DOCUMENT RESUME

ED 237 057 IR 010 881

AUTHOR Clippinger, John H.; Fain, Sanford B.
TITLE Planning and Evaluating Telecommunications Demonstration Projects and Assessing the Costs of Telecommunications Demonstration Projects. Final Report #146-03.
INSTITUTION Kalba Bowen Associates, Inc., Cambridge, MA.
SPONS AGENCY Department of Education, Washington, DC.
PUB DATE May 80
NOTE 154p.; For related documents, see IR 010 880 and IR 010 882.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC07 Plus Postage.
DESCRIPTORS Case Studies; *Cost Effectiveness; Delivery Systems; *Demonstration Programs; Disabilities; Grants; Information Services; *Program Development; *Program Evaluation; Questionnaires; *Social Services; *Telecommunications
IDENTIFIERS Evaluation Reports; Office of Telecommunications Policy; *Telecommunications Demonstration Program

ABSTRACT

This two-report volume was prepared to describe approaches for evaluating individual Office of Telecommunications Policy (OTP) demonstration projects in the future and to aid demonstration project directors in project planning and development. The first report focuses on the role of planning and evaluation activities, stressing their importance in helping the program to promote telecommunications use in social service delivery more effectively. It also presents an overview of the types of information that are useful in various phases of project development and includes an outline for the annual evaluation reports required of grantees. The second report examines the economic and financial characteristics of telecommunications demonstrations, presents a method for analyzing project costs, and then applies the method to the three projects that had generated sufficient data for an analysis. These case analyses are presented as case studies in an appendix. (LMM)

PLANNING AND EVALUATING TELECOMMUNICATIONS DEMONSTRATION PROJECTS

and

ASSESSING THE COSTS OF TELECOMMUNICATIONS DEMONSTRATION PROJECTS

Final Report
#146-03

Submitted to the
Department of Health, Education and Welfare

in response to
RFP 147-78-HEW-05

May 1980

Principal Authors
John H. Clippinger
Sanford B. Fain

Contributing Author
Yale M. Braunstein

EXECUTIVE SUMMARY

This report is the third in a series of reports submitted to the Office of Telecommunications Policy (OTP) of the Department of Health, Education and Welfare (DHEW) in response to RFP 147-78-HEW-05.* The goals of the contract, awarded to Kalba Bowen Associates in September 1978, were to (1) review and evaluate the first-year activities of OTP's Telecommunicatio Program; (2) develop approaches for evaluating individual demonstration projects in the future; (3) identify factors that have an influence on the successful institutionalization and transfer of innovative uses of telecommunications; and (4) provide information on which to base future actions for Program development and offer recommendations concerning future rules for the program.

This volume has been prepared in response to the second goal. It is intended primarily for use by demonstration project directors as they plan and develop their projects. The first report focuses on the role of planning and evaluation activities. The report points out the importance of using planning and evaluation activities in helping the Program to promote more effectively the use of telecommunications in social service delivery. It also presents an overview of the types of information that are useful in various phases of project development. This is followed by an outline for annual evaluation reports grantees are required to submit.

The second report examines the economic and financial characteristics of telecommunications demonstrations. It presents a method for analyzing project costs. This method is then applied to those projects that had generated sufficient data to permit an analysis to be conducted. These cost analyses are presented as case studies in an appendix to this report.

Other reports resulting from Kalba Bowen Associates' research include:

- Evaluation of Telecommunications Demonstration Projects and Recommendations to the DHEW Telecommunications Demonstration Program, Executive Summary Report #146-01

---

*/ During the preparation of the final reports, OTP was moved from DHEW to the Department of Education. While, in some cases, the impacts of this move are discussed within the context of the reports, we have chosen for the most part to refer to OTP/DHEW since this was the location of the Telecommunications Demonstration Program at the time of our research.

- Evaluation of Telecommunications Demonstration Projects and Recommendations to the DHEW Telecommunications Demonstration Program, Summary Report #146-02

- Strategies for Institutionalizing Telecommunications Demonstrations: A Review of Innovation Barriers and Program Alternatives, Final Report #146-04.

TABLE OF CONTENTS

PLANNING AND EVALUATING TELECOMMUNICATIONS DEMONSTRATION PROJECTS

1.0 INTRODUCTION

Planning and evaluating activities, as they relate to the Telecommunications Demonstration Program and its projects, can be used as techniques for a dynamic process of institutional learning. This model is very different from the generally accepted notions of planning. Unlike the more traditional, static approaches to planning in which objectives are firmly established and a sequence of events is put into motion to accomplish them, objectives in a dynamic learning model are established with the expectation that they will be modified or changed. This perspective follows directly from an assumption that in some problem solving situations a detailed and precise formulation of a problem or mission cannot be accomplished at the start of the effort.

Three levels of success can be identified from the Program's basic mandate "to promote" the use of telecommunications for social service delivery.[1] Successful promotion can be accomplished by:

- Projects completing all tasks on their demonstration agendas;
- Projects becoming institutionalized and continuing to operate after Program funding ceases; and
- Project concepts being adopted by other organizations and in other locations.

1/ The Act created the Telecommunications Demonstration program to "promote the development of non-broadcast telecommunications facilities and services for the transmission, distribution, and delivery of health, education, and public or social service information."

Each of these levels is some form of success, but clearly each succeeding level goes further in promoting telecommunications uses.

The Telecommunications Demonstration Program has developed beyond the start-up phase. The task before it is to improve as quickly as possible at turning projects into successful Program outputs. The more explicit the Program is in its intended actions, the more explicitly expected consequences of these actions are identified; the more explicit the Program is in monitoring and measuring the consequences of its actions, the faster the Program will learn to be successful. The learning process can best be internalized through the dynamic use of planning and evaluation activities. The information needs and reporting procedures required by these activities are described in detail below.

2.0 INFORMATION NEEDS FOR PROGRAM EVALUATION

2.1 The Purpose of Telecommunications Demonstration Projects

Telecommunications demonstration projects for the delivery of social service or public information may be divided into those that demonstrate:

- an alternate means of service delivery for an existing information service;
- aggregation of demand to expand access to existing services; and
- new services that are made possible through the use of telecommunications.

Individual projects will not necessarily be included in only one category. For example, the project conducted by the Deaf Community Center demonstrates an alternative to the TTY for communication among the deaf, but it also involves new services such as the utility of asynchronous communication and videotext services made possible through advances in computer technology.

Regardless of which substantive category(ies) a project falls under, telecommunications demonstrations serve three basic functions. They are conducted to:

- develop experience in the use of telecommunications for social service delivery;
- serve as operational examples of service delivery concepts; and
- generate data to be used in further development or transfer of the concept.

With respect to planning and evaluation activities of the Program and its projects, the last of these functions should receive the most attention. With respect to the output of the Program, all three functions are of relatively equal importance because each plays a significant role in promoting the use of telecommunications for social service delivery.

2.2 Information Needs by Phase of Project Development

In considering the successful execution of a demonstration Program, there is a variety of information needed at different stages of project development. This section provides an overview of the basic types of data that can be useful in each developmental stage. As the discussion below illustrates, information requirements can be extremely burdensome. This section is not intended to suggest that all the types of data listed are required for all projects; rather, that projects varying in size and substance may have different information needs. Nevertheless, the full range of types of useful data are presented for reference purposes.

The conduct of a demonstration project may be divided into seven developmental phases. These are:

1) Policy Formulation and Planning

2) Preliminary Project Design

3) Selection and Funding

4) Feasibility

5) Pilot Testing/Demonstration

6) Project Operation

7) Marketing and Transfer

While these phases appear to occur in sequential order, activities in some phases may be parallel or recurring. For example, as discussed above, policy formulation and planning is dynamic and modifications in policies or planned objectives may change during the course of the project. Similarly, activities related to marketing and transfer of the demonstration concept may begin in very early stages of the project as other organizations or individuals are alerted to the project and in some instances are actively courted to encourage their involvement. Not all phases are the responsibility of OTP; some are mainly conducted by the grantee and others are a joint effort of the Program staff and the grantee.

The following paragraphs briefly list and describe the information needs for each of the above seven project phases.

(1) <u>Policy Formulation and Planning Phase</u>: During this initial phase, policy is established as to the overall

11

goals and the funding and staffing requirements for the project. It is also at this time that decisions are made as to the intended scope and focus of the demonstration. This entails efforts at understanding the program's purpose and selecting and planning a course of action. Since a number of groups should be involved, these planning activities would be a major undertaking. Moreover, user groups who have a potential interest in the services should be involved both in determining what services and technologies are desired and in planning for the design and selection of the demonstration. These planning activities are especially important where a project is perceived to be a relatively high risk.

Information relevant to these activities should be action-oriented and should address the specific questions of all the involved parties. The following are information products that could be developed or made available during this phase:

- clarification of short-term priorities and long-term goals;
- criteria for project selection and funding;
- data and information on related projects (in public and private sectors);
- identification of potential benefits, savings, efficiencies to be achieved;

- identification of target groups: end users, service providers;
- preliminary needs assessment of intended beneficiaries;
- schedules, strategies, and mechanisms for ensuring adoption and risk sharing;
- estimates of demand for services and willingness to pay for and support services on a local basis;
- estimates of service costs: start-up, operational, expansion (opportunities for economies of scale, cost-sharing);
- identification of roles of participating and contributing agencies and offices, within and beyond the immediate organization;
- evaluation criteria for all phases of project development;
- staffing requirements to administer, monitor, and assist the project;
- preliminary identification of potential subcontractors;
- identification of services to be provided including estimates of cost and development times;
- identification of regulatory, legal, and political barriers;
- identification of institutional barriers;
- identification of opportunities for aggregating services;
- identification of technology specifications, costs, capabilities, and availability.

(2) Preliminary Project Design Phase: Once the policy and planning activities have been completed, an effort should be made to design or outline in a preliminary fashion the

components, goals, and characteristics of the proposed demonstration. This effort entails going several steps beyond the planning activities of the first phase into a consideration of the details and problems of the proposed project. The purpose of this exercise is to anticipate problems before they arise and involve participant groups, including potential users, in the design process.

In the Program's current mode of operation, this activity is conducted by grantees after a solicitation has been issued because grantees directly control the nature of the demonstration project. Were the Program to take greater control over the formulation of demonstration concepts, then it would also be more actively involved in the preliminary design. During this phase an effort would be made to identify potential grantees to determine if they would have an interest in submitting proposals and if they have the resources and expertise to undertake successfully a demonstration project. On the basis of the design work and these preliminary assessments of potential grantees' capabilities, a funding strategy would be implemented and an RFP drafted. Currently, basic criteria for demonstrations covering all technologies and all services are issued with the solicitation, and innovation in substance and method is left to those who choose to respond.

The information produced in this phase should be directed towards resolving those issues and problems associated with the design of the demonstration projects and the identification and funding of potential grantees. Below are listed some of the information products and activities that would be produced during this phase:

- verification of availability, appropriateness, and reliability of proposed technologies
- preliminary design of proposed demonstration project
- anticipated problems/barriers
- funding strategy
- potential grantees identified and assessment of capabilities
- RFP.

(3) Selection and Funding Phase: During this phase the funding strategy is implemented, the RFP sent out, and a review committee designated to evaluate and select grantees. On the basis of the work completed in the previous phase, criteria reflecting established guidelines should be applied to the selection of projects to ensure that only projects which exhibit a high probability of achieving their first year goals are chosen. Groups with specific interests or expertise in different aspects of the proposed project should be involved in developing the selection criteria.

Naturally, first year grantees should be subject to a different set of selection criteria than those applying for renewal or continuation grants. Although during the first year it may be a useful strategy to fund several projects on a one-year trial basis, there should also be a commitment to fund those projects that evidence success for the full duration of their "life cycle."

The information products of this phase are relatively minimal:

- selection criteria
- criteria for first year and continuation funding
- list of funded projects.

(4) <u>Feasibility Phase</u>: For most projects, this phase typically lasts from six months to two years during which time either the feasibility of the concept is demonstrated or it is not. During this period the project produces data on the cost effectiveness of the technology and services, the needs of intended beneficiaries, financial and funding plans, projected expansion costs, management plans, estimates of total development costs, and plans for encouraging widespread adoption.

In order to carry out this phase, the project should implement its services and systems on a trial basis to test the viability of the proposed system and to gauge users' and institutional receptivity. This is one of the most important phases of the project cycle; based upon the information gathered during this phase, a decision is made whether or not to commit funds to the complete development of the demonstration concept. Therefore, the funding organization should provide clear and succinct guidelines as to what is expected of the grantees at the conclusion of this phase. Even with this assistance, however, independent assessments of the projects should be made. These assessments should not simply be evaluations, but in-depth analyses of the feasibility of the projects, both in terms of the concepts being tested and in terms of the project's ability to achieve its long term goals. Typically, the costs of the feasibility phase run about 10% of the total development costs. Although its costs can be high, it can be justified in terms of potential savings and improved performance.

Since this phase entails considerable analytic and research work, there is a potential conflict between the grantee's need to initiate the project and deliver services and the sponsor's need to assess the feasibility of the project. Consequently, technical assistance may be required from the beginning. Whether or not this is the case, the grantees should be made aware of the "paper" requirements of this phase, and they should have the capabilities to provide the necessary information and data to complete the feasibility phase.

The following are the rather extensive information and data requirements of this phase. Most of these requirements are a part of the feasibility study:

Feasibility Study

- cost-effectiveness of technology (comparative analysis if appropriate)
- cost-effectiveness of services (software) (comparison with other modes if appropriate)
- projected development costs and plan
- financing plan
- management plan
- needs assessment (and/or data on demand for services) of end users
- adoption/promotion strategies
- plans and agreements for institutional support and cooperation
- plans for overcoming legal, regulatory, and political barriers
- technical assistance information on conducting feasibility studies.

(5) Pilot Testing Phase: Once a demonstration project has passed the feasibility phase, it is then in a position to develop its capabilities and resources and pilot test its technologies and services. The purpose of this phase is to further test out the technologies and services to eliminate any unforeseen problems or obstacles. One can think of this phase as a trial exercise whereby the system is subjected to a real world test but under protected conditions.

During this phase, the information requirements are not as extensive as in the feasibility phase because the project has demonstrated its worth and viability by this time. However, the same criteria that were used in the feasibility phase should also be reconsidered during the testing phase to correct any mistakes in the feasibility study and to focus on those problems that may come up in the future such as financial support, increased scale of operations, institutional cooperation, and adoption and transferability. Particular attention should be paid to those problems that may prevent the technology and service from becoming fully operational in the next phase.

(6) Operational Phase: When a project has reached this phase, it has eliminated most of its major problems and is delivering services to all of its intended clients at the cost and efficiency levels projected in the proposal. It has become self-supporting and does not require funding support for staff or equipment. It will, however, need funding to gather data and information used to evaluate its success and facilitate the transfer of the technology and service to other users. It may also need some additional funds to improve and expand upon its operations, but these funds should not be used for changes in fundamental design or content.

The information produced during the operational phase has several purposes: first, it is to be used to determine whether or not the project should be promoted and transferred to other user groups and how promotion and transfer should be done. It is also used to evaluate the success of the project in achieving its intended objectives and provides information and data to sponsors as well as user groups to assess the reliability of the original estimate in the feasibility studies and to better select new projects for funding. The data produced at the conclusion of this phase are similar to those produced in an evaluation except that the data can be compared to initial estimates and are collected to address specific policy questions raised in the first phase.

In addition to assessing the performance of the project in reaching its operational phase, the data gathered at the conclusion of this phase should focus on those factors that affect its expansion and/or adoption by others. Although estimates were made in previous phases of the costs to expand or transfer the service and technology, and although the project may be intended as a model for others to follow, it is only at the conclusion of this phase that sufficiently detailed and reliable data are available to determine how easily the project can be imitated by others. Therefore, careful attention should be given to those often unique factors that either contributed to the success or failure of the project to determine how situational success or failure was. If the ingredients of success were highly idiosyncratic to the circumstances and personalities of the project, and these in turn are not easily replicable, then despite a project's success, it may be wise not to try to encourage its adoption and utilization. If the decision is made to promote transfer, it may be essential to look for those conditions and ingredients in other settings that are similar to those of the successful project. In making this assessment, it is also important to determine if the demand for the services and technologies, as well as the incentives for adopting the technology and services, are as high as those in th successful demonstration. If this is the case, then a decision should be made to promote the adoption of the technology and service, otherwise, the better decision may be to terminate funding.

Below are listed some of the principal types of information products of this phase. A distinction is made between those information products used to assess the overall success of the project, and those used to decide whether the funds should be committed to encourage the adoption and dissemination of the project.

Project Evaluation Information

- start-up, pilot, and operation costs
- cost-effectiveness of service delivery
- economies of scale (if appropriate)

- unit service delivery costs
- ratio of operating costs to fixed costs
- cost sensitivities
- effectiveness of funding procedures
- effectiveness of service in meeting needs
- performance of management and staff
- assessment of institutional cooperation
- assessment of commitment of continuing support and success

<u>Prospects for Dissemination and Adoption</u>

- assessment of key situational factors contributing to success
- estimates of demand for service, benefits in other settings
- estimates of replication of successful factors in other settings
- identification of targets of opportunity
- estimates of costs for promoting adoption
- incentives for adoption in other settings
- identification of residual barriers to dissemination and adoption
- estimates of costs and risks for service aggregation

(7) <u>Marketing and Transfer Phase</u>: If the decision is made to commit funds to the widespread promotion and adoption of the demonstration project, this phase of the project could consume major resources of the sponsoring agency.

Furthermore, the promotion, marketing, and transfer of the project to other settings require different skills and resources than the development and evaluation of the demonstration. Consequently, the sponsoring agency will need to acquire these skills and resources at the onset of the marketing and transfer phase

As the experience of federal agencies in the public sector [2] and the experience of private firms [3] have demonstrated, unless there is an effort to adopt the technology to the needs and circumstances of potential users, no amount of "push" can make up for a lack of "pull." Therefore, prior to any promotion or transfer activities, market studies should be undertaken to identify potential adopters and their specific needs, resources, and incentives for adoption. The results of these studies will help identify those users that may become earlier adopters as well as help identify those changes or modifications in the "transfer package" that would increase the prospects for adoption.

With the completion of the market studies and the identification of target users, efforts should be made to

---

2/ Baer, W., Johnson, L., Merrow, E., Analysis of Federally-Funded Demonstration Projects: Final Report, Rand Corporation, R-1926-DOC, April, 1976.

3/ Utterback, J., "Innovation in Industry and the Diffusion of Technology," Science, V. 183, Feb. 15, 1974, pp. 620-626.

identify the appropriate media and activities to reach prospective adopters. However, depending upon how major and active a role the sponsoring agency wishes to take in promoting transfer, risk sharing and technical assistance may be required. In those cases where the technology is relatively new, expensive, and not widely available, efforts should be made to stimulate private sector development and marketing.

In promoting the transfer and adoption of new telecommunications technologies and services particular attention should be given to the interests and needs of those decision-makers responsible for funding and administering the technology and service. Unfortunately, the clear demonstration of benefit to the end user or client is not always sufficient incentive for adoption by the administrator or provider. New technologies often entail budgetary and organizational changes, undermine positions of authority, and jeopardize organizational boundaries. Consequently, there should be "something in it for everybody"; -- administrators, funders, and service providers have to see that it is in their best interest to adopt this innovation. For this reason the best adoption or transfer strategy is one which "piggybacks" upon established habits and which has clear and demonstrable benefits to all concerned. Once the initial concept is accepted, improvements and embellishments can be added gradually on a modular or trial and error basis. For example, unsophisticated users of telecommunications services are highly unlikely to be receptive to telefax, video conferencing, and packet switching. Rather, experience has to be gained with simple technologies and more obvious uses before technically and behaviorally sophisticated applications can be assimilated. Therefore, the transfer of an innovation should proceed in a step-wise fashion before leading into more sophisticated and intensive applications. Very often the best innovator is the user, who knows his/her needs and is able to adapt the technology and service to his/her own circumstances and resources. The transfer strategy, as well as the technology, should be sufficiently flexible to allow for modifications and mid-term alterations.

There are two types of information produced during the marketing and transfer phase. The first is operational information, used to plan and complete the marketing and transfer; the second is evaluation information used to assess the success of the marketing and transfer activities.

Operational Information

- design of the "transfer package"
- market studies of potential uses
- strategies for "fitting" technology and services to potential users
- strategies for reaching potential users
- incentives and risk sharing schemes to encourage transfer

- identification of market segments and strategies for reaching each segment
- budgets for marketing, promotion, and transfer activities
- plans for encouraging private sector involvement/turnkey arrangements

<u>Evaluation Information</u>

- cost-effectiveness of marketing efforts (by method and for each target group)
- identification of success factors
- identification of barriers in service and technology
- identification of barriers with marketing and promotion
- critique and recommendations.

3.0 PROJECT REPORTING AND EVALUATION PROCEDURES

The legislation creating the Telecommunications Demonstration Program requires that the grantees themselves be responsible for conducting project evaluations. The purpose of this section is to help projects standardize and simplify their evaluation efforts. The particular objectives of demonstration projects may vary from project to project. For example, one project may focus primarily on determining the cost-effectiveness of one technology over another, while another may focus primarily on organizing several agencies or institutions to share an expensive telecommunications facility. Thus, not all items suggested below may be applicable; however, an effort should be made by grantees to be as comprehensive and detailed as possible.

The purpose of the evaluation report is to document the experience gained over the project's life and to determine the degree to which the demonstration is successful in promoting the use of telecommunications in the delivery of social services. As discussed earlier, ideally there are three levels or tiers of success that a project can attain:

- completing all intended project tasks;
- demonstrating that the project concept is meeting a local need by continuing operation after Program funding ceases; and
- transferring the project concept to other locations.

Each successive level has a greater impact on meeting the Program's goal of promoting telecommunications in service delivery. Of course, the first and second levels may not apply to projects that have completed only their first or second year of Program funding, so that the majority of the information contained in the grantee's evaluation will relate to the successful completion of project tasks. It should be made clear, however, that a useful evaluation is dependent to a great degree on a well designed demonstration. If a project is to produce the needed evaluative data, it must be designed from the beginning to generate that data. Thus the items discussed below are in essence design elements for demonstration projects.

Project Evaluation

The project evaluation report should be divided in six sections as follows:

- Statement of the Problem
- Project Status
- Cost Analysis
- Barriers to Implementation and Utilization
- Assessment of Benefits
- Strategies for Institutionalization

A brief description of the topics to be covered and questions to be answered in each of the sections of the project evaluation report is presented below.

Definition of the Problem: Demonstration projects can be thought of as a technique for problem solving. Every idea for a demonstration project results from the perception that there is a problem with the existing social service delivery system. The purpose of this section is to articulate clearly the boundaries of that problem and to outline how a successful demonstration will solve the problem.

The definition of the problem is one of the most crucial aspects of conducting a project evaluation because it establishes the basic hypotheses and premises that the demonstration is to prove. It should also be noted that there may be alternative formulations of what appears to be the same problem. The following hypothetical examples of problem statements constructed for a demonstration project illustrate this difficulty and its implications:

> Statement 1: There is an increasing need for life-long or continuing education, but often particular education needs cannot be met because individuals interested in a particular subject are geographically dispersed and cannot be gathered at one location. Constructing a network of local cable television systems would enable educational programming to reach a greater geographic area, thus permitting the aggregation of this dispersed demand.

> Statement 2: Educational programming has been developed for a wide variety of subjects, but it has not been widely used because only a limited (local) means for distributing the programming is currently available. A network of local cable television systems could be used to increase the distribution of educational programming.

Each of these hypothetical problem statements, which are quite different from each other, has the development of a network of local cable television systems as its solution. The first statement has four components:

1) There is a demand for continuing education;
2) The problem is that demand is dispersed and no individual can by himself support the programming;
3) The solution is to aggregate demand;
4) A network of cable systems is the tool for aggregating demand.

In contrast, the second statement implicitly assumes that there is an audience interested in viewing the available programming. Its components are:

- A variety of educational programming exists;
- The problem is that there is not a sufficient means of distribution;
- A cable network would provide the necessary distribution system.

In the first statement, the problem actually has nothing to do with technology. There is a perceived structural problem with demand for services. The demonstration would focus on a means of alleviating or resolving that structural problem which would require assembling a cable network. The second demonstration, in contrast, would focus primarily on the construction of the network. An observer viewing these two demonstrations would see basically the same activities: the development of a network and efforts to sign up viewers for the broadcasts. But the demonstrations would be attempting to examine two completely different problems.

The importance of properly and clearly formulating the "demonstration problem" is that it is the projects' organizing principle. A properly formulated problem statement should spell out the expected benefits of using telecommunications for the concept being demonstrated. The definition of the problem influences the types of data that are generated, activities of the project staff, and the types of external audiences that may be interested in the project. Equally important, it is extremely valuable in avoiding a pitfall that often besets technology demonstrations: taking a technological solution and finding a problem in which to use it.

Project Status: The purpose of this section is to describe as specifically as possible how far along a project is in completing its demonstration agenda. Four project phases have been distinguished and are described below. Although no particular time periods for each phase can be specified, these phases are not arbitrary. They correspond to developmental periods in which project costs may differ. The project cost analysis is based on data that is disaggregated by project phase. This portion of the project evaluation report should describe project activities according to the following phases.

(1) Start-up Phase: This is the initial phase of project development during which equiment is procured, staff is hired

and briefed, service agreements are finalized, and needs assessment are performed. This phase is completed when all these tasks have been performed. If for some reason a project is not able to complete one of these tasks and has proceeded to the following phase, a brief explanation should be given. In some cases, some of these tasks may carry over into the next phase, but since such a carry-over can affect project performance, it should be noted.

(2) Trial Operations Phase: The purpose of this phase is to train staff in the use of equipment and in the methods of service delivery. In most cases, a small group of end users is selected to work closely with project staff to iron out problems. Typically, this is a period of great flux during which changes have to be made in staff, services, and, in some cases, equipment. While services are delivered during this phase, the primary intent is to discover problems and work them out so that service delivery can proceed more smoothly in the next phase. As in the case of the previous phase, this phase is only completed when all principal tasks have been completed. This generally occurs when all major problems have been worked out and stable operating and service delivery procedures have been implemented and understood by all principal participants. If this has not occurred, these problems should be noted and brief explanations provided.

(3) Demonstration Phase: For many projects this would constitute the final phase of their development under DHEW

support. It is during this phase that all intended (revised) services are delivered. Since by this time all major managerial, organizational, service delivery, and institutional problems should have been either overcome or accommodated, it represents a fair demonstration of what telecommunications-based services can achieve. The successful completion of this phase comes not only with the delivery of all intended services, but also with the evaluation of the success and problems of the project. Since the objective of demonstration projects is not just the delivery of services, but the assessment of the benefits/disbenefits and cost savings of the project to encourage adoption by others, it is critical that the evaluations are complete and answer the concerns of potential adopters and funders.

(4) <u>Institutionalization Phase</u>: When a project has reached this phase it has sufficiently demonstrated its value to become self-supporting and adopted by local or other service organizations. It is no longer dependent upon federal funds for its survival, receiving ongoing support from state and local agencies. By this time it is also servicing a stable population of end users who have benefitted and can expect to continue to benefit from the services. A demand for the project's services has been established and a means for meeting both that demand and financing the services has been achieved.

Cost and Financial Analysis: A major argument for employing telecommunications in the delivery of social services is that its use is cost-effective.[4/] At an identifiable volume of service delivery, it is often less expensive to use telecommunications to deliver services than to employ another method. Demonstrations must explore the economic characteristics of service delivery. The primary purposes of conducting a cost and financial analysis are to:

- Identify the structure of costs by type of resource used over the four project phases;
- Analyze cost sensitivities including the substitutability between labor and technology, the substitutability of alternative technologies, and the effect on cost of increasing the volume of services delivered over the demonstration system;
- Compare the cost of delivering services using the demonstration system to the costs of service delivery using other existing or possible delivery modes.

The identification over time of the structure of costs such as labor, equipment and space provides important financial information to others who may want to adopt or adapt the system for their own use. Analyzing cost sensitivities provides valuable data on the potential for economies of scale and may permit a determination of the optimum size of an operational system since demonstrations often serve a relatively small number of users. The comparison of costs for service

4/ A detailed discussion of the methods and inforamtion requirements for conducting a cost analysis of a telecommunications demonstration project is presented in the following report of this volume.

delivery by the demonstration system versus other delivery methods is an analysis of cost-effectiveness. It can only be conducted when data on alternative delivery methods are available; such comparisons are the true test of economic viability of the demonstration concept. Because demonstration projects are often unique, such comparable data may not, however, be available.

Barriers to Implementation and Utilization: While economics may be a good reason for wanting to employ telecommunications, there are often a series of barriers to implementing the demonstration system and using it for delivering the intended information services. Several demonstration projects already funded serve as examples. PACE Institute faced major delays in obtaining and installing equipment and as a result progress was greatly impeded. Other projects faced organizational barriers. For example, the Pennsylvania State University cable network project relied on the state cable industry to take the initiative to assemble the network. Much of the control over the future of the project was not in the hands of the grantee, and major delays resulted. Still others have run into legal or regulatory impediments. The continuing medical education project by the Medical Care Development Center required that the FCC issue a special license, which in the end the Commission did not grant. The efforts by the Center for Excellence to establish a special radio station for the blind, deaf and homebound were very successful, but copyright laws restrict the use of their programming materials to particular target populations. The special receivers required to receive the Centex broadcasts cannot be commercially sold which suggests the prospect of permanent subsidies to support the system. Thus, legal barriers greatly inhibit audience expansion beyond the demonstration participants.

In this portion of an evaluation report the barriers to implementation and utilization should be carefully documented. The experiences encountered by individual projects will be extremely useful to the Demonstration Program staff. It will assist them in identifying projects in the future that might encounter similar problems. It will also be useful to other organizations attempting to replicate the demonstration system.

In completing this section of the report, care should be taken to identify the barriers encountered, and successful as well as unsuccessful attempts to overcome the barriers and the reasons these efforts failed or succeeded.

Barriers to implementation and utilization may be classified into three categories:

- Technical
- Organizational/Institutional
- Regulatory and Legal

Technical barriers may include obstacles such as difficulties in obtaining equipment, in developing or using necessary software, in establishing and implementing an effective training program, as well as resistance by system users to using a new technology or service.

Organizational/institutional barriers often involve difficulties in obtaining the support or at least the acquiescence of other agencies or service organizations. Just as an innovation can be resisted by new users, it can also meet considerable resistance by other service-providing organizations that perceive that the demonstration will have some negative impact on their activities. To the extent possible actions taken by organizations that impact the demonstration should be documented.

Legal or regulatory impediments should generally be identified very early in the project. These might include regulations by government agencies such as the FCC, copyright laws or privacy laws.

Assessment of Benefits: Assessing the benefits of telecommunications demonstration projects is a particularly troublesome task. Often they are not quantifiable or even easily observable. Frequently benefits accrue indirectly from action taken as a result of improved access to information made possible by the telecommunications based service. Benefits of a demonstration system may be assessed at several different levels. For example, the use of a telecommunications system in the management of regional blood banking, such as that being demonstrated by the Tri-State Red Cross Blood Center, may have as its primary benefits the reduction in time in locating and distributing blood on request. These may be measured in terms of minutes saved. But the ultimate benefit may be that the time reduction plays a part in saving lives. These benefits are not easily measured. In this section of an evaluation report the benefits to service delivery of the project's use of telecommunications are to be documented. These may, of course, not be evident until the project has been operating for several years.

Wherever possible, quantifiable measures of benefits should be used. The following are examples:

- cost savings
  - dollars per transaction, program or other unit of service
  - dollars per client
  - total dollars
- productivity gains
  - volume of information per unit of time
  - units of time saved
  - reduction in units of labor input
- access
  - number of (potential) additional clients served
  - total volume of information available.

Of course, there are many other measures that may be used. Care must be taken to ensure that the measures that are chosen accurately describe the service benefits received. For example, additional hours of specialized radio programming for the handicapped are not benefits unless there is an audience that listens to the broadcasts. Demonstration outputs do not necessarily translate into service benefits.

The assessment of benefits can be organized according to the following three points:

- Identify the beneficiaries of the project (e.g., clients, service providers, administrators) and describe how information services provided through the demonstration were previously provided.

- Present evidence demonstrating gains/losses of methods and technologies employed by the project over previous methods and services.

- Present evidence illustrating the comparative advantages (and disadvantages) of technologies and services of the project versus other available technologies and services.

Strategies for Institutionalization and Transfer: Two of the ways in which the Telecommunications Demonstration Program can promote the use of telecommunications in social service delivery are to encourage projects to continue operating after Program funding is withdrawn and to transfer the demonstration concept to other locations that face similar service delivery circumstances. In this final section of the annual evaluation report, the grantee should articulate the role it intends to play in the institutionalization and transfer process. At the end of the first year these strategies may not yet be developed in detail, but by the end of the second year a fully developed plan should be articulated.

The approach to a strategy for institutionalization is essentially a plan to obtain revenue for continued and/or expanded operation. That plan can vary depending on the thrust of the project. For example, for a project such as the continuing education network being attempted by the Pennsylvania State University, the future of the network depends on generating income from viewers. In this case the strategy for institutionalization amounts to a marketing plan, on a statewide, or at least regional level. Such an effort is no small undertaking, requiring substantial resources and a good deal of planning. In contrast, a project such as the Western Alabama Emergency Medical Services Demonstration may involve a strategy for obtaining operating funds by getting budget commitments from various agencies or institutions. In this case, funds might be obtainable from service programs in DHEW or directly from the participating hospitals. This approach, however, is clearly different from the one required of Pennsylvania State University.

In addition to specific plans for generating revenue, the institutionalization strategy should take into account other barriers that might inhibit long-term operations. Such barriers may be encountered as part of the demonstration but possibly at a smaller scale. It will be necessary in this portion of the report to identify any such barriers and the plan for surmounting them. As discussed earlier, these may be of a technical, organizational or legal nature.

In addition, the report should describe a plan of action for the project's effort in helping to get the demonstration concept put into use in other locations. This is also a form of marketing. In developing the transfer strategy, the grantee may want to consider the following activities:

- Identification of other target locations with similar service needs as those for the demonstrations.
- Identification of key individuals in those target locations to contact.
- Identification of target groups or audiences that would have an interest in the demonstration project and the appropriate means for contacting those audiences such as:
    - presentations at conferences
    - attendance at regular meetings
    - distribution of literature describing the project.

Finally, this section of the report should consider the cost of carrying out the proposed strategies. As discussed above, marketing efforts to end users can be an expensive proposition and must be planned.

ASSESSING THE COSTS OF TELECOMMUNICATIONS DEMONSTRATION PROJECTS

May 1980

1.0 INTRODUCTION

This report presents a method for assessing the costs of telecommunications demonstration projects. The method is:

- grounded in basic economic principles;
- sufficiently versatile and simple so that it can be applied to a wide variety of technologies and services, while providing necessary information on costs of a project to be useful in decision-making;
- takes into consideration the unique characteristics of telecommunications demonstrations; and
- focuses on providing information needed by several audiences including system operators, funding agencies and others interested in conducting similar projects or providing similar services.

Decision-makers are frequently faced with situations in which choices must be made from among several alternatives. Methodologies have been developed to assist decision-makers in identifying the alternatives that are the most efficient in economic terms. Principal among these methods are cost-benefit analysis and cost-effectiveness analysis. Cost-benefit analysis entails valuing the benefits or output of an alternative in monetary terms and directly comparing benefits to costs. Any alternative which generates benefits in excess of costs is worthwhile for a society to undertake. When several alternatives are compared, the alternative that generates the largest benefits to cost ratio is the most efficient alternative. Because costs and benefits for all alternatives are expressed in one measure (dollars), comparisons among alternatives are easily made. Cost-effectiveness analysis, in contrast, does not rely on valuing benefits in monetary terms. Instead, costs are compared to non-monetary measures of output such as numbers of recipients, volume of information disseminated, or time reduction for service delivery. This provides a means of comparison, although direct comparisons of alternatives often are not possible. Two alternatives may have slightly different outputs, so that effectiveness measures are not commensurate.

In the telecommunications demonstration context, cost-benefit analysis is difficult to apply. Telecommunications demonstrations, particularly ones focusing on social service delivery, provide information services. The monetary value of public information is very difficult, if not impossible, to determine. Benefits to society do not accrue from the information itself, but rather from the action the information precipitates. To cite an extreme example, conducting a cost-benefit analysis of the use of telecommunications to provide simultaneous transmission of voice and biomedical data from remote emergency medical sites to a hospital would essentially require determining the value to society of saving a person's life. Obviously, in many instances the monetary value of information is not easily determined.

The use of cost-effectiveness analysis in the demonstration context has its difficulties as well. The primary limitation is that demonstrations are frequently innovative and there are no directly comparable alternatives. Thus, no determination can be made of the relative cost-effectiveness of the project.

An additional difficulty is that the cost-effectiveness techniques that have been developed are applied to large operations systems. Sophisticated statistical techniques such as multiple regression or path analyses are employed in conducting the analysis. Those techniques require a rather large data base developed for a large population over a number of years. Telecommunications demonstrations are funded for a limited time period and usually include a small population of recipients or clients. Thus, the data base generally needed for a full-scale cost-effectiveness analysis cannot be generated. Still, the notion of systematically comparing costs to output is an important one, and is necessary to obtain some measure of effectiveness. The method discussed below focuses on the cost-effectiveness concept and uses some simplifying assumptions to avoid some of the difficulties mentioned above.

There is another important consequence of the uniqueness of a telecommunications demonstration. As a one-of-a-kind system that must be assembled in a short time frame using technology that is available, the costs associated with the project may not accurately reflect the costs of an operational system. In such situations it is still necessary to examine the potential costs of an operational system, although in many cases this can only be done qualitatively.

In addition to the need to provide cost information for analyzing alternative systems, there is another important reason for conducting cost analyses. Demonstration projects may yield very positive results, and it may be desirable to expand the existing system. Also, other organizations may want to develop the same, or similar, service systems. Cost analyses can be instrumental in planning the expansion or transfer of the system or concept. This requires examining costs from a different perspective. For example, in transferring the system a project manager would need to know about the amount of initial outlays required to establish the service and the budget required to sustain the service. A manager of an existing system would be interested in determining whether the potential exists for cost savings in system expansion. (This is also important for analyzing cost-effectiveness.) The method discussed below takes these needs into account as well.

The method for analyzing costs is presented in Section 2. The presentation focuses on three questions:

- What costs are to be considered in conducting a cost analysis?
- How are cost data best organized for later analysis?
- How are the data useful in evaluating telecommunicatons demonstrations?

2.0 COST ANALYSIS METHODOLOGY

The methodology presented below is organized around four major elements of analysis:

- the determination of true costs;
- the disaggregation of costs by input and by time;
- the sensitivity of costs and output to variations or substitutes for inputs; and
- the consideration of technological characteristics of the demonstration.

An analysis of the economics of demonstration projects is designed with certain goals in mind. Principally, these are consistency, replicability, and clarity. To be able to accomplish these goals, we need to know the "true" costs associated with the design, implementation, and operation of the system. Being able to identify the true costs plays a central role in the cost analysis.

Costs must also be viewed in sufficient detail so that key components of the demonstration can be examined. Thus, it is necessary to examine the costs of individual inputs (labor, equipment, communications), as well as how the cost of inputs vary throughout the duration of the project. Technology is central to telecommunications demonstrations. Its role in each demonstration should be separately discussed, and the cost considerations of substituting other technologies explored.

The comparison of system costs and outputs is the key ingredient to the assessment of cost-effectiveness. Conducting this comparison by project phase also provides insight into the sensitivity of costs over time. The following sections discuss each of the methodology components in more detail.

2.1 The Importance of True Costs

In new and innovative projects non-standard designs and equipment are frequently utilized. Similarly, managerial and technical talent is often "lent" or freely given to the system operators by individuals and organizations who have a benevolent view of the goals of the new project. However useful this may be to the project itself, both from the point of view of society and from that of others who might duplicate the system in the future, it is important and necessary to know the full magnitude of the costs of the resources used by the system.

To the economist, the only appropriate measure of true costs is what are termed "opportunity costs" -- the value to society lost by using each resource (plant, equipment, labor) for the specific project being analyzed. This value is measured by determining alternative uses of the resources and looking for the one with the highest reward to society. In the case of goods and services purchased on the open market, the opportunity cost is the same as the price paid. That is, the value of a good or service to society can be directly determined from the price people are willing to pay. Difficulties arise, however, when goods or services are not obtained through market transactions. For example, space for the project may be donated, as occurred in the TALINET project, or workers may be willing to accept wages below the going rate, as in the project conducted by the Deaf Community Center. In these cases, we use opportunity costs as the only reliable measure of the true costs of these resources to society. In the case of the donated space, it is necessary to determine how much revenue such space would bring if it were leased or sold on the open market. Likewise, we need to determine what level of pay the workers would receive if they accepted the best alternative job. Although the rule is basically quite simple -- to attempt to determine what the true cost to society is -- the application may be more or less difficult depending on the nature of the resource in question.

A second problem that often arises in cost analysis in the social service delivery field is that volunteers may be relied on for particular services. In addition to providing assistance in the construction and operation of the project, volunteer help is often used in the development and actual production of programming utilized by or presented on the system. This situation occurred in the CenTeX Special Communications Services project. Over forty part-time volunteers were used to produce programming for the project. Evaluating the opportunity costs of volunteers' time and effort is difficult for several reasons:

- equally skilled labor may not be available at any price;
- labor with a different level or mix of skills might be used if the project had to hire replacements; and
- the volunteers may have no alternative <u>paying</u> outlet for their skills. (This was the case for many of the elderly volunteers in the Reading, Pennsylvania interactive cable TV experiment.)

When these and similar problems arise in the DHEW demonstration projects, it is important to point out their existence and develop either a best estimate or a set of alternative estimates of the true system costs.

The third problem that may arise is the presence and magnitude of any "hidden" costs. The major category of hidden costs is those costs imposed on others by the existence and operation of the system. For instance, other functions carried out by the particular project may become more costly because certain commonly shared resources are now more costly to obtain or use. In the educational television network demonstration conducted by Pennsylvania State University, for example, the broadcasting facilities used for local educational programming are also to be devoted to network broadcasts. Funds to cover broadcast time are not included in the demonstration grant, but are hidden in the operation of existing university services.

Another category of hidden costs that must be considered is the one that consists of resources made available to the project without charge by government agencies or supporting institutions. Although it may appear as though the true cost is actually zero because a charge is never made for these resources, the case can be made that a charge should, nevertheless, be imputed. To give a specific example, several of the projects use portions of the electromagnetic spectrum. These frequencies are allocated without regard to their scarcity value and the fees levied are often quite small. Nonetheless, use of the spectrum by the projects may force other services to use less desirable frequencies or prevent them from being offered at all. When this problem arises, it should be indicated, although there is no widely-agreed upon way of handling these costs.

To summarize and restate the basic principle we have discussed in this section: when properly conducted, a cost analysis will include the true costs of all resources used. In almost all circumstances, the measure of these true costs will be the opportunity costs -- the value of the resources in their best alternative uses or in the marketplace.

2.2 Categorization of Costs

The previous section described, conceptually, the nature of the costs that should be examined in conducting a cost analysis. This section discusses how these cost measures might be usefully categorized and how one might use the various categorizations. A format for organizing cost data is presented in Appendix A. There are several generally recognized types of costs that may be considered including:

- Fixed Costs: costs that do not change with the level of system utilization.
- Variable Costs: costs that change with the level of utilization.
- Recurrent Costs: costs incurred for some item that is used at the time of purchase (e.g., leasing of computer services), but for which the same costs are incurred again for each specified time period.
- Capital Costs: costs incurred to purchase plant or equipment that is used beyond the time of purchase for its lifetime.

Frequently, capital costs are confused with fixed costs because both are associated with equipment and plant purchase. However, fixed costs may include such items as maintenance or administrative labor if they do not vary with system utilization. These fixed costs may also be considered recurrent costs because both administrative labor and maintenance may be purchased for a specified time period.

These types of costs may be examined by time, input, and function. No one of these is necessarily better or worse than the others; the only test is how useful they are and how much information they provide in analyzing the costs of each demonstration.

By time: Any communications system can be expected to have certain set-up costs that must be incurred before any operations are begun. These include capital investment in plant and equipment, purchases of initial supplies and programming, if any, and the wages and salaries of the personnel necessary to initiate operation.

There are other recurring costs that will continue on a regular basis even after all the plant and equipment are in place. These may include communications services and other utilities, operating personnel, and other costs incurred because of the ongoing nature of the system's operation.

Rather than utilize the rather crude division of time into the two periods -- set-up and operation -- four phases should be employed in an effort to capture more useful information about a demonstration project. The four phases are:

1) installation and start-up,
2) trial operation,
3) demonstration, and
4) institutionalization.

Each of these project phases represents a different mode of operation of the system, and it can be expected that the nature of the costs may be quite different in each. For example, in the first phase we would expect a major part of the expenses to be on the equipment for the central site and on some of the equipment for those who will be utilizing the service. In later periods the costs of equipment might be a relatively smaller portion of total expenses.

The operation period is sub-divided into the trial operations, demonstration, and institutionalization phases because it is likely that the nature of the costs will be sensitive to the number of users, the level of experience of the system operator, the types and quantities of programming, and other factors that may change as the system develops.

The following "short" definitions of the three operating phases can be used in gathering cost data for a project:

- Trial Operations: pilot test of service delivery.
- Demonstration: full operation of systems to a majority of the intended users.
- Institutionalization: successful ongoing delivery of services and (at least) partial self-sufficiency.

Unfortunately, exact times when a specific project will move from one phase to the next cannot be prescribed. This can cause a certain degree of non-commensurability between the various projects, as slightly different standards or definitions may be used. As long as the system operator is careful to explain how the dividing lines were drawn, the impact of any inconsistencies in defining the starting and ending points of the various phases is likely to be small.

Having information on the time-phasing of the costs can be useful for several reasons. Primary among these is that both profit and non-profit organizations place a premium on expenses that must be incurred sooner rather than later. By postponing expenditures, the organization can earn interest on the funds that are not being currently used. As a result, expenditures to be made in the future are effectively reduced.[1/]

A related concern is the impact of the expenditures on the cash-flow of the organization. It is useful to be able to predict the approximate times at which funds will be required so that plans can be made in advance to have

---

1/ We will not go into a detailed presentation of the theory of the time value of money and discounting future costs with the interest note here. For more on this topic, see D.T. Jamison, S.J. Klees and S.J. Wells, Cost Analysis for Educational Planning and Evaluation: Methodology and Application to Instructional Technology, Agency for International Development, Office of Education and Human Resources, January, 1976, pp. 13-19.

those funds available. This is particularly important where there are long lead times in the funding process.

By input: It is possible to characterize any particular service by looking at either its inputs or its outputs. For information and telecommunications services, it is often quite difficult to develop output measures that allow for a consistent comparison across projects. However, this is not a major problem for demonstration projects that are acknowledged to be unique. For such projects, we are not always interested in a direct comparison of the outputs.

On the other hand, being able to compare the mix of inputs used by each of the projects is useful. To do this, we need information on the configuration of the system, the operating requirements (both labor and other necessary inputs such as utilities and supplies), and the space required. The obvious solution to the problem of how to aggregate and then compare these numbers is to collect the cost data for each type of input.

Specifically, the total costs of the inputs can be disaggregated into six categories:

- equipment (purchased or leased);
- communications and computer services (purchased or leased);
- space;

- labor (administrative and operating);
- programming and software; and
- miscellaneous.

Any division of costs into categories is arbitrary to some degree. However, these specific categories are chosen to provide certain types of information to system operators, funding agencies, and evaluators. For example, the space, equipment, and software categories individually and together provide information on the fixed costs -- those costs that are relatively independent of the level of operation of the system. Conversely, the levels of communications or computer services and labor may vary systematically with the volume of usage of the system so that total variable costs can be examined. It will be useful to determine these relationships as their character can provide information about what costs we might expect for various levels of system operation.

By function: In addition to the usefulness of cost breakdown by input categories, additional information can be obtained by using the breakdowns of costs by time and by input in combination with one another. As an illustration, it is possible to determine if virtually all of the equipment and software costs are incurred in the start-up phase or if a significant portion of these costs continue into the operating phases.

2.3 Sensitivity Analysis of Cost Data

There are three other important ways in which the information described above can be used by researchers or administrators. Cost data can be used to:

- analyze the sensitivity of total costs to changes in the configuration of the system or in the prices of any inputs;
- analyze the sensitivity of the cost of output as system utilization increases; and
- obtain some indication of system cost-effectiveness when the costs of alternative modes of providing information services are available.

Conducting a "sensitivity analysis" of costs and inputs can provide insight into which of the inputs can be varied without any major effect on the level of total costs. The degree of sensitivity of total costs to changes in the price or quantity of any one of the inputs will depend on several factors. Among these are the proportion of total costs accounted for by that input and the degree to which other inputs can be substituted for the one in question.

As mentioned earlier, demonstrations are often unique and there are no alternative systems that can be used for comparison. Thus no opportunities exist to examine the cost-effectiveness of the system. This sensitivity analysis, in effect, is a substitute for the replications of the demonstration projects that do not exist. With unlimited funds we would like to design several alternative systems, each somewhat different in configuration, but accomplishing similar goals. This idealized approach would enable us to determine which of the various configurations were more or less efficient, or which had relatively high capital requirements. However, the nature of demonstration grants is such that each system is usually one of a kind. Therefore, we use the sensitivity analysis to predict the likely effects of the changes that, in reality, we are unable to make.

A second type of sensitivity analysis involves examining the relationship between changes in system costs and changes in the levels of output of the system. This sensitivity analysis is known as marginal cost analysis. Where the analysis mentioned above was primarily concerned with the effects of changes in the level and mix of the inputs, here the concern is focused on the consequences of changes in the volume of the outputs. This analysis requires additional information on the output of the system produced in each of the project phases. A format for organizing output data is presented in Appendix A.

There are three more definitions of costs that must be considered. These are:

- <u>Total Cost</u>: the total amount of money spent on the project.

- Average Cost: the total cost divided by the number of units of output. 2/

- Marginal Cost: the cost to produce an additional unit of output.

Marginal cost analysis is of major importance in evaluating the costs of telecommunications projects. To explain why we concentrate on marginal costs, consider the simplest case -- that of a system with a single output. In this situation there is a unique relationship between changes in the marginal costs with changes in outputs and the existence or non-existence of economies of large-scale operation. Specifically, if the marginal costs are declining, it is less expensive per unit of output to produce at a greater level of output than at a lower level, although the converse is not true. There are "economies of scale" to be realized in operating systems of increasing size.

In the single output case we can also uniquely define average costs or the total costs divided by the level of output. This enables us to define three cases:

- when average costs are declining (and the marginal cost is below the average cost), there are economies of scale (economies of large-scale operation);

2/ This definition applies when the system can be reasonably thought of as generating a single type of output.

- when average costs are increasing (and the marginal cost is above the average cost), there are <u>diseconomies of scale</u> (increasing unit costs with larger scales of operation); and

- when average costs are constant, neither increasing or decreasing (and the marginal cost is equal to the average cost), there are no cost advantages from either larger or smaller scales of operation.

Unfortunately, the analysis becomes more complex when there is more than one output. If the <u>mix</u> of the various outputs were to remain constant, we could continue to use the single output analysis by using multiples of the constant mix in place of the single output. However, keeping the mix constant is unlikely at best. As a result, additional considerations would have to be added in our analysis. Specifically:

- changes in the mix of outputs may change the level of costs (even if the total level of output is held constant);

- because total costs are dependent on the levels of all of the outputs, we can no longer uniquely define the average cost of each output;

- nevertheless, we can still use the concept of marginal cost, but there is no longer any simple relationship between marginal costs and scale economies.

Although the theory acquires a greater degree of complexity as it becomes more realistic, it is often the case that we can abstract somewhat from the full complexity of the situation to keep the analysis manageable while capturing the significant features of the system and its market. For example, the CenTeX demonstration provided special broadcast services to several different handicapped groups. Although the form of output varied (some were audio and some were hard copy via teletype), all of the services could be characterized in terms of total broadcast hours. Thus, average costs could be examined in terms of the total costs divided by total broadcast hours, and marginal costs could be examined in terms of the cost of an additional broadcast hour. Under this assumption, the analysis could proceed and inferences about the behavior of system costs could still be made.

Admittedly, some detail is lost in analyzing the costs of individual services using this simplifying assumption. But the alternative involves a quantum leap in the complexity of conceptualizing the cost measures, generating the necessary data base and performing the analysis. Thus, wherever the single output assumption can reasonably be used, it should be applied.

To conduct this analysis, the output of each project phase is divided into the total cost of each project phase to determine the average cost per unit of output by phase. These several average costs can be examined to determine whether average cost declined as system output increased. When this occurs, marginal costs are declining and economies of scale exist. Where average costs do not decline, the indication is that there are no cost advantages to operating a system larger than the demonstration project, given that system's configuration.

The two types of analyses discussed above focus on the sensitivity of the relationship between costs and inputs or outputs. Using data developed in the analysis of marginal costs, a third analysis may be conducted. In particular, some conclusions may be made about the cost-effectiveness of the system if data on comparable alternative information services are available. Data on the average costs and/or marginal cost of output, for the phase of the demonstration that most closely approximates a fully operational system, can be compared to the commensurate costs of the alternative system. The system exhibiting the least cost per unit of output is the most cost-effective.

In some cases, the demonstration may be designed to examine the costs of alternative technologies. This was true of the TALINET project. Data generated during that project could be used to directly compare the costs of information delivery using two different telefacsimile systems. However, very often data on alternative delivery modes is not available and such direct determinations of cost-effectiveness cannot be made.

2.4 Changing Costs of Technology

One of the goals of demonstration projects is to introduce new technologies in the provision of specific services. To assist in determining the usefulness and desirability of these new technologies, it is important to know how the costs of the project are influenced by the choice of technology. This is made difficult by two factors:

- each project is usually one-of-a-kind and the same services are not provided by alternative technologies; and
- because new technologies are utilized, their costs generally change rapidly over time.

In some cases, the demonstration project is designed to do tasks or provide services that have been accomplished by alternative means in the past. In these situations, we ideally would be interested in knowing the costs of providing the same level of services by each of feasible alternative delivery systems. We would also be interested in any qualitative changes on the providers, on the recipients, and on the services themselves. In the absence of these alternatives, the evaluation design is useless because it relies on non-existent comparisons. We are forced instead to use hypotheticals as comparisons or to develop measures of acceptability and efficiency that are based solely on information obtained from the project and its environment alone. The use of a hypothetical alternative is employed in the CenTeX case study.[3/] In that analysis, the assumed costs of a newsletter were compared to the costs of providing a teletype service for the deaf.

The second problem related to the use of new technologies is of a different nature. It arises because the costs of performing the various tasks or of delivering services are likely to change as the personnel learn to use the system more efficiently and as the technology itself becomes more widely available. These two phenomena are widely documented. The first is characterized by the "learning curve" -- a reduction in the marginal costs as the personnel become more experienced. The second may also be a learning curve phenomenon on the part of the producers of the equipment or represent the effects of economies of scale. Whatever its cause, the analyst and decision-maker should recognize the fact that any cost estimates may only provide information about the recent past, and estimates should be used with care.

The final task in conducting a cost analysis of a

3/ See Appendix B.

telecommunications demonstration is to make some assessment of the potential for growth and transfer of the service demonstrated through the project. This assessment will result from a synthesis of the observations made during the analysis and will rely heavily on cost trends demonstrated in the project. For example, are economies of scale present, or are average costs exceedingly high? It will also require the analyst to consider the cost trends of the technology employed. Do industry trends show production cost reductions? How significant are expected decreases in the cost of purchasing the technology, and how can any such cost reductions be expected to reduce costs of service delivery? More basically, how important are the costs of technology as compared to other inputs for service delivery for a fully operational system? Questions such as these can be used to draw some conclusions from the cost perspective concerning the prospects for adoption and expansion of the system demonstrated.

2.5 Summary

The purpose of a cost analysis of a telecommunications demonstration project is to provide economic information to administrators and project managers who are considering alternative uses of limited resources for providing information services. A method for analyzing the costs of demonstration projects must be versatile enough to be applicable to a wide variety of technologies and service applications. It must also provide information that is useful to agency administrators and project managers at the same time. Such a methodology has been described above, and consists of the following steps:

- Determine the true costs of the project. True costs, in economists' terms, are the opportunity costs of using scarce resources.
- Gather cost data by type of input and project phase. (See Appendix A)
- Gather data on project output by project phase. (See Appendix A)
- Analyze the costs by input and by time to examine characteristics of the system such as requirements for fixed cost and variable costs.
- Analyze the sensitivity of project costs to changes in the configuration of the demonstration and prices of inputs.
- Analyze the sensitivity of the cost of producing system output as utilization of the system increases.
- Where sufficient data are available, compare the average costs of output for the demonstration to alternative means of providing the information service.
- Consider the cost trends in the industry that produces the technology used in the demonstration and assess the potential effect of expected changes in the cost of technology.
- Based on the above analysis, draw conclusions about the prospects for adoption and growth of the system demonstrated.

APPENDIX A

System Cost Analysis Questionnaire

In order to help DHEW evaluate the costs and effectiveness of your project, we are asking for certain cost information in a manner that will be consistent across all DHEW-funded demonstration projects. We are aware that in many cases costs may be difficult to calculate or allocate, so we are only asking that costs be broken down into six categories and as few as two time periods.

If, because of the special features of your system, you believe that we should have costs broken down more finely or in a different way, please try to use our categories and attach a note specifying the alternative categories you would like us to use.

We have divided the contract period into four phases: (1) start up and installation (vs. delivery of services); (2) trial operations (pilot test of service delivery); (3) demonstration (full operation of systems to majority of intended users); (4) institutionalization (successful ongoing delivery of services and partial self-sufficiency). Please give careful consideration to breaking down the costs and try to allocate the costs appropriate to each phase.

System Cost Analysis Questionnaire

We are also asking for measures of the volume of usage of your system. For example, give us the number of messages, segments, or programs during the same time periods used for the breakdown of costs. (Do not worry if there was no usage or output during the installation phase.) We have allowed room for more than one measure of usage if this is appropriate. If you can tell us both the number of programs (or messages) and the total time, please do so.

Please fill the form out to the best of your ability and return it to us by May 11, 1979. Feel free to let us know if you have any questions or suggestions for improving the quality of the information.

System name: ______________________________

Preliminary information:

1. Date of contract award: ______________________
2. Date system first operated: ______________________
3. Below are costs through (date): ______________________

COST SUMMARY

Cost Categories \ Time Periods	Installation and start-up from ____ to ____	Trial operation from ____ to ____	Demon-stration from ____ to ____	Institution-alization from ____ to ____
1. Equipment (purchased or leased)				
2. Communications and computer services (purchased or leased)				
3. Space				
4. Labor (administrative, operating)				
5. Programming/ software				
6. Miscellaneous				
TOTAL COSTS				

COST DETAIL

1. Please give details on major equipment items and costs:

2. Please give details on communications and computer services expenses:

3. Please give details on programming and software expenses:

4. Please give details on other space required and used but not paid for:

5. Please give details on labor required and used but not paid for (man hours):

6. Please divide labor into administrative and operations:

USAGE

ea- ures of perating Volume / Time Periods	Installation and start-up	Trial operation	Demon- stration	Institution- alization
Measure #1 (specify)				
Measure #2 (specify)				
Measure #3 (specify)				

Form filled out by ______________________________ (your name)

See the attached sheet for specific instructions. When completed, please return to:

John H. Clippinger
Kalba Bowen Associates
12 Arrow St.
Cambridge, MA 02138

APPENDIX B

Cost Analysis Methodology

Selected Case Studies

1.0 COST ANALYSIS METHODOLOGY - SELECTED CASE STUDIES

The eight telecommunications demonstration projects included in Kalba Bowen's analyses were each asked to provide the study team with cost and output information.[1/] Six projects responded, including:

- CenTeX - Special Communications Services,
- University of Denver, Graduate School of Librarianship - TALINET,
- Deaf Community Center - Computer-Assisted, Telecommunications for the Deaf,
- Western Alabama Emergency Medical Service,
- Pennsylvania State University - Continuing Education Cable Television Network, and
- Wernersville State Hospital - Interactive Cable Television.

Of these projects, only the first three listed above had progressed far enough in their first year to generate sufficient cost and output data for a cost analysis. A separate case study, following the basic methods discussed above, is presented below for each project. Different

---

1/ Data provided by the projects in the format shown in Appendix A (System Cost Analysis Questionnaire) were the basis for each of the analyses. However, as each demonstration was studied, additional questions were asked to members of each project staff and additional data were obtained. For example, questions were posed to staff members to obtain more information in determining the true cost of the demonstration. The use of additional information is identified in each case study where it is employed.

components of the method, however, receive varying emphasis depending on the unique characteristics of the demonstration.

The latter three projects, which are treated in a single review, could not provide enough information to conduct a full cost analysis. Nevertheless, examining some basic characteristics of these projects yields useful observations about important factors to consider in designing demonstrations and selecting projects for funding.

In reviewing these case studies, it is important to note that they reflect project developments through October, 1979, only. While events since that time may have altered an individual project's status, we believe that these case studies continue to reflect an accurate application of the cost analysis methodology proposed in the body of this report.

1.1 CENTER FOR EXCELLENCE, INC.- Special Communications Services Project

The Center for Excellence, Inc. (CenTeX) is a non-profit service organization that specializes in the use of communications technologies for increasing teaching effectiveness and for distribution of educational services. The CenTeX Special Communications Services Project (SCS) has as its primary objective the delivery of information services using the subcarrier band of FM radio stations to three special populations: the visually impaired, the hearing impaired, and the deaf-blind. In particular, special audio receivers are being used to provide service to the visually impaired; teletype machines are providing hardcopy to the hearing impaired; and braille teletype machines are to be used for the deaf-blind. The project has been successful in developing and providing services for the first two populations, but not for the last -- braille teletype services for the deaf-blind. CenTeX experienced difficulties in obtaining equipment, and did not find a sufficient number of deaf-blind clients in the demonstration area.

Project Costs: The costs for the first full year of the CenTeX project were provided by the project staff. These are shown in Exhibit 1. The costs cover the installation and start-up, trial operation, and demonstration phases. The project has not yet matured to the institutionalization phase.

The CenTeX project spent five months in the start-up phase, approximately 2.5 months in the trial operation phase, and approximately 4.5 months in the demonstration

Exhibit 1

CenTeX - SCS Project

COST SUMMARY

Cost Categories / Time Periods	Installation and start-up from 1/15/78 to 6/15/78	Trial operation from 6/16/78 to 8/31/78	Demon-stration from 9/1/78 to 1/15/79	Institution-alization from ____ to ____	Total
1. Equipment (purchased or leased)	$22,100				$22,100
2. Communications and computer services (purchased or leased)	$ 1,300	225	500		2,025
3. Space	-0-	-0-	-0-		-0-
4. Labor (administrative, operating)	$ 4,500	3,900	9,100		17,500
5. Programming/ software	-0-	125	250		375
6. Miscellaneous	$ 6,750	4,500	7,200		18,450
TOTAL COSTS	$34,650	8,750	17,050		60,450

B4

phase. The start-up phase was the most costly both in total dollars and in average dollars spent per month. In total, the start-up phase cost $34,650, or 57 percent of the first year expenditures. The trial operation and demonstration phases accounted for 15 and 28 percent of total expenditures, respectively. Taking into account differences in the length of each phase, the start-up phase was still the most costly on an average cost per month basis. Average costs per month for the start-up phase were approximately $6,900. In contrast, average monthly costs for the other two phases combined were basically the same as the start-up phase. Monthly costs for the trial operation phase were $3,500; for the demonstration phase they were approximately $3,800.

The basic reason for this time distribution of costs can be seen by examining expenditures in the various cost categories. In particular, equipment costs were incurred entirely in the start-up phase. As seen in Exhibit 1, equipment costs totalled $22,100, or over 60 percent of the start-up costs and over 35 percent of the total costs for the project's first year. This is a significant characteristic of a broadcast system. The studio facilities and broadcasting equipment must be fully installed before any services can begin. Thus, virtually all projects of this type will incur relatively high fixed costs early in the project. However, considering fixed costs in the absolute, the cost of setting up an FM subcarrier system that can provide information and entertainment services to a potentially large population in a region is rather small, less than $25,000, according to the CenTeX project data.

In examining labor costs, a major component of variable costs, it can be seen that average monthly labor costs increased over time. In the start-up phase, labor costs averaged $900 per month. In the trial operation phase, the cost of labor rose to $1,500, and in the demonstration phase, labor costs were approximately $2,000 per month. These variable cost increases are, according to SCS project staff, attributable to the increase in programming production in each phase. Total broadcast hours increased from 10.5 hours per week in the start-up and trial operation phases to 40 hours per week in the demonstration phase. This increase in service required larger inputs of paid labor.

<u>Additional Costs</u>: The costs incurred during the first year do not completely reflect the true costs associated with the SCS project. An important characteristic of this project, as with many public service projects, is that its success is heavily dependent on volunteers. According to data provided by CenTeX, the SCS project used 46 people who volunteered 1[illegible]96 hours of labor during the first year. Additionally,

the program manager contributed an estimated 650 hours of time over and above those for which she was paid, and approximately 10 percent of the Chief Operations Officer's time was spent on the project without direct charges for his time. In total then, 2054 hours of labor were "donated" during the first year of the project. The estimated value of that labor is $11,900. (See Exhibit 2) 2/

The SCS project also incurred no space costs for its first year, although a studio/office using 250 square feet was established for the project. The estimated cost of this space, if CenTex had had to pay for it, is $2,750.

If the project paid for these resources, the profile of project costs would be considerably different. Total project costs would have increased 24 percent. Labor inputs would increase by 68 percent, making them the most costly item.

2/ This total includes an estimated value of $4,784 for volunteer labor. Some argue that in using volunteers (or unemployed persons), there are no opportunities foregone by society for that labor resource; therefore, their opportunity (true) cost is zero. However, such projects may not be able to rely on such a large corps of volunteers. The dollar estimate is presented here to reflect the costs that would be incurred in that case.

Exhibit 2

PROJECT SGS

Additional Labor and Space Costs

Input	Volume of Input	Estimated Value
LABOR:		
Program and Volunteer Manager	650 hours	$3,640 a/
Chief Operations Officer	208 hours	$3,494 b/
Volunteers	1,196 hours	$4,784 c/
SPACE:		
Studio/Office	250 sq. ft.	$2,750 d/
TOTAL:		$14,668

a/ Estimate based on $5.60 per hour.

b/ Estimate based on $16.80 per hour.

c/ Estimate based on cost of $11 per square foot per year.

d/ Estimate based on $4.00 per hour.

Cost and Output: Combining the cost information with data on the output of the system, the effect of changes in the level of operation can be illustrated. In this simplified approach, we shall assume that the various types of broadcast services have the same unit costs and that all costs were related to the production of the broadcast hours.

As shown in Exhibit 3, the average costs incurred per hour of broadcasting time in the start-up period are very high. This is because of the low level of output and the inclusion of all equipment costs in this phase. Average costs dropped dramatically in the trial operation phase as output increased more than ten-fold and expenditures included no fixed costs. As the project moved to the demonstration phase, the number of broadcast hours took another quantum leap. Again, only variable costs were incurred and average costs continued to decline to $22/hour. If the present configuration and broadcast schedule (40 hours/week) remained constant over the next year, average costs incurred per broadcast hour would decline only slightly if at all.

The column on the far right in Exhibit 3 presents the estimated average true costs for the output in each phase.

B10

Exhibit 3

Project SCS Output and Total and Average Cost by Phase

Phase	Output Broadcast Hours	Total Incurred Costs	Incurred Average Cost	Estimated True Cost Total	Estimated Average True Cost
Start-up	21	34,650	$1,650	37,619	1,791
Trial Operation	237	8,750	$ 37	12,097	51
Demonstration	760	[illegible]	$ 22	25,403	33

When the hidden labor and space costs are taken into account, the effect is quite noticeable. Estimated true average costs in the demonstration phase, the phase most closely approximating costs for full scale operation, are 50 percent higher than the costs actually incurred by the project. The declining average costs, either for estimated true costs or for costs actually incurred, indicate the presence of scale economies resulting from increased broadcast hours.

Technological Considerations: In examining the services CenTeX is providing through Project SCS, two basic issues arise concerning the choice of technology: (1) Are there substitute means of providing similar services that are more cost effective? and (2) Are project costs sensitive to changes in the configuration of the system CenTeX has developed?

The project offers audio and teletype information services including local and national news, sports, books, interview programs, and religious programs. The largest portion of the services are provided in the audio mode (37.5 hours per week for audio broadcast compared to 2.5 hours per week for teletype services).

At first glance, it might appear that the variety of regular radio broadcasts would satisfy the needs of the print-handicapped. But according to SCS project staff, the information provided is significantly different from that broadcast by regularly licensed radio stations in the area. For example, the broadcasts announce meetings and events important to the handicapped community. The news is a major component of the SCS broadcast. Local stations provide only 15 minute summaries while SCS provid as much as two hours of news. Thus, in the project area, appears to provide alternative information services not already available to the print-handicapped. This may be characteristic of smaller communities. In larger metropolitan areas, however, there are all-news radio stations, hour of religious programming and interview shows. In these areas, existing programming may directly substitute for aud services such as those provided by the SCS project. Also, National Public Radio provides a significant amount of programming for the blind, although this service is not curren available in the project area.

It is instructive to compare the costs of a newsletter a more conventional means of disseminating printed materia with SCS costs of teletype service. A weekly newsletter is not a direct substitute for the current SCS bro because SCS services are daily, providing curren announcements important to the deaf community. Nevertheless, examining the simplified cost comparison provided below provides insight into the relative costs of these two alternatives for information dissemination.

As mentioned above, teletype broadcasts are currently limited to 2.5 hours per week, or about 30 minutes per day. According to SCS project staff, it takes approximately four to five hours to prepare the programming for each day's broadcast. Much of the preparation time involves rewriting material using vocabulary that is more easily understood by deaf persons. Similar preparation time would also be required in developing equivalent information for a newsletter. The important factor, then, is the relative costs of disseminating information; that is, how do the costs of broadcasting the information (including the teletype service share of the fixed and operating costs for the broadcasting facilities and the costs associated with the receiving equipment) compare to the costs of having the same material printed and delivered by mail?

Exhibit 4 shows the relative costs of printing and distributing a weekly newsletter and SCS teletype broadcast services that provide the same information. In determining these costs, the following assumptions have been made:

Exhibit 4

Comparison of Information Dissemination Costs for a Newsletter and SCS Teletype Services

Number of Recipients	Annual Cost for Newsletter	Cost for SCS Service	Years for Newsletter Costs to Equal SCS Cost
1	$ 124	3,906	31.5
5	$ 338	4,170	12.4
10	$ 606	4,500	7.4
50	$ 2,751	7,140	2.6
100	$ 3,350	10,440	3.1
200	$ 6,534	17,040	2.6
300	$ 9,914	23,640	2.4
400	$ 13,194	30,240	2.3
500	$ 16,476	36,840	2.1
1000	$ 22,482	63,240	2.8
2500	$ 57,000	152,340	2.7
5000	$112,130	300,840	2.7

- The weekly newsletter containing the same information as current SCS teletype services would be 20 typewritten pages in length; it would be distributed using non-profit organization bulk mail rates; and printing costs would decline as the volume of weekly copies increases according to the following schedule:

less than 100 copies	5¢/page
101 to 500 copies	3¢/page
more than 500 copies	2¢/page

- For the teletype services, the share of fixed and operating costs is determined by prorating total SCS costs (exclusive of labor costs since they are assumed to be the same for the newsletter and teletype services) in the proportion of teletype broadcast hours to total broadcast hours. This amounts to approximately $3,840 over two years. The cost associated with the teletype reception is $66 per terminal. A reduction in cost of 5 percent and 10 percent is assumed for systems operating with 500 and 1000 receivers, respectively.

As shown in the table, the cost of the SCS service always exceeds the cost of the newsletter, regardless of the size of the market for the information. However, it is very important to note that the costs of printing and disseminating the newsletter are virtually all recurring costs while the costs for dissemination by teletype are virtually all fixed costs. Thus, after a certain period of time, the cumulative costs for the newsletters will equal and then exceed the costs of SCS teletype service. The column on the far right in Exhibit 4 shows the number of years of operation it would take for the costs of the newsletter to equal the costs of the teletype service under the assumptions listed above.

As the number of recipients increases from one to 50, the period required to reach a break even point drops very quickly. However, for a system of 100 recipients, the years it would take to break even increase. This is a direct result of assumed economies in printing costs at this level of production. As the number of recipients increases further to 500, the years to the break even mark decline once again, but the rate of decline is much slower. Then, for a system of 1000 recipients, the number of years (until the newsletter costs will equal SCS costs) increases again due to further economies in printing costs, despite an assumed 10 percent reduction in the costs for SCS receivers. Finally, systems operating at a much larger scale, 2,500 to 5,000 recipients, show no discernable reduction in the time it would take for the cumulative newsletter costs to equal the cost of disseminating the information by teletype. It can be further observed that a system of 500 recipients of information appears, under these assumptions, to be the level of operation at which the costs of the newsletter will exceed the costs of teletype service in the shortest period of time, an estimated 2.1 years.

From this example, the SCS teletype service seems to be reasonably cost competitive with a frequently used alternative means of information dissemination, the newsletter. For a system of modest size, such as 200 information recipients, the costs of SCS services would be comparable to those of a newsletter in just over two and one-half years (assuming cost sharing with other SCS services for costs of setting up and managing the studio). However, a significantly larger system offers no improvement in the relative costs of these alternative distribution methods.

The second major issue related to technology is the sensitivity of project costs to changes in the configuration of the system that CenTeX has developed. There may be some room for cost reductions through possible modifications or substitutions of the particular system components CenTeX has selected for its present system, but these would provide only minimal reductions. The technology being used is relatively mature and major innovations in broadcasting techniques are not expected to provide any cost reductions in the near future.

While technology costs do not appear to be easily reducible, the cost/output ratio may be reduced if SCS is successful in its second year objectives. CenTeX intends to expand its broadcasting radius by networking with an additional FM station. This will greatly increase the potential audience served at only the cost of redistribution of the programming (approximately $5,000 for additional leases according to SCS project staff).

Equally important, CenTeX intends to utilize multiplexing technology which would allow all three modes of information (audio, teletype and braille teletype) to be disseminated simultaneously. Currently, only one mode can be broadcast at a time, limiting the total hours of service provided to any one population. Successful multiplexing will increase the system's technical capacity for information dissemination, but it may also increase the total costs for preparation of programming because more programming will be required.

<u>Potential for Economies of Scale</u>: The section on "Cost and Output" briefly described the relationship between the volume of broadcast hours and project costs. It is important to remember that as broadcast hours increase from the trial operation phase to the demonstration phase, the average cost per broadcast hour declines both in terms of costs incurred and estimated true costs. At the end of the demonstration phase, SCS was broadcasting 40 hours per week. Except for increases resulting from expected multiplexing of programming, it is not likely that the system will increase its volume of broadcast time. Thus, any further reductions in average costs of broadcasting hours will come from productivity improvements, and not from increases in the scale of broadcast operations.

Economies of scale may also be examined from the perspective of demand for the services offered by CenTeX. More specifically, what is the significance of scale economies as the size of the audience increases?

In its first year, the SCS project served a population of only 80 persons, as the staff concentrated on establishing the programming and broadcast services. The cost of receivers related to the project thus far is less than $6,000, a small portion of the project costs.

It is important to consider the importance of the cost of receivers as the scale of the system increases. At their current price, the cost of receivers will equal the cost of a year of operations for SCS if the scale of the system increases to an audience of 1000. Above that level, receiver costs will dominate project costs. If information services such as those provided by SCS are to reach a large number of persons, then the potential for price reductions in the receiver costs becomes an important issue.

The actual reduction in receiver costs with increasing scale is unknown. However, according to SCS project staff, the manufacturer of the receiver has suggested that price reductions can be realized beginning with orders of 500 receivers. At this scale, the price should decrease approximately 5 percent. Orders of 1000 to 2500 should yield a 10 percent reduction in cost.

The question of scale economies may be secondary to market barriers which currently are prohibiting the penetration of SCS programming to any great extent. For scale economies to be realized, the manufacturer has to be assured of the market demand. Either SCS has to place a bulk order for receivers or normal market signals must be generated to induce production by the manufacturer. Because of copyright laws, the receivers must be owned by CenTeX to ensure that the handicapped are the sole recipients of the information taken from newspapers and magazines. Thus, the receivers cannot be sold on the open market, and no normal market signals can be generated so that the manufacturer can determine the demand. CenTeX must provide the manufacturer with a large order for any cost reductions to be realized which will require an extremely well organized and intensive marketing effort. This obstacle will act as a deterrent to the expansion of the SCS audience and to the reduction in the price of receivers. It is likely that receivers will continue to be specially built upon receipt of individual orders.

1.2 TALINET
University of Denver
Graduate School of Librarianship

TALINET is a consortium of libraries using telecommunications for educational and information services. The demonstration focuses on comparing the utility of slow-scan TV and two types of telefacsimile equipment (Qwip and Rapifax) for improved information resource sharing among libraries in different locations. Five remote libraries (Durango, CO; Casper, WY; Dodge City, KS; Billings, MT; and Rapid City, SD) are linked with the University of Denver Library School, the National Oceanic and Atmospheric Administration (NOAA), and twelve members of the Federal Library Network Prototype Project (FLNPP). Principal activities of TALINET have been the sharing of library resources and the provision of information services. Community analysis, training, and evaluation programs are also part of the demonstration program.

Project Costs: The costs of TALINET for its first 14 months of operation were supplied to us by the Project Director. These costs cover the first three phases and are summarized in Exhibit 5. The project had not yet developed to the institutionalization stage.

Exhibit 5

TALINET COST SUMMARY

Cost Categories / Time Periods	Installation and start-up from 1/15/78 to 9/11/78	Trial Operation from 9/11/78 to 12/20/78	Demonstration from 12/20/78 to 3/15/79	Institution-alization from 3/15/79 to 9/15/79	Total
1. Equipment (purchased or leased)	$10,080.00	$24,120.00	$ 9,900.00	---	$ 44,820
2. Communications and computer services (purchased or leased)	1,852.00	2,027.00	1,771.00	---	5,650
3. Space provided through overhead 800x $5.00 = $4,000	2,664.00	1,332.00	1,332.00	---	5,328
4. Labor (administrative, operating)	25,225.00	11,904.00	11,796.00	---	48,925
5. Programming/software	2,470.00	5,120.00	2,138.00	---	9,728
6. Miscellaneous - Travel	4,275.00	8,271.00	1,445.00	---	
- NOAA	5,000.00	15,000.00	6,000.00	---	
- Tuition	4,018.00	5,563.00	6,091.00	---	
- Other	6,303.00	7,008.00	2,540.00	---	71,514
TOTAL COSTS	$61,777.00	$80,345.00	$43,013.00	---	$185,135

As Exhibit 5 shows, the costs for the project vary considerably in each phase. Costs for the nine-month installation and start-up phase were $61,777, or 34 percent of the total costs. Despite the fact that the trial operation phase was only three months long, the costs of that phase were 43 percent of the total, or $80,345. The costs for the demonstration phase, which was also three months long, dropped to $43,013, or 23 percent of total cost.

Fixed costs were approximately 32 percent of the project costs, with variable costs accounting for the remaining 68 percent. Equipment accounted for 24 percent of the total costs, and labor costs amounted to 26 percent of the total. Interestingly, miscellaneous costs were the highest of any cost category, nearly 40 percent of all costs.

A closer look at costs by project phase and cost category provides some explanation of these expenditure patterns. First, the relatively high total outlays in the trial operation phase are due largely to expenses associated with the lease of slow-scan video equipment. The slow-scan equipment was removed for much of the demonstration phase, and the equipment costs dropped dramatically. It is also interesting to note that equipment costs were not incurred entirely in the installation phase. Fixed costs for projects such as this are not necessarily incurred early in the project.

It is also important to note that labor costs remained relatively constant in the trial operation and demonstration phases, despite a 50 percent drop in output between the two phases (outputs are discussed in more detail below). The implication is that labor costs are not sensitive to decreases in demand. Particularly in TALINET's institutional context (i.e., university and government), it is difficult to adjust labor inputs downward to meet declining demand for services. This says nothing, however, about the relationship between labor requirements and output as demand increases.

Finally, the large share that miscellaneous costs account for is an important characteristic of TALINET as a demonstration. A large portion of these costs would not occur in an institutionalized system. In particular, expenses for travel are attributable to training, interviewing, and evaluation activities conducted as part of the demonstration. Second, miscellaneous costs associated with NOAA were incurred as part of an agreement between TALINET and NOAA. TALINET agreed to assist in paying for equipment costs for the FLNPP in exchange for training, library resources, and a telecommunications technician. Third, tuition payments were incurred as part of the educational component of the demonstration. Thus, in an institutionalized system, miscellaneous costs would likely be only those shown as "Other" in Exhibit 5.

Additional Costs: Demonstration projects often are fortunate in that they attract devotees who provide individual and institutional support. During the 14 month period from installation and start-up through the demonstration period, TALINET received services in the form of supporting labor and training from NOAA and the five remote libraries. Similarly, NOAA, the remote libraries, and the Library School each provided space to the TALINET system. These contributions of labor and space are itemized in Exhibit 6.

Some of these apparently "donated" resources were paid for, indirectly, through the agreement with NOAA mentioned in the previous section. Payments to NOAA by TALINET totalled $26,000. The estimated value of the labor and space provided by NOAA is only $13,220. In addition to this, however, is the value obtained by the TALINET system in being able to work at the NOAA library and use NOAA resources to fill information requests from the remote libraries. These resources are assumed to have a "rental" value equivalent to the difference between the payments made to NOAA by TALINET and the estimated value of the labor and space provided by NOAA. This amounts to $12,780.

Exhibit 6

TALINET

Additional Labor and Space Costs

Input	Volume of Input	Estimated Value
Labor[1]	Hours	Dollars
NOAA-GRA Staff Training	320	1,920
NOAA Machine Operator	1440	8,300
Five Site Libraries	7200	27,692
Total	8960	37,912
Space[2]	Sq. Ft.	Dollars
NOAA	400	3,000
Five Site Libraries	500	1,000
Library School	200	1,000
Total	1100	5,000

[1]Estimates of value calculated from wage and salary data provided by the project director:

NOAA-GRA Staff Training	$6.00/hr. or $12,480 per year	
NOAA Machine Operator	$5.77/hr. or $12,000 per year	
Five Site Libraries	$3.85/hr. or $ 8,000 per year	

[2]Estimates of value calculated from rental rates provided by project director:

NOAA	$7.50 per sq. ft. per year
Five Site Libraries	$2.00 per sq. ft. per year
Library School	$5.00 per sq. ft. per year

Additional labor and space used, but not paid for, has an estimated value of $29,692. When these additional costs are considered, basic cost characteristics of the TALINET system change somewhat. True labor costs are 57 percent higher than those actually incurred and space costs are 38 percent higher. This has the effect of slightly decreasing the ratio of total fixed costs to variable costs; however, the proportion of labor requirements to requirements for equipment, changes drastically. Where inputs of labor and equipment were approximately equal for costs actually incurred during the demonstration (when the true costs for the demonstration are considered) the cost of labor is nearly twice that of equipment. Furthermore, when the costs of the final configuration of the communications system are considered (see section on "Technological Considerations"), the labor inputs exceed equipment requirements even more.

<u>Cost and Output</u>: The cost of information can be combined with the data on outputs in an effort to determine how the levels of total costs and average costs respond to changes in the level of operations. In doing so, it is assumed that all costs were directly related to the transaction fulfillment part of the project. In addition, the two types of transactions, information and administrative, are aggregated to develop a single measure of system output.

The output levels and total and average costs for both incurred and estimated "true" costs are shown in Exhibit 7.

It would appear from these data that the average cost per transaction increased slightly from the total operation phase to the demonstration phase. This occurred even though the level of system output fell from 794 transactions to 384.

For this particular demonstration, examining average costs using the format we have chosen can yield some misleading results. It cannot be concluded that as TALINET approaches a fully operational phase, the average cost per transaction will remain high. As mentioned above, the first year of the project included testing three systems. Thus, the average costs, as shown in Exhibit 7, reflect the costs of these three systems. An operational system would use only one technology.

<u>Technological Considerations:</u> In some ways, the costs of the TALINET system are dependent on the choices made about the specific technologies to be used. These choices are the driving forces behind the equipment and communications costs during the three periods. These costs are itemized in Exhibit 8.

Exhibit 7

TALINET

Output and Total and Average Cost by Phase

OUTPUT

PHASE	Information Transactions	Administrative Transactions	Total Transactions
Trial Operation	674	120	794
Demonstration	284	100	100

PHASE	INCURRED COSTS		ESTIMATED "TRUE" COSTS	
	Total	Average	Total	Average
Trial Operation	$80,345	$101	$90,241	$114
Demonstration	$43,013	$112	$52,909	$138

Exhibit 8

TALINET

Equipment and Communications Cost Detail

Equipment	Cost
QWIP telefex ($40/month x 6 sites x 8 months)	$ 1,920
RAPIFAX telefax ($300/month x 6 sites x 7 months)	$12,600
Slow Scan TV ($960/month x 6 sites x 5 months)	$28,800
Total	$43,320

Communications	Cost
Telephone Service and Long Distance	$ 5,650
GRAND TOTAL	$48,970

It is obvious from the table that the choices made regarding the specific technology to be used and the metho of communications play an important role in the determination of the costs. For example, the slow-scan TV system represents 66 percent of the equipment costs. During the course of the trial operation phase, the project staff determined that the slow-scan equipment provided no advantages over the facsimile equipment, or at least none that would justify the cost. As a result, the slow-scan equipment was eliminated from the TALINET system.

Had slow-scan TV not been part of the experimentation of this project, equipment costs would have amounted to only $14,520. This clearly shows the effect substitution of technology has on costs. In an operational system, the cost would be even further reduced, because only one telefacsimile system would be used. Thus, the aggregate technology costs incurred during this demonstration project do not provide an accurate indication of the costs likely to be incurred by an operational system.

An important aspect of the TALINET demonstration is the examination of alternative telecommunications technologies for library resource sharing. Using supplementary data and analyses provided by the TALINET project staff, a cost comparison of the two telefacsimile systems used, Qwip and Rapifax, is presented below.

The two facsimile systems provide five different modes for transmitting information. These modes and the unit costs incurred for document delivery (including only the technology costs) are presented in Exhibit 9. These costs are based on average document length and the average monthly volume of transactions TALINET experienced during its first year of operation. Documents averaged six pages each, and an average of 137 transactions were completed each month.

As can be seen from Exhibit 9, at this volume of transactions the Rapifax system operating in the high speed mode is the least expensive. The reason Rapifax performs more efficiently than Qwip is that the variable costs of telephone lines are much lower for Rapifax, given that TALINET must use long distance lines. For Qwip in the six-minute mode, the cost per six-page document for the telephone line is $20.97 as compared to $2.47 for Rapifax (High Speed) transmission to the same location. However, the use of leased lines, given sufficient demand for the service, would make the cost of communications a fixed cost.

Exhibit 9

TALINET

Unit Costs for Telefacsimile Document Delivery*

Telefacsimile System	-- Mode	Cost/Transactions
Qwip	4-minute mode	$17.81
Qwip	6-minute mode	$22.72
Rapifax	(High Speed)	$14.73
Rapifax	(Standard Speed)	$16.25
Rapifax	(Fine Detail)	$17.77

* Based on an average of 137 transactions per month, and 6 pages per transaction.

The TALINET staff also provided their estimates of the break even volume and unit costs per transactions for the Qwip 1200 versus the Rapifax 100 equipment. These are presented in Exhibit 10. Once again, these estimates include only the costs of technology utilization. Below the break even volume, shown in Exhibit 10, Qwip will be less expensive, and above the break even volume, Rapifax will be less expensive. At the unit cost shown in the Exhibit, the systems are comparable from a cost standpoint.

As these data show, the TALINET project found Rapifax facsimile to be the most effective of the three technologies used in the demonstration. But there remains the question of how cost competitive telecommunications systems are with alternative document delivery methods. In particular, is the Express Mail Service of the U.S. Post Office (24-hour delivery) competitive with Rapifax? Once again, data were provided by TALINET.

The highest Express Mail rate to any of the sites for a six-page document is $7.55. Note that this is approximately one-half of the $14.77 per transaction that TALINET experienced on the average during the course of the project. Exhibit 11 shows the number of transactions required per month for Rapifax to compete on a cost basis with Express Mail Service. It is apparent from the Exhibit that the average

Exhibit 10

TALINET

Monthly Breakeven Volume and Estimated Unit Costs
Per 6-Page Transaction for
QWIP 1200 and RAPIFAX 100 Telefacsimile Systems

	Rapifax Hi Speed		Rapifax Standard		Rapifax Fine Detail	
	Transactions	Unit Cost	Transactions	Unit Cost	Transactions	Unit Cost
QWIP 4-minute mode	106	$18.32	120	$17.99	137	$17.77
QWIP 6-minute mode	78	$24.01	85	$23.75	94	$23.38

monthly volume of transactions made by TALINET (137 per month) does not yet make it cost competitive with Express Mail Service where it exists (no service exists to Durango and Dodge City.) At $7.55 per transaction there would have to be 207 transactions per month for telefacsimile to be cost competitive. Moreover, since Express Mail offers 24-hour delivery directly to the client, instead of the library, as in the case of TALINET, the time-saving advantages of telefacsimile for this type of document delivery are also limited.

Exhibit 11

TALINET

Monthly Breakeven Volume Per Six-Page Transaction - Rapifax vs. Express Mail

	Rapifax High Speed	Rapifax Standard	Rapifax Fine Detail
Express Mail	207	270	340

A final point to be made concerns how the cost of technology can be expected to grow with increased utilization. From a technological standpoint the system is not being fully utilized at the present volume of transactions; a much greater volume can be transmitted for the same fixed cost of equipment. Although this is not necessarily true for communications costs, we need not conclude that telephone costs will grow proportionately with the number of transactions. Increased usage may make it more economic to use leased lines, WATS, or similar services. Also, documents are currently being transmitted during the daytime when long distance telephone rates are highest. Use of off-peak hours, made possible by machine-to-machine capability, can also yield reduced costs. This delivery mode might also eliminate the need for a separate telephone for telefacsimile, assuming usage is not sufficient to justify leased lines.

Potential for Economies of Scale: As discussed above, there are cost advantages for increasing the utilization of the technology. The marginal technology cost (for telefacsimile) of each additional transaction beyond the initial one is the cost of the telephone line where lease lines are not used. This is true up to the point where the machine is being used 100 percent of the time. When the volume of transactions is sufficient to justify leased lines, all technology costs are fixed, and the marginal technology cost is zero. Thus, average costs are declining as the fixed cost is distributed among the transactions, and, in either case, cost advantages accrue by increasing the scale of output.

In contrast, the potential for declining average labor costs, as the number of transactions increases, is quite limited. The type of information services offered by the TALINET system are very labor intensive. Total processing time for requests averaged 14 to 16 days, with delivery time to the remote library accounting for less than one day. TALINET offers three kinds of research services: literature searches, responses to reference questions, and interlibrary loans. Although the cost of labor varies for each kind of service, each information request must be researched by at least one member of the research staff. There are no short cuts and few opportunities to substitute technology for labor in completing the research tasks.

As research staff members become more skilled at filling information requests, the project director has observed a modest reduction in the amount of time needed per request. Moreover, these increases in productivity are reached rather quickly as research staff become familiar with the types of requests that are made. At the same time, the project director has observed that users of TALINET have also grown more sophisticated in the types of questions they ask. Thus, the marginal labor costs of completing information transactions are likely to remain relatively constant.

Although we do not have enough information to know precisely the relationship between costs and service levels, we can expect that average total cost per transaction (as opposed average cost for equipment or labor only) will decline slowly, owing to the economies that can be reached through increased use of telecommunications. However, since labor costs will dominate as system utilization increases, the potential for achieving significant economies of scale is expected to be limited.

1.3 DEAF COMMUNITY CENTER
Computer-Assisted Telecommunications for the Deaf

The Deaf Community Center (DCC) of the Roman Catholic Archdiocese of Boston is demonstrating the usefulness of an electronic message system for the deaf. The system allows deaf and hearing participants to store, forward and retrieve messages and to access special information services through a computer. Currently, deaf persons must rely on the teletype as a substitute for the telephone. To use the telephone, both parties must simultaneously be connected. The computer-assisted telecommunications of an electronic message service can provide this "synchronous" communication, but it also offers a number of other advantages

- All messages can be centrally stored so that the person receiving the message does not have to be on the network when the message is sent, i.e., communication can be "asychronous".
- A message can be sent to one or any number of persons on the network simultaneously.

- Any individual can access a variety of information services at any time, such as on-line news, weather, sports, special announcements for the deaf community, or programs on health, consumer affairs, etc.

- Given the impending ubiquity of remote computer terminals, computer-assisted telecommunication offers the potential for greatly increased interaction with the leasing community. (Teletype communication occurs almost exclusively among deaf persons and has an isolating effect.)

Thus, electronic message services are much more versatile than the teletype and are particularly useful for members of the deaf community who cannot use the telephone.

In its first year, the DCC focused primarily on the question of whether deaf persons would actually use computer terminals to communicate, using computer terminals being somewhat more complicated than using a teletype. DCC has successfully implemented a demonstration network that includes 34 families, five public providers of information, four agencies serving the deaf, five schools for the deaf, and two deaf clubs. Users have been trained on the system, and they now use it regularly to obtain and exchange information.

Project Costs: The first year costs for the DCC project, as provided by the project staff, are presented in Exhibit 12. The costs shown cover the installation and start-up, trial operation, and demonstration phases. The project was not institutionalized in its first year.

As can be seen from the Exhibit, the three-month installation and start-up phase was the most costly, totalling $72,900, or 53 percent, of the first year costs. Although the trial operation phase was also three months long, its costs totalled only $23,336 or 17 percent of the total. Finally, the demonstration phase, which lasted the remaining six months of the first year, required expenditures amounting to $42,059, or 30 percent of the total costs.

When differences in the lengths of the project phases are taken into account, a distinct downward trend in costs becomes visible. Average monthly costs in the installation phase were $24,300. Costs declined considerably in the trial operation phase to $7,780 per month. Monthly costs continued to decline through the demonstration phase. In that phase, costs per month averaged $7,010.

Costs may also be viewed by type of expenditure. As Exhibit 12 shows, equipment was the most costly item in the project's first year, accounting for $50,223, or 36 percent of the total. The second most costly category was communications and computer services, which amounted to $37,422, or 27 percent of total costs. Labor charged to the project accounted for 23 percent of the costs, or $31,474. It should be noted, however, that labor costs for operating and maintaining the computer system are included

Exhibit 12

Cost Summary
Deaf Community Center
Computer Aided Telecommunications for the Deaf

Cost Categories / Time Periods	Installation and start-up (3 months)	Trial Operation (3 months)	Demonstration (6 months)	Institutionalization	Total
1. Equipment	50,223			---	50,223
2. Communications and computer service	9,434	10,296	17,692	---	37,422
3. Space	900	900	1,800	---	3,600
4. Labor	7,202	7,906	16,366	---	31,474
5. Programming/ software	*	*	534	---	534
6. Miscellaneous	5,141	4,234	5,667	---	15,042
TOTAL	72,900	23,336	42,059		138,295

*Some programming and software costs could not be disaggregated from computer services.

in computer services because these services were leased. Miscellaneous costs were approximately 11 percent of total costs, and space requirements accounted for less than three percent of total costs. Finally, programming costs were less than one percent of the total. This is also somewhat misleading, since the bulk of the software costs are also included in expenditures for computer services.

Several other observations about project costs are worth noting. First, all of the equipment costs were incurred in the start-up phase. This was a direct result of the project staff's decision to purchase rather than lease the equipment. It also explains why costs were so high for the initial phase. Equipment costs represent 69 percent of costs incurred during the start-up phase. As discussed above, average monthly costs declined through the three phases. The dramatic decline between the start-up and trial operation phases is attributable almost entirely to equipment costs. The less visible, but still significant, decline in average monthly costs between the latter two phases is partly the result of reductions in computer service costs. Computer service costs declined from $3,432 per month in the trial operation phase to $2,948 per month in the demonstration phase. As explained below in the section on "Technological Considerations", this decrease resulted from experimentation with leasing less computer capacity for the network. Finally, it is interesting to note that average monthly labor costs remained relatively constant throughout the first year. The intensity of labor requirements did not vary greatly even though use patterns changed in each of the phases.

Additional Costs: There are several areas where costs incurred by DCC do not reflect the full value of the resources used. Because the project director is a member of the clergy, his salary does not reflect the salary that the director's position would normally receive. For the first year, the DCC project director was paid $2,500. A director of a project of this level of sophistication would normally earn a salary of at least $20,000. Secondly, according to the project staff, there was some instruction provided to users by DCC instructors that was not directly charged to the project. Rather, it was donated through the enthusiasm of the participants in the experiment. Although no estimates of the amount of time volunteered are available, the costs of this labor would not significantly increase project costs. For example, if the amount of instructors' time donated was half that actually paid for, project costs would increase only $1,250 for the year. According to the project director, it is unlikely that the donated time exceeded that amount.

Third, some equipment was donated for use in the project. Eight Model 33 teleprinters were provided by Bolt, Beranek and Newman, Inc. (BBN), the company providing computer services to DCC, at no cost to the project. According to the project director, these units have an estimated value of $600 each, or $4,800 in total.

Overall, then, approximately $23,550 ($17,500 for the director, $1,250 for training, and $4,800 for donated equipment) in additional cost may be attributable to the project. However, it should also be noted that no telephone communications costs are charged to the project either. Communications costs were incurred by the users since they generally already had telephone service for other reasons.

When these additional costs are added to the costs shown in Exhibit 12, the basic cost characteristics of the demonstratior change. Total project costs for the first year amount to $161,845, an increase of 17 percent. Labor costs total $50,224, and as a percent of total cost, increase from 23 percent to 31 percent. Equipment costs total $55,023. However, as a percent of total cost for the first year, equipment declines very slightly from 36 percent to 34 percent.

Cost and Output: Based on data provided by DCC, the average cost per message for the network was calculated for each project phase. Average costs are shown by phase in Exhibit 13 along with data on total usage and total costs. The DCC usage data are estimates based on average use for selected periods of each phase. 4/ Additional costs discussed in the previous section could not be disaggregated by phase so that estimates of total and average true costs are not presented in Exhibit 13.

During the start-up phase, an estimated total of 5758 messages were exchanged. That volume increased to 9,100 messages in the trial operation phase, and to 18,186 messages in the demonstration phase.

4/ Also, because the time periods applied to usage, data provided by DCC did not completely correspond to the periods DCC used to present cost data; additional adjustments were made in the usage data so that direct comparisons could be made. The adjustments affected only the estimate for the demonstration phase.

Exhibit 13

Deaf Community Center Demonstration of Computer-assisted Telecommunications for the Deaf

Output and Total and Average Cost By Phase

Project Phase	Output No. of Messages	Total Incurred Costs	Average Incurred Costs	Estimated Total True Cost	Estimated Average True Cost
Installation and start-up	5758	72,900	12.66	*	*
Trial Operation	9100	23,336	2.56	*	*
Demonstration	18,186	42,059	2.31	*	*

B46

*Estimates by phase could not be made from available data.

With each phase the costs per message dropped. The initial high average cost per message of $12.66 is the result of the large equipment outlays for the network during the start-up phase. In the trial operation phase average costs incurred per message were much less ($2.56). In the demonstration phase average costs declined once again to $2.31 per message, a decrease of approximately 10 percent.

It is also useful to look separately at average costs for computer services as the volume of usage increased. Average computer costs per message declined from $1.64 in the start-up phase, when usage was relatively low, to $0.97 in the demonstration phase when usage was relatively high. Between the trial operation and demonstration phases, average costs dropped $0.16. Note that the decline in average computer costs accounts for nearly two-thirds of the $0.25 reduction in average total cost per message between these two phases shown in Exhibit 13.

The declining average costs indicate the presence of scale economies in the network; however, for two reasons, the data presented in Exhibits 12 and 13 may not provide an accurate picture of size of the economies that can be realized. First, the computer services are leased at a fixed rate so that they are not very sensitive to increased changes in the volume of usages. Secondly, the project staff had to experiment with the amount of computer capacity the network requires at its present size. During the demonstration phase, computer capacity (and costs) were halved to determine whether the network could function well at a lower cost. System overcrowding resulted and computer capacity was later increased. The experimentation resulted in reducing computer costs, but it also reduced the quality of service available to users. Nevertheless, the declining average costs suggest that there are cost advantages to increasing usage of the network.

Technological Considerations: The DCC project costs outlined in Exhibit 12 show that technology costs dominated the expenditures. Equipment and computer services costs accounted for 63 percent of total project costs. It is appropriate then, as in the previous project cost analyses to address two issues:

- Are there other technologies (other than computer-based) that can provide similar services more cost-effectively?
- If there are no close substitutes for such computer-based systems, is the system used by DCC the most appropriate one? That is, are project costs sensitive to changes in the configuration of the DCC network?

In examining the latter issue it is necessary to separately discuss the DCC system as a demonstration and as a possible fully operational and institutionalized system. These issues are discussed in sequence below.

There are no effective substitute technologies for the type of services offered through the DCC concept. The electronic message system, with its asynchronous communication, is essentially a new service. It allows messages to be exchanged between one or more persons so rapidly that mail cannot compete with it. It allows, but does not require, that the sender and receiver of the message be on the system simultaneously so that it substitutes for, and enhances, existing teletype service currently used by the deaf. These features, in combination with additional information services (such as health care, social service and consumer information; on-line news, sports and weather; or announcements important to the deaf community), make the computer-assisted telecommunications concept an extremely powerful means of information dissemination and exchange for the hearing impaired. The power of the concept lies in the convenient access to a wide variety of information sources that a computer-based system provides. Individuals and groups can be easily contacted and information easily obtained through one device -- the remote terminal.

Assuming that there are no close substitutes for computer-assisted telecommunications for the deaf, what are the technological cost characteristics of the DCC network and how would alternate configurations affect project costs?

In developing its system, DCC had to acquire:

- computer terminals for remote access;
- computer capacity for processing and storage of messages and information;
- software for inputting, processing and outputting messages; and
- communications for dial-up access to the computer.

In constructing its network, DCC was guided more by the need to demonstrate the usefulness of the concept of computer-assisted telecommunications than to explore the technology cost considerations for a fully operational system. Thus, DCC sought to build a workable system at a reasonable cost for demonstration purposes. The costs of this system do not necessarily reflect the lowest possible cost for an operational network of this size.

The demonstration is being conducted using a commercial time-sharing service provided by Bolt, Beranek and Newman, Inc. The software package, HERMES, was already available through BBN, but some customizing was necessary to meet the needs of deaf users. The remaining equipment acquisition included the purchase of 45 teleprinters with integrated modems (Teletype Corporation, Model 43) for a total cost of $49,500. Originally, the terminals were to be leased, but when DCC was given the opportunity to purchase them at the reduced government rate ($1,100 each versus $1,600 for commerical purchases), the purchase of terminals became more economic, assuming at least a two-year lifetime for the demonstration. Also, six acoustic couplers were rebuilt for use with the less sophisticated Model 33 teleprinters that were donated to the project. Total equipment costs were $50,223. Telephone communications lines necessary for transmitting data were provided at the expense of each of the users.

There are a variety of computer terminals and commercial computer services available. In selecting the appropriate terminals DCC had to balance cost with ease of interfacing with computer services, the ability of the supplier to meet early delivery schedules and provide maintenance services, and the presence of a monitor light for detecting computer carrier frequency. Few vendors could provide terminals on short notice and fewer had the monitor light that deaf persons need. DCC also had to choose between the use of CRT screens and hard copy printers. Hard copy printers were chosen because deaf persons are accustomed to them from the TTYs they currently use. However, the project director believes that CRTs are much more useful for composing and editing messages. They are also less expensive and can be purchased for half the cost ($500 to $600) of the printers currently being used. According to the project director, the use of CRT's will be more fully explored in the demonstration's second year.

DCC also had to acquire computer services and electronic message service software. The choice of a vendor was not based on least cost criteria. Rather, the services of BBN were purchased because of that firm's interest in telecommunications for the deaf and their commitment to the project.

Costs for using BBN's computer services totalled $34,992 for the first year. Depending on the fee structure, computer costs may be considered either fixed or variable costs. DCC's arrangement with BBN is to pay a fixed monthly fee for guaranteed access to a set portion or number of "shares" of BBN's computer capacity. DCC paid $344 per share per month. Alternatively, DCC could be charged separately for its variable consumption of connect time, processing time and utilization of storage capacity. The leased shares agreement, however, also provides the DCC network with a "windfall" during off-peak usage. The network gains additional computer capacity at no extra cost during those periods when the computer is not fully utilized. This is of particular importance because the DCC network usage occurs primarily during off-peak periods for the BBN system, so that the network receives substantial windfall. The effort of this windfall arrangement is to provide DCC network users with improved service by reducing the response time in interacting with the computer; and, because of the windfall benefits, it is less expensive than being charged separately by BBN for connect and processing time.

DCC has experimented with determining the minimum number of shares it needs to provide adequate service in order to keep computer costs to a minimum. Initially, ten shares were used, providing substantial capacity and windfall. (The amount of windfall available to a user is determined partly by the number of shares leased.) Computer costs were reduced when the number of shares was reduced to five; but network crowding occurred and the number of computer shares was raised to its current level of eight.

Thus, while cost considerations were taken into account in constructing the DCC network, factors relating to the uniqueness of the project as a demonstration also influenced the system configuration. The project staff chose hard copy printers over less expensive CRTs, assuming that they would be more readily accepted by deaf persons. That assumption needs to be tested. Also, the selection of a computer services supplier (including software and hardware) was strongly influenced by one vendor's expressed interest in telecommunications for the deaf. Other electronic message services may have been less expensive.[5] In short, while DCC has developed a network that permits the demonstration of the computer-assisted telecommunications concept for the deaf, the costs of such a system can be reduced by substituting other existing technologies.

The foregoing discussion focused only on the demonstration network, which operates with about 50 terminals. The configuration currently used would not be cost-effective in a larger operational context. For the purposes of this discussion, a "larger operational context" is taken to mean a network with 400 users using available technology. Although examining alternative configurations in detail is beyond the scope of this analysis, several major factors distinguishing the demonstration system from a potential operational system can be pointed out here:

- The use of commercial time-sharing services will be more expensive than a dedicated computer utility.
- An operational system would have to consider the incorporation of the existing TTY network.
- The selection of terminals would have to consider the cost-effectiveness of "dumb" versus "intelligent" terminals.

The use of commercial time-sharing services currently

5/ For a more detailed overview of available services, see Kas Kalba, et.al., Electronic Message Systems, The Technological, Market and Regulatory Prospects, submitted to the Federal Communication Commission, (Cambridge: Kalba Bowen Associates, Inc.) 1978. As the report shows, it is difficult to compare the costs of different systems, because each has a unique pricing structure.

used by DCC would not be cost-effective in a larger system. A separate larger demonstration sponsored by DHEW/BEH concerning computer-assisted telecommunications for the deaf is currently being conducted by SRI International, Inc. A major objective of that project is to conduct a detailed design and cost analysis for a large scale system. In planning their demonstration SRI examined the relative costs of using commercial time-sharing services versus the outright purchase of a computer dedicated to the network. According to preliminary calculations made by SRI in planning its demonstration, a dedicated mini-computer is much more cost-effective for a network with as few as 400 to 500 users than are time-shared services. For example, assuming a (very low) charge of $1 per connect hour and an average of 5 hours per week per user, total connect time cost per year of operation would amount to $127,092, according to SRI. This figure does not include processing and storage costs. Similarly, assuming an average of 20 seconds of CPU usage per connect hour, SRI conservatively estimates that approximately 14 hours of CPU time would be consumed per week. According to SRI, at typical rates for CPU time (e.g., $400 per hour), this translates to an estimate of over $291,000 for time-shared processing costs.

In companison, SRI estimates that the same services could be provided by purchasing a dedicated mini-computer such as a DEC PDP-11/60, at a cost of $110,000, plus approximately $15,000 in yearly support costs. 6/ Thus, it is likely an operational system of reasonable size would use its own computer rather than purchasing commercial services.

A second issue that distinguishes the DCC demonstration from an operational system is the existence of a relatively large TTY network. An estimated 30,000 terminals and modems in that network represent a considerable investment. The integration of the TTY system into a computer based system would be an essential component of any large scale network. The SRI demonstration is also focusing on this problem. The existing TTY network employs the 5-level Baudot character code which is incompatible with the standard 8-level American Standard Code for Information Interchange (ASCII). SRI is developing the necessary interface so that new, faster terminals and TTYs will be able to communicate.

A third, and related issue, is the selection of terminals. Currently, DCC is using so-called "dumb" terminals,

---

6/ All cost information was provided through personal communication with personnel at SRI International, Telecommunications Sciences Center. These estimates were made only for preliminary planning purposes of SRI and do not represent actual costs for an operating system.

which have no internal capability for storing and processing information. Thus, all network users must be constantly on-line with the computer, increasing the potential for system congestion. Data provided by the DCC project show that in an average 12-minute session, over one-half of the time is spent composing, editing and reading messages. The use of intelligent terminals would permit much of this activity to be conducted off-line, reducing operating costs and potentially increasing the number of users that could be accommodated by the computer. There are some intelligent terminals without hard copy printers available for the same cost ($1,100) as the dumb terminals currently being used.

All of this discussion is based on currently available technology, but all facets of computer technology are rapidly changing. Indeed, it has been predicted that costs of hardware and computer logic will decrease by a factor of ten every five years in the next decade, and that software and communications costs will decrease by a factor of ten in the next decade. 7/ In addition, therefore, the cost reductions achieved by operating a larger network using current technology, technological advances can be expected

---

7/ Stefferud, E., "Economics of Network Delivery of Computer Services", Computer Networks, June, 1976, pp. 53-64.

to yield an even greater reduction in costs.

Potential for Economies of Scale: It would appear from the data presented in the section on "Costs and Output" and from the discussion of technological considerations that the potential for economies of scale is relatively high. As the system grows in number of users, the cost of adding an additional user or sending an additional message through the network will decline substantially. A brief examination of the major components of the system illustrates where those economies are likely to be achieved. 8/

A computer-assisted telecommunications network for the deaf can be thought of, overall, as consisting of five components:

- Terminals
- Communications
- Computer services
- Software
- Labor

8/ This discussion pertains only to cost reductions achieved by increases in the scale of the network. It should not be confused with cost reductions expected from technological advances mentioned earlier; these will occur independent of the network.

As with most communications systems, a network of this kind is very capital intensive. But the costs for these components are borne by different parties, so that increases in volume of usage on the network may not result directly in scale economies in each component.

For example, communications costs will be borne by the individual users. Local telephone charges for dial-up access to a network port are not affected by system use and are determined externally by the telephone companies and regulatory agencies. Communications charges for access will, therefore, not decline as the number of users increases. However, some economies can be achieved in a network that includes long distance message forwarding. Messages being forwarded from one city to another can be accumulated and sent in batch and at a time that is most economical. SRI is using this approach in its demonstration to forward messages between Washington, D.C. and the San Francisco Bay Area, or Boston.

Terminals for the DCC project were purchased in bulk and their costs were covered as part of the demonstration. In an operational system, terminals would be purchased or leased one at a time by individuals. Although the potential market in the deaf community for modern terminals may be substantial, it is only a small share of the overall terminal market. Demand for terminals from the deaf community alone would have little effect on the pricing structure used by manufacturers. So terminal costs will not decline as a result of increases in the size of the network, particularly if more than one type of terminal is used.

There are economies to be gained from the computer component. As discussed earlier, the network does not have to be very large to make the purchase of a dedicated mini-computer more economic than buying commercial computer services. The marginal cost of computer time, for any additional user,is zero, up to the point that the mini-computer is used to capacity. Beyond that, according to BBN, it is possible to develop a larger system incrementally, where the cost of adding capacity to the system is quite small and justifiable in terms of incremental use.

The software component is generally a one-time expense for a system that is owned by an organization operating the network. Its development costs are fixed so that the marginal cost of sending each message beyond the first one is zero. Thus, it is advantageous to increase usage as much as possible to cover the cost of the software component.

The fifth system component is labor. This includes functions such as system administration, computer maintenance, and training of new users. The cost of administration and maintenance will not grow in direct proportion to increases in the number of users, or the volume of use, so that some scale economies in labor will result. The training function is relatively labor intensive, although some economies are achievable through the development of large group training techniques. DCC will experiment this year with the use of a large screen video beam for instruction of deaf users. Thus, there are some cost advantages here also for increasing the size of the network.

It appears that there are scale economies to be realized in developing a large system. Marginal costs decline for the computer software and labor components of the system. The communications and terminal components offer little, if any, cost improvements by increasing the number of users. However, the magnitude of the economies is uncertain, largely because of the influence of terminal costs. For example, if one assumes that the dedicated computer component costs approximately $110,000 (as SRI did in planning its demonstration), and the cost of a modem terminal is $1,100 (as it was for DCC), then for a system of 1,000 users in a metropolitan area, the terminal costs dominate the system costs.

1.4 Western Alabama Emergency Medical Service, Wernersville State Hospital Interactive Cable, Pennsylvania State University Continuing Education Cable Television Network

Three other demonstration projects provided cost data for their first 18 months of operation. These included the Western Alabama Emergency Medical Service (EMS), the Wernersville State Hospital Interactive Cable intercon-nection and the Pennsylvania State University Continuing Education Cable Television Network (PENNARAMA). These projects made less progress in their first year than TALINET, CenTeX or the Deaf Community Center, and none progressed to the demonstration phase. Thus, the cost data provided was not sufficient to conduct detailed cost analyses. However, there are several issues relating to the design of demonstration projects that have surfaced from reviewing the available information on the projects. Specifically, the three projects are associated and integrated with other systems, institutions and funding sources to a greater degree than TALINET, CenTeX and the DCC. These organizational arrangements make the task of isolating and evaluating the costs attributable to the demonstration very difficult. Before turning to design issues, a brief description of each project and its reported costs for the first 18 months of operation is appropriate.

Western Alabama Emergency Medical Services

The Western Alabama EMS is an attempt to establish a regional radio/telephone system in a seven county area to simultaneously transmit voice and biomedical data from remote emergency sites to local and regional medical staff. The system links emergency medical technicians in traumatic injury situations with local community hospitals and a regional hospital. The purpose of the project is to provide rural populations with medical expertise and services that are currently available in metropolitan areas.

In the first 18 months of the project the system was installed and testing was begun in the seven county region. DHEW/OTP provided funds necessary to purchase equipment for four counties. These costs, provided by the project director, are shown in the first column of Exhibit 14. As shown in the table, the Western Alabama EMS project appears primarily under equipment purchase during the first 18 months. Equipment, including radio/telephone switching stations, vehicular repeaters and field consoles, was purchased for a cost of $117,308. This represents 93 percent of the first costs. The only other major expense was labor ($8,140), and expenditures for equipment installation . However, these costs reflect only about one-third of the total project costs. The project director estimates that costs have been approximately $350,000 during that first time period. Additional funds were provided by the Emergency Medical Services Office of DHEW and the Governor's Office for training of paramedics and the purchase of equipment for three other counties in the region. Participating hospitals have also contributed by making improvements in their communications facilities, although the project director was not aware of the cost of these improvements. 9/ Data on total costs for the regional system were not available at the time of this cost analysis.

9/ These costs are not included in the $350,000 estimate mentioned above.

Exhibit 14

Project Costs Incurred for West Alabama EMS, PENNARAMA and Wernersville State Hospital

	Western Alabama EMS	PENNARAMA	Wernersville State Hospital
	1/15/78 6/15/79	1/15/78 6/30/79	1/15/78 6/25/79
Equipment	$117,308	$ 4,700	$ 67,274
Communications and Computer Services	340	500	
Space	0	0	4,711
Labor	8,190	55,118	35,135
Programming/ Software	0	0	
Miscellaneous	0	7,000	1,560
TOTAL	125,838*	67,318	108,680

*$27,000 of this total was incurred during the trial operation phase for service on communications.

PENNARAMA

The PENNARAMA demonstration focuses on expanding the educational cable television service provided by the University to the Scranton/Wilkes-Barre area to a statewide service by interconnecting existing other local cable systems. The original proposal was to provide interconnection using Instructional Television Fixed Service transmitters, but technical and legal complications prohibited that approach from being implemented. Instead, efforts have been made to provide interconnection using CARS, a microwave service assigned to the cable industry. In order for any networking to be completed, local cable operators must reach agreement on financial and organizational commitments. In the project's first year operators have been unable to reach an agreement so that interconnection has not yet been achieved. Other project objectives are to aggregate program supply through collaborative arrangements with other providers and to promote utilization of services. Because PENNARAMA has been unable to expand its audience beyond the existing local audience, there has been little progress in accomplishing these objectives as well.

As shown in Exhibit 14, costs for the first 18 months of the PENNARAMA expansion project were predominantly labor costs for efforts in organizing the statewide network and obtaining programming from other providers. Total project costs were $67,318 of which $55,118, or 82 percent, were for labor. Once again these costs reflect only efforts to expand the PENNARAMA services. Costs associated with the broadcast services that were being provided before the DHEW demonstration began are not included. (PENNARAMA began providing local educational programming two years before the DHEW demonstration began.)

In the view of PENNARAMA project staff, all of the project costs should be considered as occurring during the demonstration phase since their project was to demonstrate that an organization could be built that would expand the use of an already operational system. In any case PENNARAMA costs are attributable to only one project phase since the networking has not been accomplished at the time of Kalba Bowen's investigations.

Wernersville State Hospital Interactive Cable

The Wernersville State Hospital Interactive Cable project is an attempt to link a state mental hospital with an existing interactive cable system operating in Berks County, Pennsylvania. The cable-microwave link to be established will allow hospital patients, many of whom are elderly citizens, to participate in interactive social service programming produced by the New York University-Reading Consortium. At the end of the project's first

18 months the interconnection had not been completed.

Costs incurred by the Wernersville State Hospital project are also shown in Exhibit 14. In its first 18 months the costs of equipment were 62 percent of total project costs. Labor was the only other major expense and represented 32 percent of project costs. Space costs included those for modification of the studio. It is important to note that costs shown for the Wernersville project in the table reflect both federal and state expenditures. Of the $108,680 spent, $61,880 were funds provided by the DHEW demonstration program. Costs for all labor, space and $6,954 of the equipment costs were borne by the state.

Design Issues

As discussed in Section 2, clarity in project design is essential for the identification of true cost and the output for a telecommunications demonstration. Meaningful economic analysis can best be conducted for demonstrations in which costs and output can be isolated. These three projects do not exhibit this characteristic. The principal factors that will make it difficult to conduct a meaningful cost analysis include the following:

- the project is integrated in an existing system in such a way that costs associated with the demonstration cannot be clearly identified;

- the project is integrated in an existing system in such a way that output attributable only to the demonstration cannot be clearly identified.
- multiple participants in the demonstration make assembling complete cost information extremely difficult.

Each of the three projects exhibits at least one of the above characteristics. For example, the educational television networking demonstration is integrated with the existing PENNARAMA broadcasting service, but the broadcast services are not included in the direct costs of the project. Once a network is established, how can the costs and output of the network be separately examined if the output (programming) originates from outside the demonstration? Costs associated with broadcasting the programming including fixed and variable costs will have to be determined indirectly through some prorating procedure. These will be major costs of operating the network.

Similarly, the Wernersville State Hospital project is dependent on the existence of outside interactive programming. While the cost of operating the equipment at the hospital can be easily determined, the costs of creating an interactive system are shared with Berks County TV, with which the hospital will interconnect. What portion of those costs, then, are attributable to the Wernersville demonstration? There is no conceptual framework for resolving this question. Just as perplexing is the difficulty in determining the output of system that is attributable only to the Wernersville demonstration where the same problem arises. In an interactive system the costs of one component of the system cannot be accurately analyzed separately from the whole. The costs are inherently tied to the whole system and the analyst will have to resort to a somewhat arbitrary prorating procedure.

The task of analyzing the true costs of the Western Alabama EMS is also very difficult but the reason lies in the organizational arrangements for conducting the project. Direct funding for the project is being provided through several sources. The Office of Telecommunications and Office of Emergency Medical Services in DHEW provided funds for equipment purchases. The Governor's Office is providing funds for training and local hospitals are absorbing a portion of the operating costs. This can lead to confusion over the interests of the various funding agencies. For example, data submitted for this cost analysis by the project director included only funds provided by DHEW/OTP. When contacted about this, the project director was unaware that in this analysis we are interested in the entire demonstration.

Responsibility for the project is also fragmented. Funds were obtained by the Telecommunications Division of the Alabama Development Office, but the project is being run by medical personnel from other agencies and institutions. Thus, the responsibility for tracking costs lies with one agency while project performance lies with another group. From discussions with the project director, it is unclear how costs and output are to be analyzed in the evaluation the project staff intends to conduct. Given the relatively small portion of funds DHEW/OTP is contributing to the project, and the fact that responsibility for the project is fragmented, the question of whether DHEW/OTP will have sufficient control over the project to conduct a cost analysis arises.

In short, all three projects are designed such that they have substantial additional costs. In the PENNARAMA and Wernersville State Hospital projects these costs are hidden in the systems in which the projects are integrated. In the Western Alabama Emergency Medical Service project additional costs are borne by federal, state and local funding institutions and represent a large majority of total project costs. In many instances the determination of these additional costs will be judgmental. In others there is the practical difficulty of sorting out costs and output from the many participants. These problems of analyzing the performance of the demonstrations greatly reduce the usefulness of any cost analyses that may be conducted. From an analysis of these three projects, it can be concluded that telecommunications demonstrations should be designed, where possible, as stand-alone systems so that cost and outputs are easily identifiable. Where this is not possible, projects should be designed from the start in such manner that the demonstration can still be conducted as a controlled experiment. True costs and outputs attributable only to the demonstration should be clearly identifiable.