for cable systems is the same as for ITFS, likewise using mailed materials with the number of headends to be interconnected equal to hN.

PTV BROADCASTING

Public television stations have broadcast educational programs for in-classroom instruction since they began operating. Large networks such as the Eastern Educational Network connect stations which receive programming sometimes for daytime simulcasting, sometimes for taping and rebroadcasting. With PBS switching to a satellite-based interconnection network with three or four channels, this means of interconnection should remain available.

The number of schools able to receive PTV broadcasted programming is limited to the broadcast range of the stations. There is also the additional limitation that since most stations operate on one channel, only about six hours of programming can be broadcast daily.

Broadcasting Fee

Whether or not a local PTV station is compensated for providing ITV, operating the station is expensive (although operating and capital costs vary highly from station to station). A figure of $150 per broadcast hour

schools so that VHF channels will be used for viewing. Convertors cost about $50 and can be expected to last 10 years.

School Reception

High quality reception anntennas can be used to improve signal quality and, effectively, to increase the broadcast range of the PTV stations. As an average, the antenna and mounting could cost $150, though the price at different schools may vary greatly. These outdoor antennas can be expected to last five or more years.

APPENDIX B*

DERIVING COMPARATIVE COST EQUATIONS

Comparative cost equations are derived from the comparative cost components (see Section III). In the following five tables, the name of the cost components, their full mathematical expression, and their simplified mathematical expression are presented. The columns of simplified expressions are summed to derive the basic comparative cost equations from which the comparative cost per school equation is derived by dividing the original equation by N, the number of schools.

SATELLITE SYSTEM

Component	Expression	Simplified Expression
Satellite Rental	(180) ($500) Q_S	$90,000 Q_S
Uplink Facility and Studio	$200,000 + ($250,000/10) (1.15)	$228,750
School Headed	($500/10) (1.15) N_S	$ 58 N_S
School Reception	(6,00[illegible]) (1.15)	$ 826 N_S

Satellite System Comparative Cost: $\$228{,}750 + \$90{,}000\ Q_S + 920\ N_S = C$

Satellite System, Comparative Cost per School:

$$\frac{\$228{,}750 + \$90{,}000\ Q_S}{N_S} + 920 = C/N$$

$$\frac{\partial(C/N)}{\partial N} = -\frac{\$228{,}750 + \$90{,}000\ Q_S}{N_S^2}$$

size, perhaps as a proportion of total system cost though one might except some economies of scale in administrative functions.

It is not clear that a delivery system based on one communications mode or another would require sufficiently different management duties to cause costs to vary by type of delivery mode. The figure used in the cost estimates of Section II is roughly based upon the experience of the ESCD and was used only to complete the example.

Programming

The example in Section II (of Chapter Two) was constructed to underscore how important programming costs are in the overall cost picture of a delivery system. The $15,000 per hour figure in the sample estimates was based upon production costs from the Satellite Technology Demonstration (STD) (see the STD Final Report, page 298) and is not its most expensive program. The variability of program costs is immense with Sesame Street running over an approximate $50,000 per hour with hours of commercial programming over $200,000 per hour (see Noll, Peck and McGowan, Economic Aspects of Television Regulation, p.224). Alternatively, locally produced programming, effectively the taping of lectures, experiments, or events can cost relatively little. Sometimes, programming will be donated "free" to local schools or larger organizations.

However, to a certain extent, quality can expect to be a function of price

The satellite system for which costs are estimated in Section II (of Chapter Two) was a multi-channel version of the ESCD. A central uplink facility transmites the programming to a high-powered ATS-6 type satellite in geostationary orbit which broadcasts to relatively low-cost receive-only terminals each of which has a parabolic dish antenna, a down-converter and a receiver. It is because the satellite is high-powered that low-cost reception equipment can be used, making the system feasible for direct broadcast to schools. A number of studies have been written about cost optimizing--the trade-off between the cost of high-powered satellites and low-cost ground terminals (see Stagl et al., Computer-Aided Communications Satellite System Analysis and Optimizations and reference therein)--and no attempt will be made to deal with that complicated subject here.

It might be useful just to make note of some recent experiences with satellites. Educational experiments are continuing over high-powered satellite with CTS (Communications Telecommunications Satellite) as the carrier. However, the availability of high-powered satellite transmission time is not established, though a large-enough commitment by an educational system could promote making the capacity available. Video transmission over less powerful satellites is occurring with Home Box Office connecting its cable distributors by satellite. The Public Broadcasting System has announced plans to rent three (eventually four) satellite channels from WESTAR at a rate of approximately

the STD (see the STD Final Report, p. 294). It is considerably larger than the approximately $100 per hour PBS will be paying for one hour of broadcast. However, ATS-6 is a higher-powered satellite. The crucial assumption is that for a flat $500 per hour fee, educators could rent as much satellite broadcast time over as many channels as they need when they need it. Perhaps common carriers will someday be able to fulfill such requirements, though they cannot at present. Moreover, if educators sponsored the launch of a satellite, any unused time would increase the average cost per hour of broadcast time, raising the rental figure.

One other point is the insensitivity of the rental fee to N, number of users, as presumed in Sections II and III. However, if larger values of N entailed a larger area to cover with a beam from a transponder, then the satellite's radiated power density would fall, thus increasing reception costs.

Uplink Facility and Studio

It is assumed all earth-to-satellite transmission originates from one transmission point. The $250,000 capital cost of the broadcast studio and uplink is based upon current PBS estimates for their multi-channel system

before being sent through the school wiring system ...
The amplifier's cost is about $500 and can be expected to last ten years. The headend may also contain videocassette machines and other ITV equipment.

School Reception Equipment

The receive only terminals of the ESCD consisted of a 10-foot parabolic antenna, a preamplifier, and demodulator. The cost of the terminals was approximately $3,000 each. The $6,000 figure used in Sections II and III is a multi-channel receiver version. However, recent rumors suggest that Japanese developers may be able to market receive-only terminals for under $1,000, indicating that the $6,000 figure is pessimistic. An expected life for the terminals of eight years is longer than that suggested in the STD final report (p. 292) which helps to counter-balance the $6,000 figure.

Technology is progressing so quickly that these cost estimates are highly susceptible to change, and they are also dependent upon the type of satellites (in terms of high-or low-power and type of waveform transmitter), that will actually be finally available for broadcast purposes.

INSTRUCTIONAL TELEVISION FIXED SERVICE

Thirty-one channels in the 2,500-2,690 MHz range are reserved for ITFS educational uses. A National Association of Education Broadcasters survey for

mountainous region or a region with other obstructions inhibits the effective range of the broadcast signal. Trade-offs occur between the cost of the reception and broadcast equipment, especially the broadcast tower and the number of receiving sites. We attempt to quantify the effects of terrain and population distribution by using a variable, t, (the inverse of the quotient, the number of schools N per ITFS broadcast site). The inverse is used so that the product tN yields the number of broadcast sites.

The symbol t can be thought of as an average derived empirically by calculating the simple weighted average of all the t values of all the broadcast sites. Effectively, this makes it impossible to differentiate between a perfectly uniform region and one which has highly varying population densities. For example let us imagine two regions with t values of .05, each using two transmitting stations. The two in the first region could each serve 20 schools while one in the second region could serve 30 schools and the other, ten. Using an average t for the entire region disguises the within-region differences. Though this is acceptable in models designed to make estimates of aggregate cost or to compare systems in aggregates, it obscures details important in ITSF system design.

Not all transmission sites in an ITFS system require broadcast studios. Some sites can be repeaters which receive, boost, and rebroadcast a signal. To prevent interference, translators are sometimes uses to translate from one

origination site with 8 transmission sites would ...

ITFS Transmission

For either a repeater or broadcast origination transmitter, transmission costs are fairly uniform with a price of $15,000 per transmitter i e., per channel I. One channel is required for each six hours of broadcast time. However, the most important segment of transmission cost could be the cost of the transmitting tower. The tower cost could range from under $10,000 to over $300,000 depending upon topographical and man-made physical features. This capital equipment has an average expected l... of ten or more years.

The importance of tower costs cannot be understated since they can vary by a factor of greater than 30. Also, the greater the number of transmission sites, the greater the effect of average tower cost on total system cost. A high t value means an expensive system, a low value suggests a less expensive system.

ITFS Broadcast Studio

An ITFS broadcast studio contains the equipment necessary to feed the programming into the transmitter including whatever format is used to play

mailing and dubbing cost for each hour of programming was estimated at [illegible] although this is highly variable. Estimates from different organizations have provided a range of per hour costs from $2.00 to $20. The stock of cassettes each studio requires is (PQ), P, the number of school days in four weeks and Q, the number of program hours per day. P is taken to average 20. If programs are repeated during the week, then the hours of programming on tape will be lower than the number of broadcast hours. Microwave and satellite broadcast can also be used as interconnecting modes though Sections II and III are based upon interconnection by mailed materials.

School Headend

The school headend component for the ITFS system is the same as under the satellite system.

School Reception

A parabolic antenna, antenna mounting and down-converter are required at each school. The cost of this equipment should be about $1,500 and the equipment should last ten years. Additional costs could be incurred if the antenna requires a tower.

soon. Videodiscs with players selling ...
$5.00 could become important.

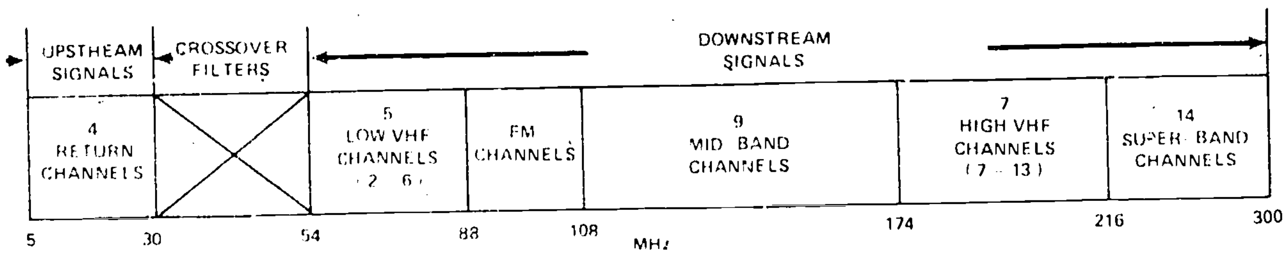
School Headend - School Reception

Besides an amplifier at the school headend, a mailed materials system requires videocassette machines at the headend. Effectively, videocassette machines play a role analogous to reception equipment in systems based on other delivery modes. One videocassette machine is required for every six hours of broadcast time over the school's wiring system. Comments made under the Videocassette Machine component are applicable here.

CABLECASTING

CATV in the United States is beginning to experience the rapid growth many observers thought would occur a decade ago. The FCC made a ruling in the spring of 1976 which will likely increase the rate of growth of CATV systems even further. There is abundant evidence that the new FCC rulings are partially, at least, a response to the widespread view among CATV system operators that individual set-top converters are (1) unduly expensive, representing up to 40% of total system costs in some instances, (2) a major source of system maintenance problems, and (3) a favorite target for thieves. With the new regulations in effect, it becomes both legal and practical to wire up communities with a single or dual cable system which incorporates no house-

cable and broadband solid state amplifiers which are essentially linear over 300 MHz. In brief, they will be able to cablecast high quality video over very nearly 300 MHz with high mean time between failures and (owing to amplifier boxes using plug-in modules) with low adjustment and maintenance costs. Old systems seldom share these virtues. The combination of high cable losses and non-linerarites of the trunk amplifiers effectively limits their video signal carrying capacity to a very few more channels than the 6 to 12 they are presently cablecasting. Accordingly, the following remarks will be primarily (though not exclusively) applicable to 'new' systems.



A glance at the attached chart shows that an imagined new system will have a great deal of room for cablecasting video signals, particularly in the mid-band and super-band regions. Even assuming that the spectrum space below 54 MHz is set aside for upstream signals and filters and the 88 to 108 band is reserved for FM audio, this still leaves a theoretical maximum of 23 channels of spectrum

have to be interconnected, and it is presumed that mailed materials will be used.

The key to cable cost is the concessions the cable operator can be convinced to give to the local municipality. Strong bargaining before a local license is granted can ensure schools being hooked-up and that they can have access to channel space either at a nominal cost or no cost at all. Cable operators find that community good will can be acquired by making excess channel space available.

Cable Rental

Rental fee for cables can be expected to be highly variable. One channel will commonly be avilable for free, and any unused channel space might also be had for free unless extra tape machines and operators are required at the headend. If it is necessary, a modulator per channel can be installed at the headend to access unused space between channels. As discussed above, modulators cost about $2,500 with one needed for each channel. The expected life of a modulator is ten years.

School Headend

Switch, amplifier and converter are required at the school headend for the cable system. The price of the switch and amplifier is $1,000, converters cost $50. This equipment should last ten years.

or four channels, this means of interconnection should remain available.

The number of schools able to receive PTV broadcasted programming is limited to the broadcast range of the stations. There is also the additional limitation that since most stations operate on one channel, only about six hours of programming can be broadcast daily.

Broadcasting Fee

Whether or not a local PTV station is compensated for providing ITV, operating the station is expensive (although operating and capital costs vary highly from station to station). A figure of $150 per broadcast hour was derived from New York State data as an estimate of cost with Q hours broadcasted daily for 180 days. The $150 can be thought of as an average over the bN stations where b equals the inverse of the average number of schools, N, per station.

School Headend

For UHF stations, it may be desirable to install a convertor at the

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* These comments are designed to accompany the cost analysis in Chapter Two.

Satellite System Comparative Cost: $\$228,750 + \$90,000\ Q_S + 920\ N_S = C$

Satellite System, Comparative Cost per School:

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