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FINAL REPORT TR 80-8-317

Evaluation of Video Teleconference Systems

Paul J. Sticha
John F. Patterson

DECISIONS and DESIGNS, INC.

Prepared for
Office of the Assistant Secretary of Defense
Manpower, Reserve Affairs, and Logistics
Washington, D.C. 20301
Contract MDA903-80-C-0289

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EVALUATION OF VIDEO TELECONFERENCE SYSTEMS

by

Paul J. Sticha [redacted] *John F. Patterson*

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The Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (OASD, MRAL) plans to improve productivity by taking advantage of recent technological advances in the following areas: video teleconferencing facilities, database management, and word processing systems. The benefits of technological advancement cannot be obtained without considerable investment. In order to make the most cost-effective decisions, MRAL

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE has contracted for several studies in the three areas listed above. This report describes work performed by Decisions and Designs, Inc. (DDI) to investigate the costs and benefits of a large number of video teleconferencing configurations. The purpose of this investigation was twofold: to find those configurations which best match the needs of MRAL, and hence offer the greatest benefit given the amount invested; and to document the benefits of various teleconferencing systems to determine the overall value derived from teleconferencing.

A video teleconferencing system is a complex one, comprising many relatively independent parts. The system components may be organized in these four general areas: the audio-visual channel connecting the conferees; the capability to display and store data; the number of sites; and the central switching and storage facilities. Decision-analytic techniques were used to identify those areas in which the greatest enhancements in performance could be obtained for the least cost. A second analysis examined selected teleconference systems to determine which, if any, should be procured by MRAL. Systems were evaluated on sixteen attributes describing costs and benefits affecting the teleconference decision. The results indicate that procurement of a video teleconference system may be justified by the benefits. Several options are described in this report allowing MRAL to make a final decision on the potential for procurement.

SUMMARY

The Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (OASD, MRAL) plans to improve productivity by taking advantage of recent technological advances in the following areas: video teleconferencing facilities, database management, and word processing systems. The benefits of technological advancement cannot be obtained without considerable investment. To make the most cost-effective decisions, MRAL has contracted for several studies in the three areas listed above. This report describes work performed by Decisions and Designs, Inc. (DDI) to investigate the costs and benefits of a large number of video teleconferencing configurations. The purpose of this investigation was twofold: to find those configurations which best match the needs of MRAL, and hence offer the greatest benefit given the amount invested; and to document the benefits of various teleconferencing systems to determine the overall value derived from teleconferencing.

A video teleconferencing system is a complex one comprising many relatively independent parts. Each system component may vary in degree of sophistication. The components may be organized in the following four general areas:

1) the audio-visual channel connecting the conferees;

2) the capability to display and store data;

3) the number of sites; and

4) the central switching and storage facilities.

Decision-analytic techniques were used to identify those areas in which the greatest enhancements in performance

could be obtained for the least cost. The methodology provides a framework for making decisions in which a limited resource must be allocated among competing programs.

The results of the analysis indicate that a substantial proportion of the benefits possible through system enhancements may be obtained through a relatively small investment cost. Particularly cost-effective enhancements include the following:

a) increasing the number of sites;

b) enhancing audio-visual communication between conferees except for color video; and

c) enhancing central features.

There was great variation in the cost-effectiveness of enhancements of the capability to store and display data, but all enhancements in this area were less cost-effective than enhancements in the above three areas. The results of this analysis were insensitive to changes in the values of key model parameters.

The second analysis examined selected teleconference systems to determine which, if any, should be procured by MRAL. Systems were evaluated on sixteen attributes describing costs and benefits affecting the teleconference decision. The results indicate that procurement of a video teleconference system may be justified by the benefits. This result is highly sensitive to the relative importance of the benefits of teleconferencing, chiefly those due to time savings.

The results of these analyses lead to two recommendations. First, MRAL should examine the benefits from teleconference to determine if the estimates used in this analysis are reasonable and to pinpoint the expected benefits within the range of reasonable values. Second, if the expected benefits fall near the center of the range used in this analysis, the analysis would recommend the procurement of a twelve-site video teleconference system as outlined in this report. If the benefit is low, then MRAL should not procure a teleconference system, or it should consider an audio teleconference system. If the benefit is higher, a larger teleconference system, such as the thirty-five-site system, should be considered.

In addition to the teleconference evaluation, this contract supported a two-day working session conducted at Decisions and Designs, Inc. (DDI) on 5-6 August 1980. During the meetings, decision-analytic techniques were applied to the evaluation of potential alternative educational assistance programs. A cost-benefit model was developed that provided for a comparison of alternative program designs. The results of the analysis were presented in an interim report delivered to MRAL.

TABLE OF CONTENTS

TABLE OF CONTENTS (Con't.)

FIGURES

TABLES

EVALUATION OF VIDEO TELECONFERENCE SYSTEMS

1.0 INTRODUCTION

Recent technological advances have made it possible to improve greatly the productivity of the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (OASD, MRAL). Developments in several areas make these improvements possible in all levels of management:

- o Office video teleconferencing facilities give top-level MRAL officials the capability for high-quality communication without the high costs of scheduling and travel.
- o Database management systems allow rapid access to information and poignant analysis of its implications.
- o Advanced word processing and other electronic equipment of the office of the future provide for timely production, editing, and distribution of information.

The benefits of technological advancement cannot be obtained without considerable investment. In planning for future growth in technology, MRAL must carefully weigh the potential benefits of each technological advancement against its overall cost. In addition, advanced technologies must be designed to obtain the greatest benefit for the amount invested. To make informed decisions in these areas, MRAL has contracted for several studies regarding office of the future, database management, and teleconferencing.

This report describes work done by Decisions and Designs, Inc. (DDI) to investigate the costs and benefits of a large number of video teleconferencing configurations. The purpose of this investigation was to find those configurations which best match the needs of MRAL, and hence offer the greatest benefit given the amount invested. The approach used DDI's expertise in teleconferencing and in the methodology of decision analysis. Decision analysis is a set of techniques which aid a decision maker in solving decision problems when faced with complexity, conflict, or risk. The specific methodology used provides a framework for making decisions in which a limited resource must be allocated among competing programs. This methodology is often used for problems of budgeting and system design.

A more detailed analysis was performed on selected cost-efficient system designs. This analysis sought to document the costs and benefits of the systems so that benefit could be quantified. The results of the analysis allow MRAL to ascertain whether the benefits from the teleconference systems analyzed justify the costs. In addition, the results can form the basis for comparing the benefits obtained from investments in teleconference with those from investments in other areas.

A video teleconferencing system is a complex one comprising many relatively independent parts. Each system component may vary in degree of sophistication. The components may be organized in the following four general areas:

(1) The audio-visual channel connecting the conferees - Enhancements in this area include large-screen color displays, virtual space organization, and inclusion of sufficient displays to accommodate large meetings.

(2) Data display and storage - This capability may be enhanced in a variety of ways, including providing color graphic displays with overlay control, highlighting, variety of input sources, and local video storage.

(3) Number of sites - The number of sites may be as low as four and as high as thirty-five.

(4) Central switching and storage sophistication. Enhancements in this area include providing a variety of central inputs to the data display system such as optical and magnetic video disks, and video tapes.

With such a large number of independent system choices, there are many thousands or even millions of potential systems designs. Sections 2.0 and 3.0 describe a decision-analytic model developed to reduce the number of designs by identifying those offering the greatest benefits for any cost. This much smaller number of cost-efficient designs may be used as a menu from which to select a final teleconference system design. The general procedure used to structure the problem, assess costs and benefits, and identify cost-efficient designs is detailed in Section 2.0. The application of this procedure to the problem at hand, as well as the results of the analysis, are presented in Section 3.0. Section 4.0 offers the detailed analysis of the costs and benefits of selected cost efficient systems. Finally, Section 5.0 states the conclusion of the analyses and presents recommendations.

2.0 TECHNICAL APPROACH TO RESOURCE ALLOCATION

The major problem in video teleconference system design identified above is the efficient allocation of limited investment resources to obtain the maximum benefit for the investment cost. The technical approach to this problem is described below.

2.1 General Approach

One of DDI's methodological approaches to resource allocation is benefit-cost analysis. The modeling software used to implement this approach is called "Design." Design's basic building block is a "variable"; a Design variable is one of the projects/programs competing for limited resources. In this case, the Design variables are the system components which may be more or less sophisticated. Each competing variable is itself defined in terms of "levels" describing increasingly costly options for it; one level must be selected by the decision maker for each variable. Finally, each level is described in terms of its cost (resource use) and benefits relative to other levels. A fully defined collection of Design variables that compete for the same resource is called a Design "model." In addition to the foregoing structural definitions, any resource allocation decision, that is, any choice of one level for each variable in the model, is called a "package."

Building a Design model involves identifying a set of variables and levels and assessing costs and benefits for each level so that the total cost and benefit for any package may be calculated. A simple version of the Design methodology assumes that the costs and benefits for different variables are independent. This means that a single cost and benefit may be assigned to each level so that the cost and benefit package is the sum of the costs and benefits of its constituent levels.

The necessary conditions for intervariable independence do not hold for the present case or for any problem in which there are variables representing both quantity and quality. For example, the cost of equipping twelve sites with video teleconference stations depends on the cost of the individual stations. However, individual station cost depends on the levels chosen for several Design variables.

The interaction mentioned above has two implications on the nature of the calculations which derive the cost and benefit of a package from those of each of a number of levels. The first implication is that the variables must be evaluated in a fixed order. The cost of a given number of teleconference sites cannot be assessed until the quality of the sites has been determined. The second implication is that certain variables have costs or benefits which serve to multiply the costs or benefits already assessed. In the example, there may be a fixed cost for a given number of sites, but the major cost is just the cost of a single site multiplied by the number of sites. The Design methodology used for this problem considers both fixed and variable costs for each Design variable.

The Design methodology and software have several functions in evaluation of system configurations:

- o to organize, display, and update experts' judgments about the relative costs and benefits on each level of each variable in the model;
- o to display the overall cost and benefit of any one package compared to other packages;

- to compute and display the "efficient frontier" of designs for the model, i.e., those key designs among all possible designs that provide maximum benefit for the amount of resources they use; these designs are the key options to consider, but they are difficult to find without the computer's assistance;

- to display the levels of each variable for designs providing the greatest benefit for any given level of overall resource expenditure; and

- to compare different designs proposed by decision makers with more efficient designs that either cost less and provide the same overall benefit or provide more benefit for the same cost.

This technical approach serves to organize the options of experts on a variety of technical issues so that decision makers may determine the implications of these judgments on critical decision variables. Furthermore, it reduces the huge number of potential designs under consideration to a reasonable set of cost-efficient designs.

2.2 Procedural Steps

There are four steps involved in the development of a Design model: structuring the problem, assessing costs and benefits, identifying cost-efficient options, and exercising the model. Although these steps are listed in their logical order, there are usually many interactions among them. That is, problems encountered in assessing values may lead to restructuring the model, and exercise of the model may lead to changing the assessed values or even the problem structure.

2.2.1 Structure the problem - The task of problem structuring involves determining the set of variables and levels which characterize the range in sophistication available in the system design. The problem must be structured in a way compatible with the methods of analysis; that is, necessary independence conditions must be met. One useful way of arriving at a problem structure is by defining a baseline or least sophisticated system and a "gold plated" or most sophisticated system. These two systems define the upper and lower limits of acceptable system designs. Differences between these two systems often suggest the variables to be considered. For each variable, then, levels are defined which are intermediate between the baseline and the "gold plated."

2.2.2 Assess costs and benefits - The second step in model development is the assessment of model parameters. This step involves determining the dependencies between variables and the consequent order of variable evaluation, assessing fixed and variable costs and benefits for each level, and recording rationale for the assessments made. For each level there are two cost and two benefit parameters. Two of the parameters are a fixed cost and a fixed benefit. The other two are cost and benefit multipliers. The multipliers serve the dual functions of specifying the relative importance of benefits associated with different variables and describing the nature of the interactions between variables. Details of the assessment procedure are discussed in the next section along with the teleconference Design model.

2.2.3 Identify cost-efficient allocations - The set of cost-efficient allocations of resources is identified by using the costs and benefits assessed. The cost-efficient allocations are those which are not inferior to another allocation in both cost and benefit. That is, a package is cost-efficient if there is no other package that is both less costly and more beneficial.

2.2.4 Exercise the model - Proposed allocations are compared to the set of optimal allocations. Sensitivity of allocations to model inputs is examined until the experts involved are satisfied with the model inputs and the resultant model allocations. Exercise of the model may lead to changes in the assessed costs and benefits or even to changes in problem structure.

3.0 THE TELECONFERENCE DESIGN MODEL

The model described in this section has the same structure as the model described in the interim report for this contract. It differs in several details from that model in that refined estimates were obtained for the costs of system components. Changes in cost did not substantially affect the results of the analysis.

3.1 The Model Structure

The analysis of teleconference system designs begins with the identification of factors that can vary from one design to another. Collectively these factors, or variables, are called the structure of a design model. Eventually, once the costs and benefits of these design changes are assessed, a cost/benefit analysis of the alternative designs can be conducted.

Figure 3-1 depicts the general design for a teleconference system. At the core is a central video switching unit that routes the information to and from various teleconferencing sites. There can be any number of such sites. In addition, the sites can differ in terms of whether or not a connection to a staff is available. Although the figure suggests that both types of sites will exist within a single design, the current model does not actually permit this possibility. Instead, all sites are specified as having a common design, which may or may not include a staff. This should become clearer as the model structure unfolds.

Figure 3-2 presents the basic strategy behind the construction of the teleconference design model. It is essentially a hierarchical decomposition of the overall design analysis into several subordinate analyses. The overall

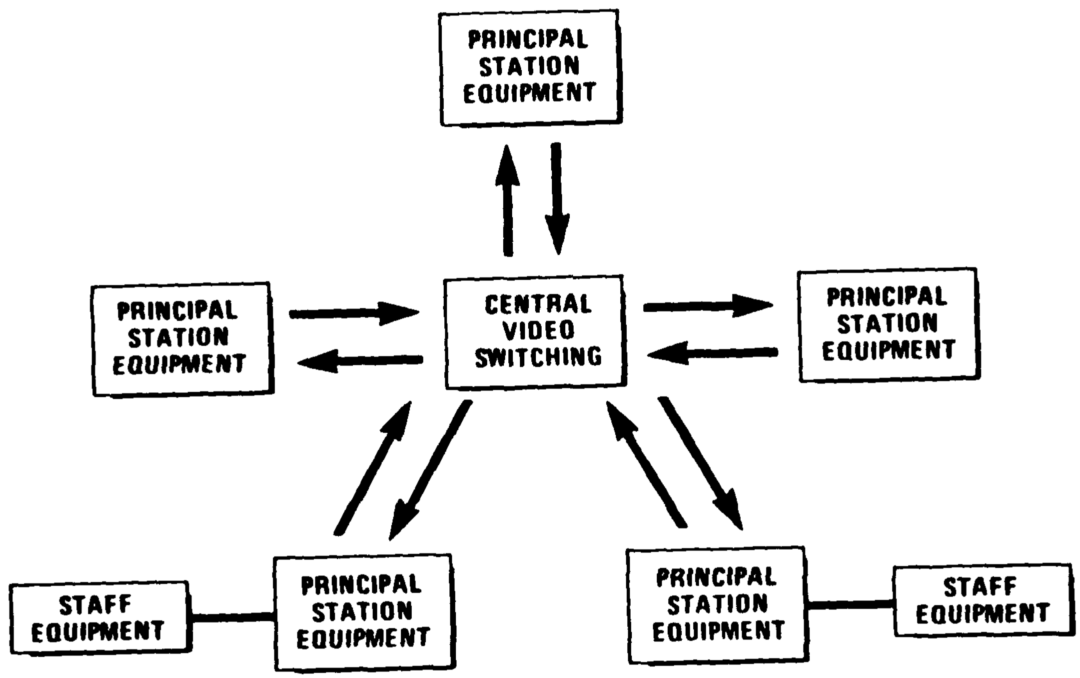

Figure 3-1

OVERVIEW OF TELECONFERENCING DESIGN
(Two Principals with Channels to their own Staff)

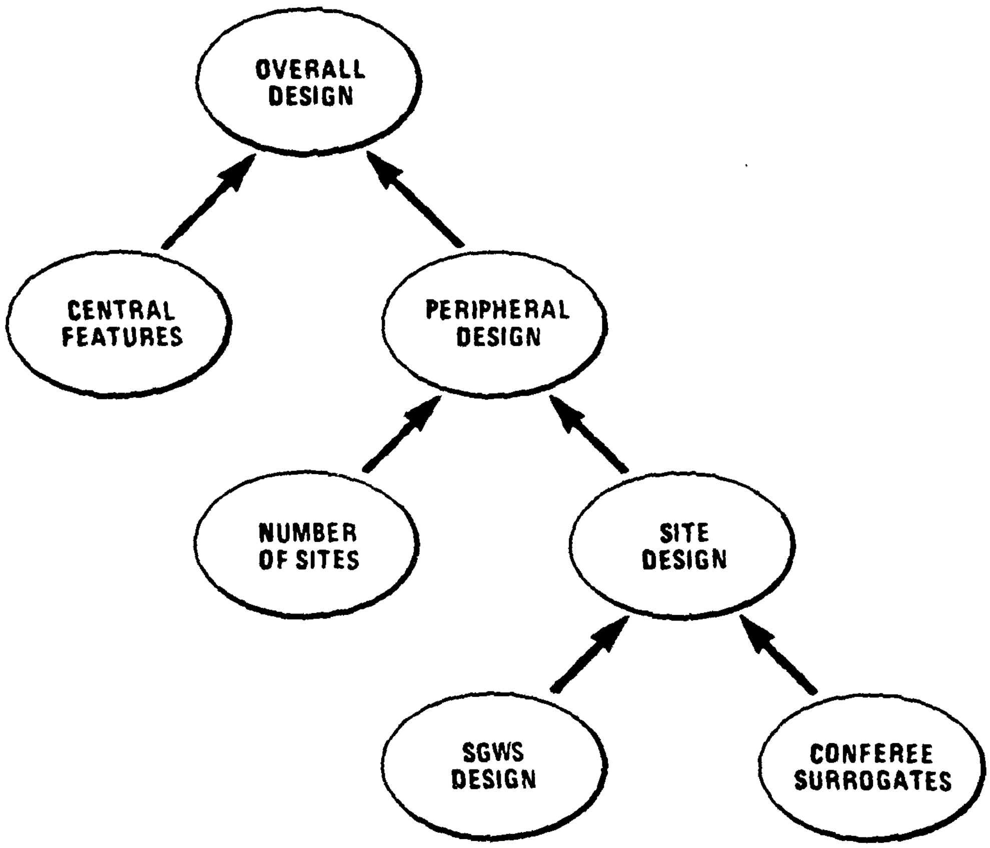

Figure 3-2

STRATEGY FOR TELECONFERENCE DESIGN EVALUATION design consists of both an analysis of central switching features and an analysis of the peripherals that will be supported. The peripheral design consists of a determination of the number of peripheral sites and the quality of these sites. And, finally, the quality of any site is provided by an analysis of the confereee surrogate (the equipment for providing interpersonal communication) and an analysis of the shared graphical work space (SGWS; a monitor that is used like a blackboard for presenting graphical information). Each of these analyses is discussed below starting with the lowest level models.

3.1.1 The surrogates model - The model for the surrogates design consists of four factors, which are depicted in Figure 3-3. The first of these factors addresses the issues of how many surrogates will be provided. This, of course, determines the maximum number of participants in a teleconference.

The baseline surrogate design consists of all that is needed to conduct a simple teleconference: two black and white monitors using small screens. One video camera at each station provides the input to the monitors, and a microphone and two speakers are provided. (Elaborations upon this simple design are discussed below.) The maximum level was designated as five surrogates because of the difficulty of arranging so many monitors in front of a conferee.

The next factor of the surrogates model is concerned with whether eye contact will be available. To obtain eye contact, it is necessary to associate a camera with each video monitor. Thus, each viewer can receive the image of the camera associated with the monitor containing his image. The alternative is to provide only one camera at a station and route this single image to all conferees.

VARIABLE	1	2	3	4
1 NUMBER SURROGATES	TWO	THREE	FOUR	FIVE
2 VIRTUAL SPACE	NO VS	YES VS		
3 BW/COLOR	BW	COLOR		
4 SIZE	SMALL	LARGE		

Figure 3-3

CONFEREE SURROGATE MODEL STRUCTURE

An additional benefit besides eye contact is the sense of spatiality that has been dubbed "virtual space." Given a camera for each monitor and assuming a generally circular arrangement of the monitors, it is possible to enhance the impression that all conferees are seated at a circular table. This is done by carefully routing the video images so that each conferee receives and transmits images in a consistent manner. Thus, if one conferee has another's image to his right, then the second conferee will have the first conferee's image to his left. Maintaining this sense of spatiality helps the conferees to determine who is being addressed at any instant.

The final two factors of the surrogates model are quite straightforward. The first simply reflects the possibility of obtaining black and white or color monitors. The second reflects the possibility of different size monitors.

3.1.2 The SGWS model - The shared graphical work space (SGWS) permits conferees to display information for discussion. A baseline SGWS is envisioned as consisting of an overhead camera at each station, which can be used to pick up information for display on black and white monitors in front of each conferee. This simple SGWS is quite austere, and the purpose of the SGWS model is to determine how the SGWS could be improved.

The SGWS model consists of the seven factors depicted in Figure 3-4. The first of these factors addresses the question of how the user will control the SGWS. At the simplest level this is a matter of providing switches to turn the camera on and off. At the next level a keyboard can be added, which now permits the user to access and control a computer. This would allow data in the computer to be routed to the SGWS. The next level of refinement is to

VARIABLE	1	2	3	4	5
1 SWITCHING/ INPUT	HARD SWITCHING	+ KEYBOARD	+ TOUCHSCREE	+ DATA TABLET	
2 PRIMARY MONITOR	B/W SIMPLE RASTER	COLOR SIMPLE RAS	B/W FRAME BUFFER	COLOR FRAME BUFF	
3 PREVIEW MONITOR	NONE	B/W SIMPLE RASTER	COLOR SIMPLE RAS	B/W FRAME BUFFER	COLOR FRAME BUFF
4 CONTROL MONITOR	NONE	ALPHANUMER IC			
5 STORAGE FACILITY	CENTRAL ONLY	CENTRAL AND LOCAL			
6 HARD COPY FACILITY	CENTRAL ONLY (COLO	CENTRAL + B/W LOCAL	CENTRAL+CO LOR LOCAL		
7 CONTROL LOCUS	PRINCIPAL	STAFF			

Figure 3-4

SGWS MODEL STRUCTURE

add a touchscreen, allowing easier interaction with a computer and permitting highlighting of the SGWS display. The final improvement is to add a data tablet, which permits a natural medium for drawing sketches.

The primary monitor factor captures two ways in which the primary monitor of the SGWS can vary. On the one hand this monitor can be either a black and white or color CRT. On the other, it can be either a simple raster device or it can have a frame buffer. A frame buffer stores a video image and automatically refreshes the CRT. In addition, it can be quite useful for mixing different types of video information, e.g., highlighting, split screens, etc.

The preview monitor is a second CRT that permits a conferee to examine his material before he transmits it to the teleconference. In addition to the issues of color and frame buffer identified above, there is also a question of whether a preview monitor is necessary. Thus, the five levels for this SGWS factor begin by assuming no preview monitor and then proceed through the same four levels identified for the primary monitor.

The control monitor is a third CRT that could be provided at a teleconference station. This monitor provides a simple alphanumeric display and would be used to communicate with a computer. Another potential use for this monitor is to convey printed messages between the conferees.

An important capability for the SGWS is the ability to store video images that have been presented on the SGWS. While it can be assumed that a central storage facility will be available, it is conceivable that the individual conferees will want a local storage facility. This could be used either for storing briefing materials or for documenting a meeting.

Another important capability is the creation of hard copy of an SGWS display. As with the storage facility, it can be assumed that a central hard copy capability is available. The issue is whether local hard copy in either black and white or color is desirable.

The final factor in the SGWS model is that of control locus. Given the potential complexity of the SGWS, it is likely that a staff will be needed to reap its full benefit. In the event that a staff is added, a communication link between it and the principal will be provided. In addition, most of the extra SGWS capabilities would be placed under the staff's control.

3.1.3 Number of sites - The surrogates model and SGWS model together comprise the site design model. This reflects the quality of the teleconference stations. The full model of the principal design includes one additional factor: the number of sites.

The number of possible teleconference sites has been specified as either four, eight, twelve, or thirty-five. Of course, at any one time, only three to six conferees could engage in a conference. There could, however, be several conferences at one time.

3.1.4 Central features model - The final component of the overall teleconference analysis is the central features model. The baseline design for the central features consists of all necessary video switching under processor control and a color hard-copy facility. The factors of the central features model represent improvements upon this basic design.

Figure 3-5 presents the three optional central features. The first anticipates the possibility of incorporating an optical video disk into the teleconference design.

VARIABLE	1	2	3
1 OPTICAL VIDEO DISK	NONE	MANUAL (R/O)	PROCESSOR (R/O)
2 MAG. VIDEO DISK	NONE	BUY	
3 VIDEOTAPE	NONE	BUY	

MODEL STRUCTURE

Figure 3-5
CENTRAL FEATURES MODEL STRUCTURE

This would permit access to a large number of fixed prestored video images such as maps, aerial photography, etc., which could be routed to the SGWS's. Because of the large number of possible images, it is desirable to place the video disk under computer control. Manual control is, however, available.

A second central feature anticipates the inclusion of a magnetic video disk. Compared to an optical video disk, the magnetic video disk has considerably less storage (about 200 as opposed to 54,000 frames of video). It does, however, provide a write capability, which is unavailable on the optical video disk. Such a video storage capability would be essential for retaining ad hoc video images that are generated during a meeting; it would also be necessary for storing briefing materials.

The final central feature entertains the possibility of including a videotape recorder at the central switching site. Such a device could be very useful for storing a record of the meeting. This could be used later to recall the decisions that were made or to restart an unfinished meeting. A voice-activated switch could be used to determine which image to record at each instance. Alternatively, a split screen might be employed.

3.2 Assessed Costs and Benefits

Final assessments of costs and benefits for various system components were obtained in several steps. An initial model was developed and briefed to MRAL personnel. The parameters of this model were assessed by DDI teleconference experts and decision analysts. Some important parameters--for example, benefit weights--could only be assessed by MRAL personnel. These weights were assessed in a working session with MRAL personnel and DDI decision analysts. Initial assessments, MRAL assessments, and model results were used to refine the weights into their final form, which is presented in this section.

3.2.1 The surrogate model - The many interactions among the variables of the surrogate model made it impossible to represent accurately total cost and benefit using any of the available Design model software. As a result, the surrogate design was handled by a separate analysis. The cost-efficient surrogate designs identified by this analysis were placed into the overall analysis, along with their calculated costs and benefits. Interactions occurred in costs; system benefit was an additive function of component benefits within the surrogate model.

Costs involved with different surrogate configurations are given by equations (1) and (2) for configurations without eye contact and with eye contact, respectively. The cost in equation (1) reflects the fact that when there is no eye contact, a single camera is sufficient at each teleconference site.

$$\text{COST} = (\#\text{SURR} \times \text{DISP}) + \text{CAM} \qquad (1)$$

Variables are defined as follows: #SURR represents the number of surrogates. DISP represents the cost of the display; this value depends on the size of the display as well as whether the display is black and white (BW) or color. CAM represents the costs of a single video camera. This cost depends on whether the displays are BW or color.

When there is eye contact, i.e., virtual space, each surrogate includes a camera as well as a display. The cost of the surrogate configuration is given by equation (2).

$$COST = \#SURR \times (DISP + CAM) \qquad (2)$$

Variable names have the same meaning in this equation as in equation (1).

The estimated costs for the surrogate model are shown in Table 3-1. These costs represent equipment costs alone and do not include costs of installation, operation, or maintenance.

Benefits for the surrogate model were represented as the weighted sum of the benefits assessed for each component. The benefits for each component were assessed on a relative scale in which the least beneficial level received the score 0, the most beneficial received the score 100, and other levels received intermediate scores in proportion to their benefit. In addition, weights were assessed to relate the range in benefit in one variable to the ranges in the other variables. The assessed benefits and weights are shown in Table 3-2. Rationale for the benefit scores is given in Appendix A.1.

3.2.2 The SGWS model - The variables of the SGWS model were constructed to have independent costs. With the exception of a single variable, the benefits are also independent across variables. The single dependency exists between the locus of control and the other SGWS variables. (Locus of control will be discussed separately.) For other variables, costs were assessed for each level, and benefits and benefit weights were assessed in the manner described in the previous section. These costs and benefits are presented in Table 3-3. Rationale for the benefits for all SGWS variables is presented in Appendix A.2.

The benefits assessed for the SGWS features assume that these features are easily controlled by the

Item	Estimated Costs
Black and White Camera	$ 500
Color Camera	$1000
Small Black and White Display	$ 300
Large Black and White Display	$ 500
Small Color Display	$ 400
Large Color Display	$ 800

Table 3-1
COST ESTIMATES FOR SURROGATE MODEL

Variable	Level 1	2	3	4	Weight
Number of Surrogates	0	60	90	100	100
Virtual Space	0	100			50
BW/Color	0	100			10
Size	0	100			30

Table 3-2

ASSESSED BENEFITS AND WEIGHTS FOR SURROGATE MODEL

VARIABLE 1 SWITCHING/ INPUT

		COST	BENFT
1	HARD SWITCHING	0	0
2	+ KEYBOARD	1000	40
3	+ TOUCHSCREEN	3000	90
4	+ DATA TABLET	4500	100

WITHIN CRITERION WEIGHTS 65

VARIABLE 2 PRIMARY MONITOR

		COST	BENFT
1	B/W SIMPLE RASTER	2000	0
2	COLOR SIMPLE RASTER	3100	20
3	B/W FRAME BUFFER	14000	60
4	COLOR FRAME BUFFER	15000	100

WITHIN CRITERION WEIGHTS 100

VARIABLE 3 PREVIEW MONITOR

		COST	BENFT
1	NONE	0	0
2	B/W SIMPLE RASTER	800	50
3	COLOR SIMPLE RASTER	1100	65
4	B/W FRAME BUFFER	14000	85
5	COLOR FRAME BUFFER	15000	100

WITHIN CRITERION WEIGHTS 25

VARIABLE 4 CONTROL MONITOR

		COST	BENFT
1	NONE	0	0
2	ALPHANUMERIC	900	100

WITHIN CRITERION WEIGHTS 10

VARIABLE 5 STORAGE FACILITY

		COST	BENFT
1	CENTRAL ONLY	0	0
2	CENTRAL AND LOCAL	18000	100

WITHIN CRITERION WEIGHTS 5

VARIABLE 6 HARD COPY FACILITY

		COST	BENFT
1	CENTRAL ONLY (COLOR)	0	0
2	CENTRAL + B/W LOCAL	5000	90
3	CENTRAL+COLOR LOCAL	11000	100

WITHIN CRITERION WEIGHTS 25

Table 3-3

ASSESSED COSTS AND BENEFITS FOR SGWS SITE MODEL principals. For most of the features, this requirement necessitates the transfer of control to a staff who functions as an intelligent interface between the principal and the system. It was judged that improvements in system sophistication would not be effective without the introduction of a staff to control these improvements. On the other hand, the least sophisticated system was simple enough that a staff was not needed to operate the system, and inclusion of a staff would not add any value to the system.

For the reasons mentioned above, the benefit from addition of staff control may be viewed as a multiplier of the benefits of the SGWS. Without a staff, SGWS enhancements have no benefits, and the benefit multiplier is 0. With staff, however, SGWS enhancements may receive their full value, and the benefit multiplier is 1.0. The cost involved with staff control involves the duplicate equipment which must be purchased to allow staff control, including a preview monitor, keyboard, and intercom. The cost of these extra items was estimated to be $3300 per site.

3.2.3 Number of sites - In addition to the items mentioned above, the cost of a site includes an estimated $8000 fixed cost for local switching, microphones, furniture, wires, video switches, and lighting. The total cost of a number of sites is simply the product of the total site cost and the number of sites. Thus, number of sites involves no cost of its own, but is a cost multiplier in determining total cost.

Benefits derived from increasing the number of sites were judged to be greater if the sites were more sophisticated than if the sites were less sophisticated. Assessed benefits shown in Table 3-4 indicate that greater benefit may be obtained from increasing the number of sites from four to twelve than from increasing the sophisitication

Site Sophistication	Number of Sites 4	8	12	35
Low-all Variables at Level 1	0	50	80	100
High-all Variables at Maximum	20	70	110	150

Table 3-4

ASSESSED BENEFITS FOR NUMBER OF SITES AS A FUNCTION OF SITE SOPHISTICATION of the sites from the minimum to maximum level. However, greater benefit is obtained from the improvement in sophistication at twelve sites than is obtained from increasing the number of sites from twelve to thirty-five. The value of the benefits and benefit multipliers assigned to this variable reflect these judgments.

3.2.4 Central features - Both costs and benefits are independent for the variables of the central features model. These parameters are displayed in Table 3-5, and rationale for the benefits is presented in Appendix A.3. In addition to the costs associated with the Design variables, there was a fixed cost of $200,000 for central switching hardware, central processing, image control, and processing and control software.

3.3 Model Results

Because of the complexity of the interactions in surrogate design, the surrogate model was developed separately from other models. The cost-efficient surrogate designs were put into the overall design as levels of a single surrogate variable. The overall analysis identified total teleconference designs offering the greatest benefit for the cost expended.

3.3.1 Surrogate model results - There are thirty-two possible surrogate designs taken from all possible combinations of the four Design variables. Of these designs, the analysis identified seven as being on the cost-efficient frontier. The levels of the variables for these seven designs are shown in Table 3-6 in order of increasing cost and benefit. A plot of the costs and benefits of these designs is given in Figure 3-6.

VARIABLE 1: OPTICAL VIDEO DISK

		COST	BENFT
1	NONE	0	0
2	MANUAL (R/O)	4000	60
3	PROCESSOR (R/O)	25000	100

WITHIN CRITERION WEIGHTS 100

VARIABLE 2: MAG. VIDEO DISK

		COST	BENFT
1	NONE	0	0
2	BUY	18000	100

WITHIN CRITERION WEIGHTS 40

VARIABLE 3: VIDEOTAPE

		COST	BENFT
1	NONE	0	0
2	BUY	1800	100

WITHIN CRITERION WEIGHTS 20

Table 3-5

ASSESSED COSTS AND BENEFITS FOR CENTRAL FEATURES MODEL

Number of Surrogates	Virtual Space	B/W Color	Size	Cost	Benefit
2	No	BW	Small	1100	0
3	No	BW	Small	1400	32
4	No	BW	Small	1700	47
3	Yes	BW	Large	3000	74
4	Yes	BW	Large	4000	89
5	Yes	BW	Large	5000	95
5	Yes	BW	Large	9000	100

Table 3-6

COST AND BENEFIT OF OPTIMAL CONFEREE
SURROGATE DESIGNS

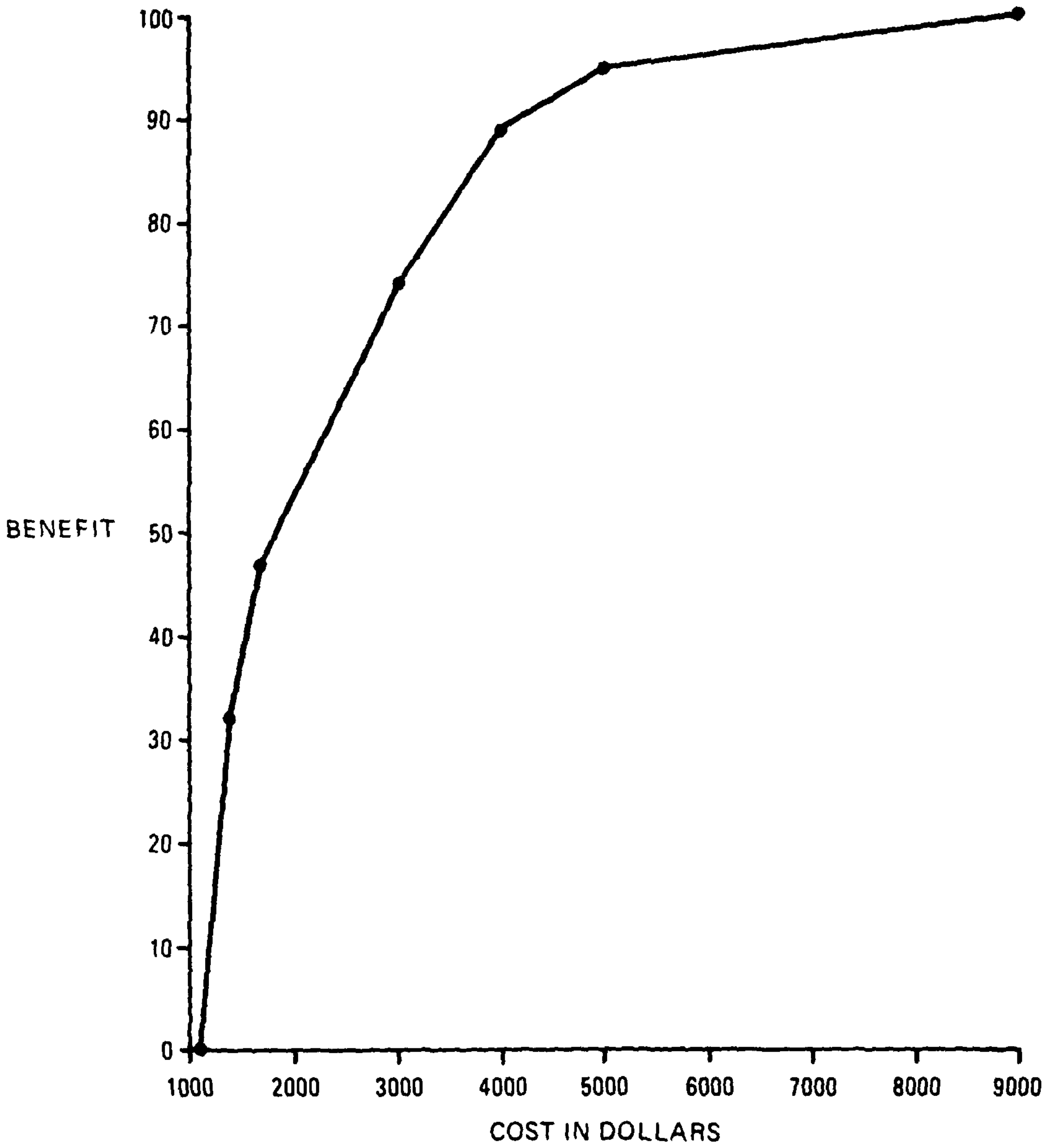

Figure 3-6

PLOT OF COSTS AND BENEFITS FOR COST-EFFICIENT SURROGATE DESIGNS

Table 3-6 shows that the most cost-beneficial enhancements to surrogate quality are in the number of surrogates, followed by the implementation of virtual space and increase in the screen size. The introduction of color surrogates was the least cost-beneficial improvement, and hence was made only at a high level of investment. These seven designs were used as levels of a surrogate variable in the overall Design model.

3.3.2 Overall model assessments - In order to perform the required analysis, it is necessary to assess for each level of each variable the four parameters, that is, fixed costs and benefit, and cost and benefit multipliers. The assessed values of these parameters are shown in Table 3-7. These values represent the judgments described in Section 3.2. In addition, two judgments were made by MRAL personnel relating the benefits obtained in the central features, surrogate features, and SGWS features. The first judgment was that the swing from the lowest to the highest level in the surrogate design was worth 2.5 times as much as the swing from the least to the most sophisticated SGWS design. Thus, if surrogate level receives a weight of 100, the total weight received by all SGWS factors is 40. The second judgment was that the magnetic video disk in central features is worth about 70% as much as the primary monitor for the SGWS. The primary monitor weight was calculated assuming staff control and thirty-five sites. Site and central fixed costs are included in variables 12 and 3, respectively.

3.3.3 Cost-efficient alternatives - The Design model identified twenty-six cost-efficient teleconference designs with costs ranging from $244K to $3.2M. The costs and benefits of these designs, shown in Figure 3-7, indicate that there are great differences in the cost-effectiveness of enhancements in different areas. As a result, it is possible to obtain a large proportion of the benefit of

VAR 1: OPTICAL VIDEO DISK

	COST	COST MULT	BENEFIT	BEN MULT
NONE	0	1.00	.00	1.00
MANUAL (R/O)	4000	1.00	1.05	1.00
PROCESSOR (R/O)	25000	1.00	1.75	1.00

VAR 2: MAG. VIDEO DISK

	COST	COST MULT	BENEFIT	BEN MULT
NONE	0	1.00	.00	1.00
BUY	18000	1.00	4.38	1.00

VAR 3: VIDEOTAPE

	COST	COST MULT	BENEFIT	BEN MULT
NONE	200000	1.00	.00	1.00
BUY	201800	1.00	3.51	1.00

VAR 4: NUMBER OF SITES

	COST	COST MULT	BENEFIT	BEN MULT
FOUR	0	4.00	.00	.14
EIGHT	0	8.00	50.00	.14
TWELVE	0	12.00	80.00	.21
THIRTY-FIVE	0	35.00	100.00	.36

VAR 5: SURROGATE LEVEL

	COST	COST MULT	BENEFIT	BEN MULT
2 NO BW SMALL	1100	1.00	.00	1.00
3 NO BW SMALL	1400	1.00	32.00	1.00
4 NO BW SMALL	1700	1.00	47.00	1.00
3 VS BW LARGE	3000	1.00	74.00	1.00
4 VS BW LARGE	4000	1.00	89.00	1.00
5 VS BW LARGE	5000	1.00	95.00	1.00
5 VS COLOR LARGE	9000	1.00	100.00	1.00

VAR 6: CONTROL LOCUS

	COST	COST MULT	BENEFIT	BEN MULT
PRINCIPAL	0	1.00	.00	.00
STAFF	3300	1.00	.00	1.00

Table 3-7

ASSESSED VALUES FOR PARAMETERS

VAR 7: SWITCHING/INPUT

	COST	COST MULT	BENEFIT	BEN MULT
HARD SWITCHING	0	1.00	.00	1.00
+ KEYBOARD	1000	1.00	4.17	1.00
+ TOUCHSCREEN	3000	1.00	9.39	1.00
+ DATA TABLET	4500	1.00	10.43	1.00

VAR 8: PRIMARY MONITOR

	COST	COST MULT	BENEFIT	BEN MULT
B/W SIMPLE RASTER	2000	1.00	.00	1.00
COLOR SIMPLE RASTER	3100	1.00	3.48	1.00
B/W FRAME BUFFER	14000	1.00	10.43	1.00
COLOR FRAME BUFFER	15000	1.00	17.39	1.00

VAR 9: PREVIEW MONITOR

	COST	COST MULT	BENEFIT	BEN MULT
NONE	0	1.00	.00	1.00
B/W SIMPLE RASTER	800	1.00	.87	1.00
COLOR SIMPLE RASTER	1100	1.00	1.13	1.00
B/W FRAME BUFFER	14000	1.00	1.48	1.00
COLOR FRAME BUFFER	15000	1.00	1.74	1.00

VAR 10: CONTROL MONITOR

	COST	COST MULT	BENEFIT	BEN MULT
NONE	0	1.00	.00	1.00
ALPHANUMERIC	900	1.00	3.48	1.00

VAR 11: STORAGE FACILITY

	COST	COST MULT	BENEFIT	BEN MULT
CENTRAL ONLY	0	1.00	.00	1.00
CENTRAL AND LOCAL	18000	1.00	.87	1.00

VAR 12: HARD COPY FACILITY

	COST	COST MULT	BENEFIT	BEN MULT
CENTRAL ONLY (COLOR)	8000	1.00	.00	1.00
CENTRAL + B/W LOCAL	13000	1.00	5.48	1.00
CENTRAL+COLOR LOCAL	19000	1.00	6.09	1.00

Table 3-7

ASSESSED VALUES FOR PARAMETERS (Cont'd)

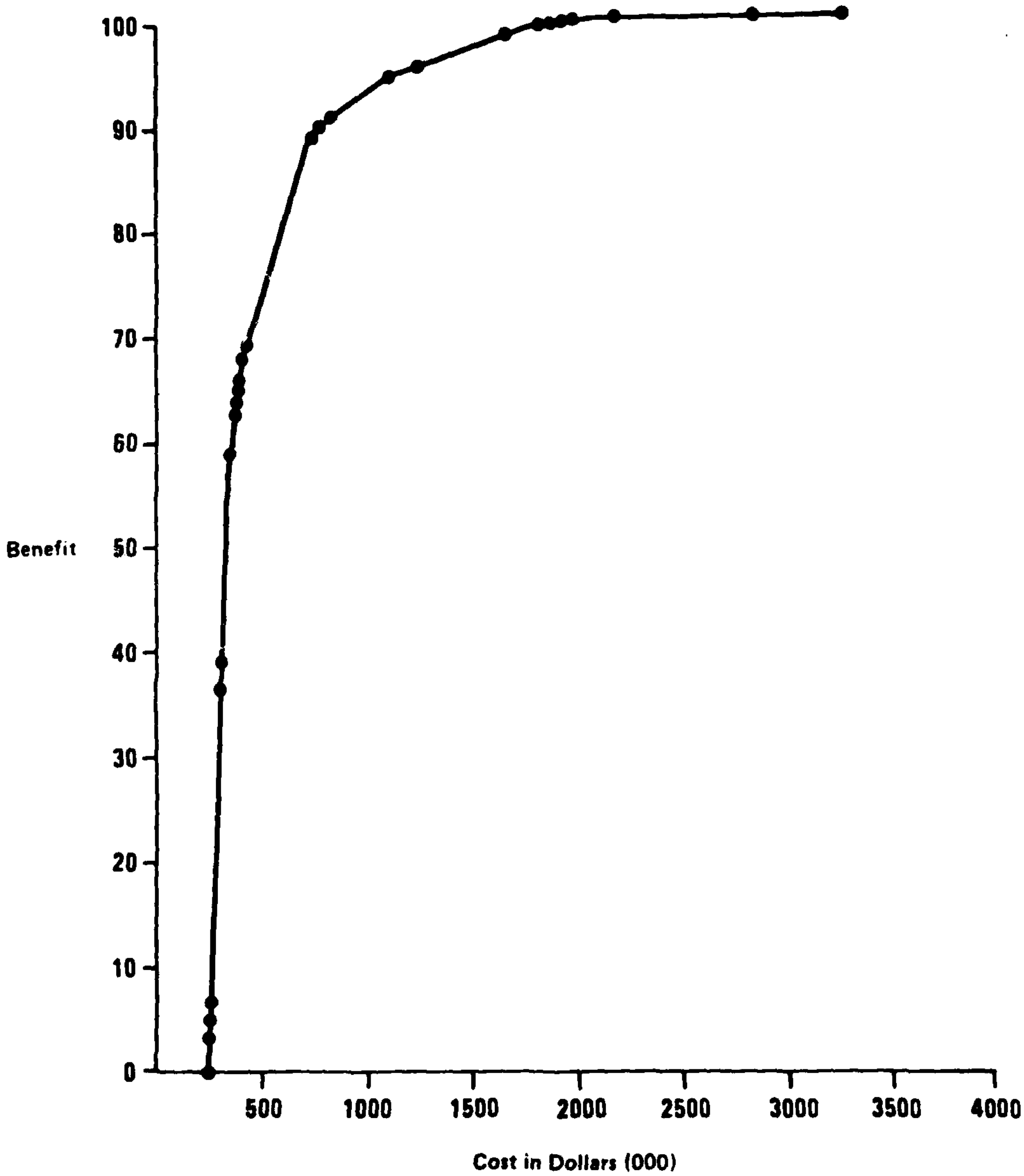

Figure 3-7
PLOT OF COSTS AND BENEFITS FOR
COST-EFFICIENT TELECONFERENCE SYSTEM DESIGNS

teleconferencing from a relatively small investment. (The details of each cost-efficient package are presented in Appendix B.) This section examines three packages varying in sophistication and cost, and makes generalizations about the cost-effectiveness of enhancements to teleconferencing in various areas.

The three designs examined in this section vary in cost from $357,800 to $1,791,800. They were chosen because the package of features they offer seemed reasonable when compared to the needs of MRAL. The least expensive and sophisticated of the designs does not include any enhancements to the SGWS but offers some sophistication in the surrogate design. The mid-level design offers staff control and some SGWS enhancements. The most expensive design includes all features except the least cost-beneficial.

Table 3-8 shows a system costing only $100K more than the minimal system that offers 62% of the relative benefit. This system involves twelve sites. The only central feature purchased is the videotape recorder. Although the videotape offers lower benefit than the magnetic video disk, its much lower cost makes it a better buy. The individual sites contain three conferee surrogates, each with its own camera to permit eye contact. The surrogates are large BW monitors. No improvements have been made to the SGWS.

A more sophisticated design, shown in Table 3-9, would cost about $1.1M and would offer several enhancements to the SGWS. These enhancements include keyboard and touch-screen input, a color primary monitor, and an alphanumeric control monitor. To obtain the benefits from the enhanced SGWS, a staff station was added to aid in system control. This particular design is the least expensive cost-efficient design in which there are any improvements to the SGWS. The

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	:	1 OF 3
MAG. VIDEO DISK	NONE	:	1 OF 2
VIDEOTAPE	BUY	:	2 OF 2
NUMBER OF SITES	TWELVE	:	3 OF 4
SURROGATE LEVEL	3 VS BW LARGE	:	4 OF 7
CONTROL LOCUS	PRINCIPAL	:	1 OF 2
SWITCHING/INPUT	HARD SWITCHING	:	1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	:	1 OF 4
PREVIEW MONITOR	NONE	:	1 OF 5
CONTROL MONITOR	NONE	:	1 OF 2
STORAGE FACILITY	CENTRAL ONLY	:	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)		1 OF 3

BENEFIT: 99.05 (62 PCT OF MAX)
COST: 357800 (11 PCT OF MAX)
THE EXCESS RESOURCE IS 0

Table 3-8

OPTIMAL LOW-COST DESIGN

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS BW LARGE	: 6 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ TOUCHSCREEN	: 3 OF 4
PRIMARY MONITOR	COLOR SIMPLE RASTER	: 2 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 149.726 (94 PCT OF MAX)
COST: 1060300 (33 PCT OF MAX)
THE EXCESS RESOURCE IS 0

Table 3-9

OPTIMAL MID-COST DESIGN

facts that several improvements were made simultaneously and that staff control was purchased along with these improvements reflect the judgments that staff control was necessary to obtain any of the benefits from SGWS enhancements. Since the cost of staff control does not depend on the number of features controlled, the purchase of staff control becomes cost-efficient only if there are several features over which the cost may be divided.

In terms of numbers of sites, central features, and surrogate quality, the design was at or near the highest level for all variables. Specifically, all central features are bought; there are thirty-five sites; and there are five large, BW surrogates, each with its own camera to allow for eye contact. The result that surrogate quality is improved before SGWS quality reflects both the judgment that improvements in the surrogates were more beneficial and the fact that the improvements in the surrogates are less costly than those in the SGWS.

Table 3-10 shows a design in which almost all enhancements have been made. This design gives 99% of the potential benefits for a cost of $1.8M. The features not included in this design are those which are prohibitively cost-inefficient. These features are the color local hard-copy facility, the local magnetic video disk, the preview monitor, and the data tablet. The preview monitor and the magnetic video disk were not included chiefly because of their extremely high cost. The other two features have a reasonable cost but do not provide great benefit in addition to features already present in the system.

Several generalizations may be made from the cost-efficient designs described above and in Appendix B. First, the quality of the surrogates is enhanced to a high level considerably before any improvements are made in the

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	3 OF 3
MAG. VIDEO DISK	BUY	2 OF 2
VIDEOTAPE	BUY	2 OF 2
NUMBER OF SITES	THIRTY-FIVE	4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	7 OF 7
CONTROL LOCUS	STAFF	2 OF 2
SWITCHING INPUT	+ TOUCHSCREEN	3 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	4 OF 4
PREVIEW MONITOR	NONE	1 OF 5
CONTROL MONITOR	ALPHANUMERIC	2 OF 2
STORAGE FACILITY	CENTRAL ONLY	1 OF 2
HARD COPY FACILITY	CENTRAL + B/W LOCAL	2 OF 3

BENEFIT 158.5064 (99 PCT OF MAX)
COST 1791800 (56 PCT OF MAX)
THE EXCESS RESOURCE IS 0

Table 3-10

OPTIMAL HIGH-COST DESIGN

SGWS. This result is reasonable when one considers the judgments made of both cost and benefit in the two areas. Specifically, the improvements in the surrogates were judged to be 2.5 times more beneficial than those in the SGWS. Also, the surrogate enchancements were obtained at a considerably lower cost than those in the SGWS. In addition to these considerations is the fact that SGWS improvements require the addition of a staff to operate them. The necessity of staff control further increases the cost of SGWS enhancements.

A second generalization is that the number of sites is increased to thirty-five at a relatively low cost. In fact, the improvement to thirty-five sites is made at a lower cost than the introduction of any SGWS improvements. This result is consistent with the judgment that improvements in site quality are worth half as much as those in number of sites. In addition, the quality improvements are worth less if there are fewer than thirty-five sites.

Finally, central features are introduced at a relatively low cost. The early introduction of central features results from the fact that these costs are shared among sites. Thus, as the number of sites increases, the central features become increasingly cost-beneficial.

3.4 Sensitivity Analyses

Section 3.3 described the results and identified some of the assessments that were critical in producing them. In this section, these critical assessments will be varied, and the results will be examined. The three critical assessments which will be examined are:

- o the weight of SGWS factors relative to surrogate quality;

- the weight of site quality relative to number of sites; and

- the costs associated with staff control.

Three dependent variables will be used in this sensitivity analysis: (1) the cost at which the number of sites is increased to thirty-five, (2) the cost at which the first improvement is made in the SGWS, and (3) the cost at which the last improvement is made in the surrogate quality.

To perform the sensitivity analyses, the model was run three additional times with changes in the parameter estimates of the model reflecting changes in the assumptions described above. The specific changes in each of the runs are described below:

For the first run, the weight of the SGWS enhancements was changed from 40% of that of surrogate quality to the same as that of surrogate quality.

For the second run, the weight of site quality was changed from 50% of that for number of sites (at thirty-five sites) to the same as that for number of sites. This change involved doubling the benefit multipliers for number of sites.

For the third run, staff control was assumed; the cost of staff was considered a fixed cost to make costs equivalent.

The results of these three analyses, presented in Table 3-11, indicate that there is little sensitivity to relatively large differences in these critical assessments. Results of each sensitivity analysis are discussed below.

	Cost At Which Change Occurs		
Weights	35 Sites	1st SGWS Enhancement	Last Surrogate Enhancement
Original Weight	$713,800	$1,060,300	$1,200,300
Increased Weight for SGWS	$713,800	$1,039,300	$1,882,800
Increased Weight for Site Quality	$713,800	$1,060,300	$1,200,300
Assume Staff Control	$829,300	$ 899,300	$1,200,300

Table 3-11

RESULTS OF SENSITIVITY ANALYSES ON CRITICAL ASSESSMENTS

Making SGWS quality as important as the quality of the surrogates has little impact on when improvements are made in the SGWS compared to improvements in the surrogate or an increase in the number of sites. As in the original model, the first SGWS improvement occurs after the purchase of thirty-five sites when the surrogate variable is at its penultimate level. The SGWS enhancement occurs before the processor is added to the optical video disk, as opposed to after in the original analysis. Also, the last improvement in the surrogate occurs much later in the analysis with revised weights.

The relative weight of number of sites and site quality seems to have little impact on the results of the analysis. In fact, none of the three costs of interest were changed by changes in this assessment.

Changing the assumptions about the staff also has a small effect on costs at which the critical enhancements are made. Since staff control is assumed, the cost of individual sites is somewhat higher than in the other analyses. Hence, the increase to thirty-five sites occurs at a somewhat higher cost. The first SGWS improvement occurs at a lower cost here than in the original analysis. Because the benefit of the SGWS features is not tied to the existence of the staff control, SGWS features are added singly, rather than as a group of simultaneous enhancements. The first change, the purchase of a keyboard, occurs earlier than in the other analyses. However, the enhancement still occurs after the move to thirty-five sites.

Sensitivity analyses indicate that the results of the analysis are relatively insensitive to changes in the critical assessments of the Design model. Consequently, one may be reasonably confident of the recommendations of the model; these recommendations indicate that central features, number of sites, and surrogate quality all offer areas in which relatively cost-efficient enhancements may be made to a teleconference system. Enhancements to the SGWS are less attractive, however, because of the relatively high cost, compared to the benefit obtained.

4.0 EVALUATION OF SELECTED SYSTEMS

The Design model described in Section 3.0 identified those functions of a teleconferencing system which could be performed with varying degrees of sophistication. The model results specified cost-efficient ways of enhancing system performance. The focus of this model was strictly to assess relative benefits for different areas of teleconferencing. The purpose of the model is to aid in allocating resources to purchase a cost-efficient teleconference system. The question of whether or not to purchase a video teleconference system was not addressed by the Design model.

Certain other characteristics of the Design model make it inappropriate as a tool for estimating the total cost of any specific teleconference system, or for documentation of the benefits of a specific system. First, the Design model includes equipment and software costs only. Other costs such as installation, maintenance, operator salary, and space for equipment were not included. Second, some of the costs which were considered fixed costs actually vary somewhat with overall system complexity. Because the variation of cost did not depend on a single variable, it was not possible to reflect it in the model assessments. Third, some interactions could not be considered in the Design model.

All of these simplifying assumptions were necessary to create a model which considered a wide range of options in many areas. Furthermore, the errors introduced by these assumptions are minor and do not affect the relative cost-effectiveness of different enhancements, especially in light of the results of the sensitivity analysis described in Section 3.0. However, they do indicate that the results of the Design model should be supplemented with a more detailed analysis of selected video teleconference systems.

This section describes such a detailed analysis. First, cost will be detailed for three selected systems, a four-site system, a twelve-site system, and a thirty-five-site system with enhancements in the SGWS. The costs of the systems will then be compared to the various benefits of the specific video teleconference systems. The purpose of this analysis is to provide a framework to assist MRAL in determining whether it is in their best interest to procure a video teleconference system, considering all costs and benefits involved.

4.1 Costs of Selected Systems

The three systems selected for detailed analysis of cost represent a wide range of size and sophistication, from a four-person demonstration system to a thirty-five-site system with staff control and several enhancements to the SGWS. In between these two systems is a twelve-site system with a baseline SGWS. All systems were chosen from the optimal systems discovered in the Design analysis. The twelve- and thirty-five-site systems correspond to the optimal low- and mid-cost systems described in Section 3.3.3.

4.1.1 Four-site system - The four-site design produced five percent of the possible benefit in the Design analysis, and has only two enhancements over the baseline system. These enhancements are the inclusion of central videotape and of three surrogates at each site instead of two. The system is monochrome for both the conferee surrogates and the SGWS. The costs involved in this system are detailed in Table 4-1.

Most of the entries in Table 4-1 correspond exactly to those in the Design model. The $32,000 for site costs corresponds to the $8000-per-site fixed costs in the Design model. Other costs are directly associated with

ONE-TIME	
Equipment:	
Site Costs (4)	
Audio System (4 @ $ 500 each)	$ 2,000
Switching (4 @ $3,000 each)	12,000
Furniture, Lighting, Video Switches (4 @ $4,500 each)	18,000
	32,000
Surrogates (3/Site)	
Small BW monitors (12 @ $ 200 each)	2,400
BW cameras (4 @ $ 500 each)	2,000
Cabinets (12 @ $ 100 each)	1,200
	5,600
Shared Graphical Workspace (1/Site)	
High resolution BW cameras (4 @ $1,200 each)	4,800
High resolution 19" BW cameras (4 @ $ 800 each)	3,200
	8,000
Central Features	
CPU	11,500
Videotape	1,800
BW Hard Copy	5,000
Time-based Corrector	20,000
Other	10,000
	48,300
Equipment Total	93,900
Software (including image processing, network control, data base management, and other)	150,000
Installation:	
Cable cost (12 lines/site, 4 sites, .1 mi./line, .10¢/ft. of cable)	2,534.40
Cable installation (4.8 mi. @ $ 400/mi.)	1,420
Site installation (4 sites @ $1,000/site)	4,000
Site Construction (4 sites @ $1,000/site)	4,000
	12,454.40
ONE-TIME TOTAL	$256,354.40
ONGOING	
Maintenance (1% of Equipment Cost/month)	11,268/yr.

Table 4-1

..TAILED COSTS FOR A FOUR-SITE TELECONFERENCE SYSTEM single Design variables. The costs of the monitors and their cabinets are separated in Table 4-1, although they appear together in the Design model. Similarly, costs for the SGWS monitors and cameras are listed separately here, although they make up a single Design variable, Primary Monitor.

The area in which detailed costs differ from those in the Design analysis is in the central features fixed costs. The Design model assumed a baseline of $50,000 for equipment and $150,000 for software, for a total fixed cost of $200,000. However, for the four-site system, the detailed costs are somewhat less, about $46,500 ($48,300 less $1800 for the videotape.) The main reason for this discrepancy is that color hard copy was assumed for the Design model, though it would not be needed for this system.

The cost of installation depends on many factors specific to the location of the sites within the Pentagon and to the ease with which necessary cables may be run between the sites and the central control facility. The cost of cables was estimated by extrapolating from corresponding costs for a research system which DDI has installed in its own facility. Because DDI's system also has four sites, the estimates are probably reasonably accurate for this design. However, the possibility that extrapolation would lead to inaccurate estimates is higher for the larger systems. In addition to costs for cable and its installation, it was estimated that it would cost $1000 for site construction and an additional $1000 for installation of each site.

The cost of maintenance was estimated to be one percent of the equipment cost per month. This cost is a typical charge for a maintenance contract for equipment of this level of sophistication. Costs involved with use of space and the system operator were not included in this detailed description.

4.1.2 Twelve-site system - Aside from the number of sites, the only difference between the twelve-site system and the four-site system described above is in the conferee surrogate design. The twelve-site system enhances person-to-person communication by incorporating the virtual space concept and increasing the size of the conferee-surrogate monitors. The system still does not incorporate color either in the conferee surrogates or in the SGWS.

Costs for this system are detailed in Table 4-2. Again, for this system, the central features fixed costs are somewhat less than those used in the Design model. Because such a system would connect all Deputy Assistant Secretaries of Defense (DASD) within MRAL, the average distance between each site and the central control location is greater for this sytem than for the four-site system. Thus, the cost per site of cabling is greater for this design than for the four-site system. All other assumptions for the cost calculations are the same for the two systems.

4.1.3 Thirty-five-site system - The thirty-five-site teleconference system provides enhanced capabilities in all three of the areas, central features, conferee surrogates, and SGWS. In addition to the videotape, the system includes an optical videodisk with processor control, and a magnetic videodisk as central features. The conferee surrogate design provides for five large, monochrome conferee surrogates with virtual space. The SGWS features include staff control, keyboard and touchscreen input, a color primary monitor, and an alphanumeric control monitor.

ONE-TIME

Equipment:	
Site Costs (12)	
Audio System (12 @ $ 500 each)	$ 6,000
Switching (12 @ $3,000 each	36,000
Furniture, lighting, video switches (12 @ $4,500 each)	54,000
	96,000
Surrogates (3/Site)	
19" BW monitors (36 @ $ 350 each)	12,600
BW cameras (36 @ $ 500 each)	18,000
Cabinets (36 @ $ 150 each)	5,400
	36,000
Shared Graphical Work Space (1/Site)	
High resolution BW cameras (12 @ $1,200 each)	14,400
High resolution 19" BW cameras (12 @ $ 800 each)	9,600
	24,000
Central Features	
CPU	11,500
Videotape	1,800
BW Hard Copy	5,000
Time-based Corrector	20,000
Other	10,000
	48,300
Equipment Total	$204,300
Software (including image processing, network control, data base management, and other)	150,000
Installation:	
Cable cost (14 lines/site, 12 sites, .2 mi./line, .10¢/ft. of cable)	17,740.80
Cable Installation (33.6 mi. @ $ 400/mi.)	13.440
Site Installation (12 sites @ $1,000/site)	12,000
Site Construction (12 sites @ $1,000/site)	12,000
	55,180.80
ONE-TIME TOTAL	$409,480.80
ONGOING	
Maintenance (1% of Equipment Cost/mo.)	24,516/yr.

Table 4-2

DETAILED COSTS FOR A TWELVE-SITE TELECONFERENCE SYSTEM

The details of the costs for this system are shown in Table 4-3. The central processor required to control such a network with so many features is considerably larger than that required for the other two systems. Thus, the central features fixed costs are $81,000, as opposed to the $50,000 which was assumed in the Design model. Because this increase in cost is related more to the overall complexity of the system than to any single variable, it cannot be accounted for in the Design model. However, an increase of this small magnitude would not be expected to have a substantial effect on the results of that analysis. All other assumptions used to calculate one-time cost are the same as those for the other systems. Since this system involves staff control, an additional ongoing expense would be the salaries of these staff. It was assumed that the system would be operated by existing staff, but that ten percent of their salary would be allocated as a cost of the system.

4.2 Evaluation Method

The method used to arrive at an overall evaluation of the selected systems is Multi-attribute Utility Analysis (MAUA). MAUA techniques are designed for the evaluation of fixed options that can be characterized as having values on each of a number (potentially large) of attributes. The procedure involves scoring each of the options with respect to its level on each of the attributes and then assessing the relative importances of the inter-attribute differences among the options under evaluation. For each option, an aggregate score is calculated by weighting the option score on each attribute by the respective importance of that attribute and summing across attributes.

ONE-TIME

Equipment:	
Site Costs (35)	
Audio System (35 @ $ 500 each)	$ 17,500
Switching (35 @ $3,000 each)	105,000
Furniture, lighting, video switches (35 @ $4,500 each)	157,500
	280,000
Surrogates (5/Site)	
19" BW monitors (175 @ $ 350 each)	61,250
BW cameras (175 @ $ 500 each)	87,500
Cabinets (175 @ $ 150 each)	26,250
	175,000
Shared Graphical Work Space (1/Site)	
Color Cameras (35 @ $2,000 each)	70,000
Color Displays (35 @ $1,100 each)	38,500
Touchscreens (35 @ $2,000 each)	70,000
	178,500
Staff (1/Site)	
Alphanumeric Terminal (35 @ $1,900 each)	66,500
Intercom (35 @ $ 200 each)	7,000
Color Display (35 @ $1,100 each)	38,500
Color Cameras (35 @ $2,000 each)	70,000
	182,000
Central Features	
SDMS Videodisc	25,000
Magnetic Videodisc	18,000
Videotape	1,800
Color Hard Copy	11,000
CPU	40,000
Time-based Corrector	20,000
Other	10,000
	125,800
Equipment Total	$941,300
Software (including image processing, network control, data base management, and other)	150,000

Table 4-3

DETAILED COSTS FOR A THIRTY-FIVE-SITE TELECONFERENCE SYSTEM

Installation:	
Cable Cost (20 lines/site, 35 sites, .2 mi./line, .10¢/ft. of cable)	73,920
Cable Installation (140 mi. @ $ 400/mi.)	56,000
Site Installation (35 sites @ $1,000/site)	35,000
Site Construction (35 sites @ $1,000/site)	35,000
	199,920
ONE-TIME TOTAL	$1,291,220
ONGOING	
Maintenance (1% of Equipment Cost/mo.)	112,956/yr.
Staff Salary ($20,000/yr per site for 10% of their time on system)	70,000/yr.
	$ 182,956

Table 4-3 (Con't.)

DETAILED COSTS FOR A THIRTY-FIVE-SITE TELECONFERENCE SYSTEM

Specific analytic steps include:

1. Develop an evaluation structure -

   - Identify the options for evaluation.

   - Identify attributes important to discriminating the values of these options.

   - Structure the attributes in an evaluation framework, i.e., decompose general attributes into more specific attributes to yield an evaluation hierarchy.

Briefly, the procedure involves the development of a hierarchical evaluation structure that appropriately interrelates a comprehensive set of evaluation criteria. These criteria have the property that they are relevant to discriminating among the alternatives under consideration. It may be, for example, that a criterion is generally relevant to the facility evaluation issue, but that all the alternatives score similarly on that criterion. Such a criterion is either omitted initially or given a zero weight when it is later discovered to be of minimal relevance to the evaluation at hand.

2. Score the options on the attributes -

   - Score each option with respect to each attribute.

   - Perform a relative evaluation; that is, assign the option considered worst with respect to the attribute a score of 0--the best is scored at 100. The remaining options are given relative scores between 0 and 100 by comparing them with the 0 and 100 options, as well as with each other.

- Record rationale for all scores and enter it into the computerized evaluation mechanism.

After scoring all alternatives for all criteria, it is necessary to combine the separate scores into more general aggregate scores including an overall summary score. The more aggregate criteria form the higher level hierarchy factors and are a weighted combination of more specific subfactors (criteria).

3. Assess inter-attribute importance weights -

   - Assign the attributes relative importance weights. The weight assigned an attribute reflects the relative importance of the difference between the 0- and 100-point options on that attribute as compared to the importance of the 100-point differences on other attributes.

Criterion weights are developed that appropriately interrelate the 100-point ranges established for each criterion. (Recall that all criteria have a 100 percent range, worst-to-best.) The importance weight assigned a criterion reflects the increase in importance or benefit involved in "swinging" that criterion from its lowest level (worst alternative on that criterion) to its highest level (best alternative on that criterion). If criterion A receives a weight of 100 and criterion B a weight of 60, this means that the observed difference in benefit on criterion B is about 60 percent of that observed for criterion A. In this manner, all criteria are interrelated. Note that these weights can only be established after the scoring has been accomplished because the structure evaluates differences in alternatives. The weights for the bottom-level criteria in the structure--those for which scores are directly assigned--are normalized to sum to 100 points. These normalized weights are denoted as CUMWTS in the printouts. The weight of a higher level criterion equals the sum of the CUMWTS of the lower level criteria that compose that criterion.

4. Compute aggregate scores for options -

   o Weight the score for an option on each attribute by the importance of the attribute. These weighted scores are summed to yield aggregate option scores.

5. Conduct sensitivity analyses -

   o Analyze the resultant aggregate scores to ensure the integrity of scores and weights. Evaluate the credibility of the results and examine the sensitivity of the results. The rationale used to justify scores permits these scores to be challenged and modified and then supported by rationale that justifies the revised scores.

   o Conduct sensitivity analyses to determine the effects of variation in weights assigned. The importance weights assigned to different factors are varied through reasonable ranges to identify potential changes in decisions that might result from a possible uncertainty or disagreement about weights.

6. Draw conclusions--decision implications.

4.3 Model and Results

A MAUA model was developed to evaluate four options for MRAL regarding teleconferencing. The options evaluated, evaluation structure, assessed scores and weights, and results are described in the following sections.

4.3.1 Teleconferencing options - The model evaluated four options regarding teleconferencing. Two of the options were the twelve- and thirty-five-site systems described previously. The four-site system was not included in the evaluation for two reasons. First, since the four-site system would serve mainly as a demonstration, it would have different kinds of benefits than the larger systems, which would offer potential benefits for actual use. Second, the twelve-site system offers considerably greater benefit at little increased cost; consequently, it offers greater value to MRAL than the four-site system. The twelve- and thirty-five-site systems are denoted in tables by V12 and V35, respectively.

Two additional options were evaluated. The first is the status quo (denoted SQ in tables), in which there is no teleconferencing, and all meetings are conducted face-to-face or on the telephone. The second option is an audio-only teleconferencing system (AUD). This system was included as a low-cost alternative to video teleconferencing, which still allowed a group of individuals to conduct a meeting without being in the same room. The audio teleconference system was envisioned to be a high-quality intercom system allowing multiple conferences. This option was not analyzed in great detail, but was included principally to provide a standard of comparison for the two video systems. It was assumed that such a system would be used about one-third as much as V35.

4.3.2 Evaluation structure - The four options were evaluated on sixteen factors which are organized hierarchically according to the structure shown in Figure 4-1. Overall, the factors were organized into two groups representing costs and benefits. Cost reflects the total cost involved in the procurement, installation, and maintenance of the system; thus, both one-time and ongoing costs were considered. Benefit reflects the facility with which meetings may be conducted under each of the options.

Four types of benefits were considered: meeting quality, scheduling, time saving, and organizational factors. Meeting quality refers to the ability of conferees to obtain and examine critical information, the ability of the leader to control the flow of the meeting, and the flexibility and privacy obtained under the options. Scheduling refers to the ability to arrange both people and facilities to schedule meetings which are either planned or ad hoc. Time savings refers to the ability of the options to reduce the unproductive time spent in travel or waiting for meetings. Finally, organizational factors measures the ability of the options to give equal access to the ASD by all DASD's and the ability of a DASD to get information from throughout the office.

4.3.3 Assessed scores and weights - Options were scored on each factor on a relative scale in which the best option received the score 100, and the worst option received the score 0. The assessed scores and weights are shown in Table 4-4. Rationale for the scores is presented in Appendix C.

The weights interrelate the ranges of scores on various factors. Two notes need to be made about the weights. As is common practice, ongoing expenses were considered five times as important as one-time expenses. The weights assigned

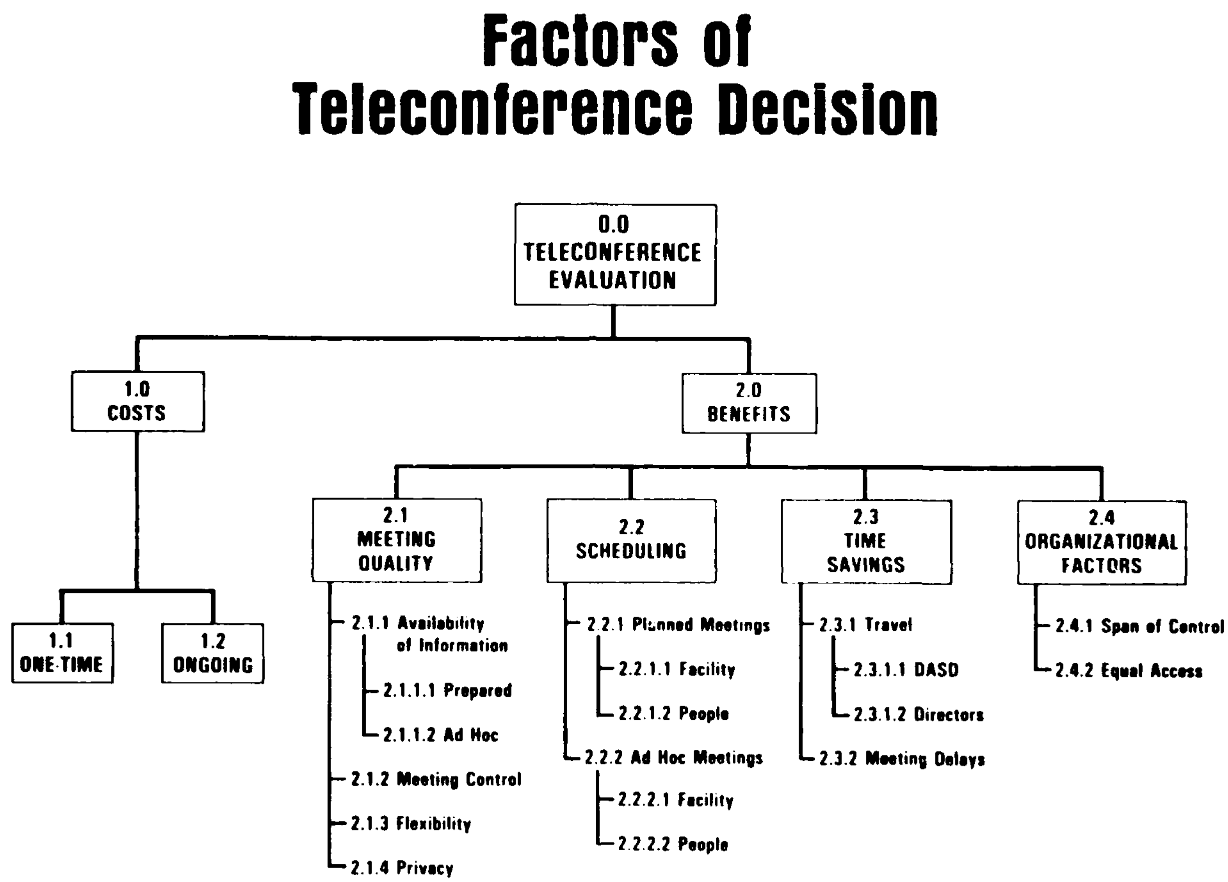

Figure 4-1
TELECONFERENCE MAU EVALUATION STRUCTURE

NODE		WEIGHT	SYSTEM SCORES SQ	AUD	V12	V35
0	- TELECONFER	(WT:100)				
1	- COSTS	(WT: 50)				
1.1	- ONE-TIME	(WT: 58)	100	97	68	0
1.2	- ONGOING	(WT: 42)	100	98	86	0
2	- BENEFITS	(WT: 50)				
2.1	- MEET QUAL	(WT: 29)				
2.1.1	- AVAIL INFO	(WT: 48)				
2.1.1.1	- PREPARED	(WT: 20)	100	0	60	90
2.1.1.2	- AD HOC	(WT: 80)	100	0	80	90
2.1.2	- MEET CNTRL	(WT: 24)	100	0	70	70
2.1.3	- FLEXIBLTY	(WT: 10)	100	50	0	0
2.1.4	- PRIVACY	(WT: 19)	100	0	30	30
2.2	- SCHEDULING	(WT: 18)				
2.2.1	- PLANNED	(WT: 38)				
2.2.1.1	- FACILITY	(WT: 80)	0	35	40	100
2.2.1.2	- PEOPLE	(WT: 20)	0	35	60	100
2.2.2	- AD HOC	(WT: 63)				
2.2.2.1	- FACILITY	(WT: 56)	0	75	80	100
2.2.2.2	- PEOPLE	(WT: 44)	0	35	70	100
2.3	- TIME SAVNG	(WT: 39)				
2.3.1	- TRAVEL	(WT: 29)				
2.3.1.1	- DASD	(WT: 60)	0	35	90	100
2.3.1.2	- DIRECTOR	(WT: 40)	0	35	0	100
2.3.2	- MEET DELAY	(WT: 71)	0	35	60	100
2.4	- ORG FACTOR	(WT: 14)				
2.4.1	- SPAN CNTRL	(WT: 56)	0	90	0	100
2.4.2	- EQUL ACCES	(WT: 44)	0	90	60	100

Table 4-4

ASSESSED SCORES AND WEIGHTS FOR TELECONFERENCE MAU EVALUATION to these factors reflect this judgment. The weight of cost relative to benefit was not assessed initially. The results of the analysis hinge on this weight, which depends greatly on the MRAL assessment of the extent of benefit, and a sensitivity analysis was performed to determine the effect of variation of the weight within this range. This analysis is described along with the other results.

4.3.4 Results - Table 4-5 shows the overall scores for the systems at each level of the evaluation structure except the top level. Each matrix represents a single node in the evaluation hierarchy. For example, the second matrix in Table 4-5 shows the utility score related to the cost of the options; one of the two major components of the evaluation. The table lists the two components of cost, one-time and ongoing. The total score is the weighted average of the scores on the two components with weights given in the column labeled "WT".

The next three columns give the scores of the four options on each of the two cost components, and the overall cost utility. The overall cost scores indicate that the thirty-five-site system is quite expensive compared to the other three alternatives. In fact, the difference in cost between the thirty-five and twelve-site systems (76 points) is over three times the difference between the twelve-site system and the status quo (24 points). The difference in total costs reflects a difference occurring both in one-time and ongoing costs. The first column to the right of the scores is a measure of discrimination which, for this analysis, is the same as the CUMWT. The CUMWT, which was explained earlier in this section, is displayed in the final column.

0 - TELECONFER

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT	FLG
1)	COSTS	(50)	100	97	76	0	50.00	50.00	
2)	BENEFITS	(50)	29	36	55	90	50.00	50.00	
	TOTAL		64	67	65	45	100.00	100.00	

1 - TELECONFER - COSTS

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT	FLG
1)	ONE-TIME	*(58)	100	97	68	0	29.00	29.00	
2)	ONGOING	*(42)	100	98	86	0	21.00	21.00	
	TOTAL		100	97	76	0	50.00	50.00	

2 - TELECONFER - BENEFITS

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT	FLG
1)	MEET QUAL	(29)	100	5	59	65	14.50	14.50	
2)	SCHEDULING	(18)	0	49	64	100	9.00	9.00	
3)	TIME SAVNG	(39)	0	35	58	100	19.50	19.50	
4)	ORG FACTOR	(14)	0	90	27	100	7.00	7.00	
	TOTAL		29	36	55	90	50.00	50.00	

2.1 - TELECONFER - BENEFITS - MEET QUAL

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT	FLG
1)	AVAIL INFO	(48)	100	0	76	90	6.90	6.90	
2)	MEET CNTRL	*(24)	100	0	70	70	3.45	3.45	
3)	FLEXIBLTY	*(10)	100	50	0	0	1.38	1.38	
4)	PRIVACY	*(19)	100	0	30	30	2.76	2.76	
	TOTAL		100	5	59	65	14.50	14 50	

2.1.1 - TELECONFER - BENEFITS - MEET QUAL - AVAIL INFO

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT	FLG
1)	PREPARED	*(20)	100	0	60	90	1.38	1.38	
2)	AD HOC	*(80)	100	0	80	90	5.52	5.52	
	TOTAL		100	0	76	90	6.90	6.90	

Table 4-5

AGGREGATED SCORES FOR TELECONFERENCE MAU EVALUATION

2.2 - TELECONFER - BENEFITS - SCHEDULING

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	PLANNED	(38)	0	35	44	100	3.37	3.37
2)	AD HOC	(63)	0	57	76	100	5.63	5.62
	TOTAL		0	49	64	100	9.00	9.00

2.2.1 - TELECONFER - BENEFITS - SCHEDULING - PLANNED

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	FACILITY	*(80)	0	35	40	100	2.70	2.70
2)	PEOPLE	*(20)	0	35	60	100	.67	.67
	TOTAL		0	35	44	100	3.37	3.37

2.2.2 - TELECONFER - BENEFITS - SCHEDULING - AD HOC

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	FACILITY	*(56)	0	75	80	100	3.13	3.12
2)	PEOPLE	*(44)	0	35	70	100	2.50	2.50
	TOTAL		0	57	76	100	5.63	5.62

2.3 - TELECONFER - BENEFITS - TIME SAVNG

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	TRAVEL	(29)	0	35	54	100	5.57	5.57
2)	MEET DELAY	*(71)	0	35	60	100	13.93	13.93
	TOTAL		0	35	58	100	19.50	19.50

2.3.1 - TELECONFER - BENEFITS - TIME SAVNG - TRAVEL

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	DASD	*(60)	0	35	90	100	3.34	3.34
2)	DIRECTOR	*(40)	0	35	0	100	2.23	2.23
	TOTAL		0	35	54	100	5.57	5.57

2.4 - TELECONFER - BENEFITS - ORG FACTOR

	FACTOR	WT	SQ	AUD	V12	V35	DISC1	CUMWT FLG
1)	SPAN CNTRL	*(56)	0	90	0	100	3.89	3.89
2)	EQUL ACCES	*(44)	0	90	60	100	3.11	3.11
	TOTAL		0	90	27	100	7.00	7.00

Table 4-5 (Con't.)

AGGREGATED SCORES FOR TELECONFERENCE MAU EVALUATION

The third matrix in Table 4-5 shows the overall benefits of the four options. This matrix indicates that status quo with exclusively face-to-face meetings offers the greatest meeting quality. However, for the other three attributes of benefit, the thirty-five-site video teleconference system offered the greatest value. The total score, representing the weighted average of the four attribute scores, gives the decided advantage to the larger teleconference system.

The first matrix in Table 4-5 does not show the total score for the options considering both cost and benefit because these top-level factors were not weighted at this point in the analysis. Figure 4-2 shows the overall cost utility and benefit of the four alternatives. Examination of this figure shows a close relationship between cost and benefit for the options; the more expensive options also give the greatest benefits. Thus, the weight of benefit compared to cost is critical in determining which option is chosen.

The problem in finding these critical top-level weights is one of determining the cost equivalent of the benefits derived from the teleconferencing. Specifically, the weight relates the benefit of a hypothetical system combining the meeting quality of face-to-face meetings with the scheduling, time savings, and organizational advantages of the large teleconference option. Of course, many of the benefits are subjective and very difficult to quantitate in terms of dollar values. Some of the factors, specifically those involving time savings, do allow a direct comparison to cost.

A reduction in the time spent waiting for meetings is one of the major benefits of teleconferencing. This factor represents 28% of the total benefits in the evaluation

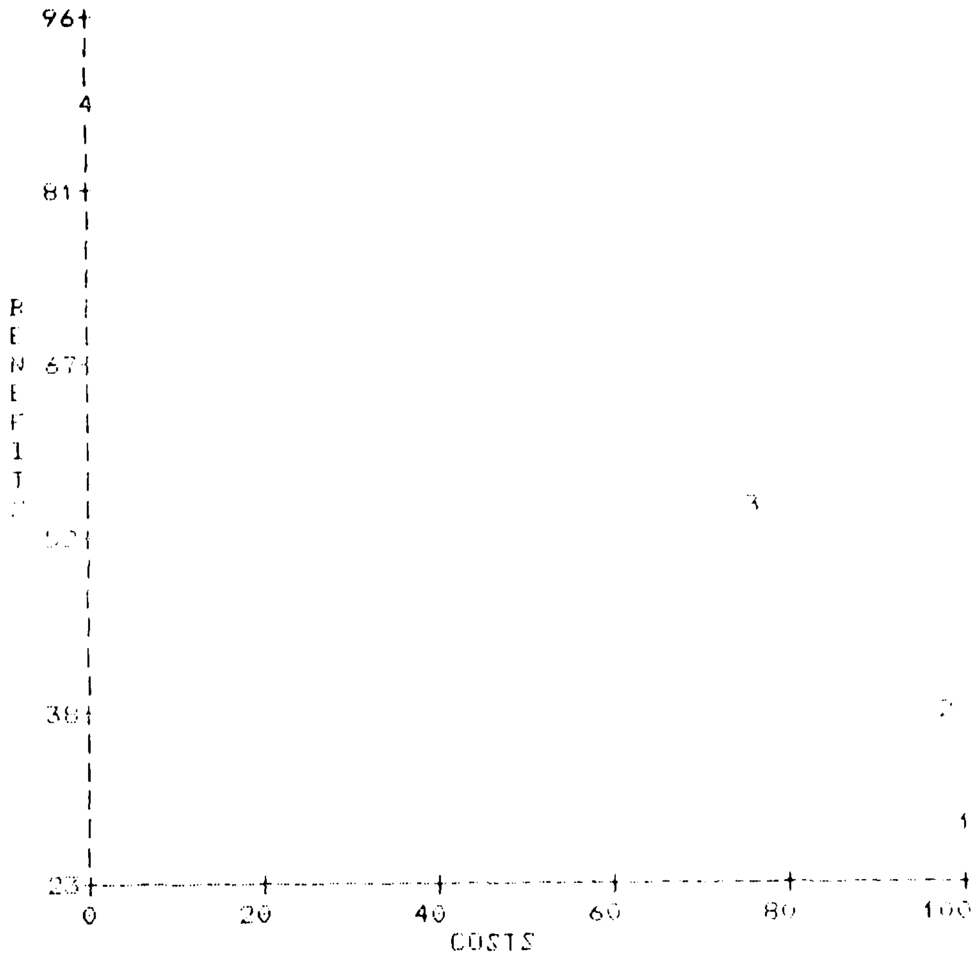

Figure 4-2
COST AND BENEFIT OF TELECONFERENCE OPTIONS

model. By placing a range on the amount of time saved by a teleconference system, and on the value of this time, one can obtain a reasonable range of relative value of benefit. At a minimum, it was assumed that a thirty-five-site system would save each of its users two hours a week. This time savings was valued at twenty-five dollars per hour. At this rate, the value of the annual time savings in waiting for meetings to begin would be $87,500 aggregated over the thirty-five users of the system. Since this factor represents 28% of the total benefits, the overall benefits would correspond to a cost savings of $312,500 annually.

For a maximum estimate of time savings, it was assumed that six hours were saved weekly by each user. This time was valued at fifty dollars per hour. With these estimates, the value of the time savings amounts to $525,000, giving the value to all benefits of $1,875,000. Using these values to determine the range for the weight of benefit implies that benefit must have a weight between 40% and 80% of all factors in the model.

The effects of varying the weight of benefit from 40% to 80% are shown in the sensitivity analysis in Table 4-6. This table shows the overall score for the four options as the weight of benefit is varied. The option with the highest score is indicated with an asterisk. Table 4-6 shows that the optimal option depends greatly on the weight of benefit within the reasonable range. If the weight of benefit is near 40%, then either the audio system or the status quo is preferred. If the weight is near 80%, then the larger video teleconference system is preferred. In the intermediate range, the twelve-site system is preferred.

The scores of SQ, AUD, and V35 all vary greatly with the weight of benefit. Thus, the forty-point shift in weight is associated with a shift in overall score of between

2 BENEFITS - CURRENT CUMWT: 50.00

CUMWT	SQ	AUD	V12	V35
40.0	72	73*	67	36
44.0	69	71*	66	40
48.0	66	68*	66	43
52.0	63	66*	65	47
56.0	60	63	64*	50
60.0	57	61	63*	54
64.0	55	58	62*	58
68.0	52	56	62*	61
72.0	49	54	61	65*
76.0	46	51	60	68*
80.0	43	49	59	72*

Table 4-6

SENSITIVITY OF RESULTS TO WEIGHT OF BENEFITS

24 and 36 points for these three options. The score of V12 is much less sensitive to variation in weights. For this option, the swing in weight leads to only an eight-point swing in overall score. Furthermore, the V12 option receives a reasonably good score regardless of the relative weights of costs and benefits within this range. If there were no further information about the extent of benefits from the video teleconference systems, then it would be reasonable to recommend the V12 option. However, the overall sensitivity of the results to the extent of benefits indicates that MRAL should quantitate carefully the extent to which a teleconference system would find use within the office, and the extent to which use of the system would save time.

4.3.5 Discussion - The results of the MAUA model indicate that video teleconferencing can offer a cost-effective solution to problems of scheduling meetings, providing access by all DASDs to decision data and to the ASD, and avoiding wasted time involved in transit to and from meetings and waiting for meetings to begin. Whether this solution is cost-effective for MRAL depends on whether benefits are more closely approximated by the minimum or maximum values of the sensitivity analysis. Without further information, it appears that a twelve-site video teleconference system would be the best option for MRAL.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The analyses described in this report address two questions: First, how should a video teleconference system be designed to obtain the greatest benefit for the cost? Second, do the benefits obtained from one of the cost-efficient designs justify its procurement? The first question was addressed using a cost-benefit Design model; the second was addressed using a MAU evaluation model.

The results of the Design model indicate several cost-beneficial areas in central features and surrogate design for enhanced performance. Enhancements in the SGWS, in general, offer less value for the cost than the other areas. Nevertheless, those areas of the SGWS providing the most attractive investment were identified. The relative ranking of SGWS enhancements versus other areas seems reasonable given the state of development of the technologies in these areas. The technology involved in transmitting the images of the conferees has existed for quite awhile; furthermore, video equipment is mass-produced at a low cost.

In contrast to the mature video technology, the technology for providing enhancements in the SGWS is still developing. Costs in many of these areas are relatively high. Although current SGWS enhancements are relatively cost-inefficient, in the future, these costs will be expected to decrease. Thus, the baseline cost for future teleconference systems will be expected to remain relatively constant or decrease slightly. The cost of enhanced capabilities will be expected to decrease dramatically in the coming years. A reasonable strategy for procurement of video teleconferencing is consistent with the recommendations of the Design model. That is, for the present, money should be directed toward developing the communication network and the communication of the images of the conferees. SGWS enhancements will be more cost-efficient in the future.

The MAU evaluation model documents both the costs and benefits associated with video teleconferencing. The results indicate that procurement of a video teleconference system may be justified by its benefits if those benefits are as great as estimated in this analysis. The benefits come from several sources. Chief among these sources is the savings derived from decrease in travel time and unproductive time spent waiting for meetings to begin. In addition, benefits are obtained from increased ease of scheduling and increased access to both individuals and information. On the other hand, the quality of teleconferenced meetings is not expected to attain the level of face-to-face meetings.

A critical assessment in the MAU analysis is that of the importance of the benefits obtained relative to the costs of procurement and operation. A sensitivity analysis indicates the importance of careful assessment of this critical weight. If the benefits are sufficient, the model would indicate that procurement of a twelve-site or even a thirty-five-site teleconference system would be justified.

The results of these analyses lead to two recommendations. First, MRAL should examine the benefits from teleconference to determine if the estimates used in this analysis are reasonable and to pinpoint the expected benefits within the range of reasonable values. The line of reasoning used in obtaining the current estimates may be used to obtain a refined weight of benefits relative to costs. The option recommended by the analysis may then be determined by examining the sensitivity analysis shown in Table 4-6.

Second, if the expected benefits fall near the center of the range used in this analysis, the MAU analysis would recommend the procurement of a twelve-site video teleconference system as outlined in this report. Such a system has advantages over smaller systems in that it is a large enough system to provide real value to MRAL, rather than value merely as a demonstration system. Furthermore, such a system would be expandable to include more sites or more sophisticated sites as the need arose or enhancements became cost-effective. However, the recommendation of the model is dependent on MRAL's evaluation of the extent of benefit obtained. If the benefit is low, then MRAL should not procure a teleconference system, or it should consider an audio teleconference system. If the benefit is higher, a larger teleconference system such as the thirty-five-site system should be considered.

APPENDIX A

RATIONALE FOR BENEFITS OF TELECONFERENCE DESIGN VARIABLES

VARIABLE 1: NUMBER SURROGATES

CRITERION:	BENFT		
1	2	3	4
0	60	90	100

With two surrogates only three individuals may participate in any teleconference. Some conferences in MRAL are this small (such as those involving the PDASD, one DASD, and one outside person), but this system would operate only in a closed environment.

Going to three or four surrogates increases greatly the flexibility of the system to handle larger conferences. Four surrogates allows meetings involving five people; it was felt that this represents a reasonable maximum for the number of conferees at a meeting.

Going to five surrogates would have a small improvement in flexibility. In addition, the large number of monitors may lead to some confusion and slightly lower performance. The net improvement is small.

VARIABLE 2: VIRTUAL SPACE

CRITERION:	BENFT
1	2
0	100

Virtual Space allows eye contact among the conferees. Eye contact makes the teleconference more realistic, and leads to smoother, more efficient meetings. The symmetric arrangement of surrogates required for Virtual Space may prove somewhat inconvenient if there is a large number of surrogates. In that case, surrogate position may deviate from that dictated by Virtual Space. However, each surrogate will have its own camera to maintain eye contact.

Appendix A.1

SURROGATES MODEL

VARIABLE 3: BW/COLOR

	CRITERION:	BENFT
	1	2
	0	100

Color monitors on the conferee surrogates leads to slightly better realism in teleconferences. This difference is less than the differences in other areas, however.

VARIABLE 4: SIZE

	CRITERION:	BENFT
	1	2
	0	100

Large monitors leads to a much more realistic teleconference. The greatest realism occurs when the image is similar to its actual size. Seventeen- to nineteen-inch monitors provide fairly good realism.

Appendix A.1

SURROGATES MODEL (Cont'd)

VARIABLE 1: SWITCHING/ INPUT

CRITERION: BENFT			
1	2	3	4
0	40	90	100

Keyboard input allows alphanumeric input and provides for an easy, legible message facility. Problem: requires user to know how to type.

Addition of a touchscreen allows the user additional features, such as highlighting of areas of interest on displays, simplified menu selection for control, and enhanced written communication among users.

The data tablet adds higher resolution input for greater capability for shared blackboard which does not interfere with graphic display.

VARIABLE 2: PRIMARY MONITOR

CRITERION: BENFT			
1	2	3	4
0	20	60	100

Assume screen size is 15".
Color would be useful for differentiating information sources, highlighting information, focusing attention, etc.

Frame buffer allows you to integrate analog and digital sources; local storage of freeze-frame images. Without frame buffer, some kinds or combinations of information would be impossible or overly expensive.

With frame buffer, color is worth more because of capabilities for color coding, complex manipulations, etc.

Appendix A.2

SGWS MODEL

VARIABLE 3: PREVIEW MONITOR

CRITERION: BENFT				
1	2	3	4	5
0	50	65	85	100

Without preview monitor, could still preview information on the main screen, using a button or switch. Having a separate preview monitor allows uninterrupted access to the main display, and simplifies operations (fewer controls to manipulate).

Becuase preview monitor does not need to mix multiple-source information as critically, frame buffer and color both become less important, and both interact less. Frame buffer is still more important than color, because the main concern is overall content, rather than detail; you would still benefit from being able to integrate digital and analog inputs (e.g., video image and touch screen inputs).

VARIABLE 4: CONTROL MONITOR

CRITERION: BENFT	
1	2
0	100

Alphanumeric monitor for menu listing, messages, etc.
Would involve input from touch screen, data tablet, or keyboard.

Main value would be to avoid clutter on primary screen.

Appendix A.2

SGWS MODEL (Cont'd)

VARIABLE 5: STORAGE FACILITY

CRITERION: BENFT

1	2
0	100

Magnetic video disk at local site to permit individual conferrees to obtain a personal record of displaysfor subsequent access or documentation.

Reliability would be higher because of redundancy, independence of central routing facility; also, psychological advantage of 'owning' personal record. Privacy might be an advantage.

VARIABLE 6: HARD COPY FACILITY

CRITERION: BENFT

1	2	3
0	90	100

Local hard copy facilities will be used to augment the capability of a central high-resolution color hard copy facility with manual dissemination.

Because the primary benefit will come from immediate access to local copies, b/w will be sufficient for the vast majority of cases (only certain color displays which do not copy well into b/w would be adversely affected).

Appendix A.2

SGWS MODEL (Cont'd)

VARIABLE 7: CONTROL LOCUS	CRITERION: BENFT	
	1	2
	0	0

Staff communications would have an intercom, preview screen, and keyboard; principal would have the same installation as before.

Principal does not need to learn mechanics of information manipulation with *staff control. Principal would be free to participate* in conference without need to search for input data, computer items, etc., but principal *needs to depend on staff's performance. Staff* would have little if any benefit for the baseline system. However, staff control is necessary to obtain the benefits of site sophistication.

Appendix A.2

SGWS MODEL (Cont'd)

VARIABLE 1: OPTICAL VIDEO DISK — CRITERION: BENFT

1	2	3
0	60	100

The optical video disk could be used for storing and displaying large quantities of video data, such as maps, pictures, blueprints, and other items which could be prepared in advance. Since there is no write capability, the optical video disk would be most useful for fairly static information.

The large strorage capacity of a video disk (54K frames) makes processor control very helpful in deriving full benefit from the video disk.

VARIABLE 2: MAG. VIDEO DISK — CRITERION: BENFT

1	2
0	100

The magnetic video disk provides the capability to store and retrieve information in video format. One use for this device would be to save the images on the SGWS for use at later conferences, or to serve as a summary of meeting accomplishments. Another use would be as a storage device for briefing materials.

Appendix A.3

CENTRAL FEATURES MODEL

CENTRAL FEATURES MODEL   TUESDAY 9/16/1980 13:20

VARIABLE 3: VIDEOTAPE

CRITERION	BENFT
1	2
0	100

Videotape would be used to provide a record of critical conferences, to present recorded briefings and other information for which it is sufficient to view material sequentially. Although videotape does not provide random access, as does video disk, the process involved in making a videotape is much simpler and less time consuming than the process involved in video-disk production.

Appendix A.3

CENTRAL FEATURES MODEL (Cont'd)

APPENDIX B

LIST OF COST-EFFICIENT SYSTEM DESIGNS

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	: 1 OF 3
MAG. VIDEO DISK	NONE	: 1 OF 2
VIDEOTAPE	NONE	: 1 OF 2
NUMBER OF SITES	FOUR	: 1 OF 4
SURROGATE LEVEL	2 NO BW SMALL	: 1 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 0 (0 PCT OF MAX)
COST: 244400 (8 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	: 1 OF 3
MAG. VIDEO DISK	NONE	: 1 OF 2
VIDEOTAPE	NONE	: 1 OF 2
NUMBER OF SITES	FOUR	: 1 OF 4
SURROGATE LEVEL	3 NO BW SMALL	: 2 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 4.48 (3 PCT OF MAX)
COST: 245600 (8 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	: 1 OF 3
MAG. VIDEO DISK	NONE	: 1 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	FOUR	: 1 OF 4
SURROGATE LEVEL	3 NO BW SMALL	: 2 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 7.99 (5 PCT OF MAX)
COST: 247400 (8 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	: 1 OF 3
MAG. VIDEO DISK	NONE	: 1 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	FOUR	: 1 OF 4
SURROGATE LEVEL	4 NO BW SMALL	: 3 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 10.09 (6 PCT OF MAX)
COST: 248600 (8 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	1 OF 3
MAG. VIDEO DISK	NONE	1 OF 2
VIDEOTAPE	BUY	2 OF 2
NUMBER OF SITES	EIGHT	2 OF 4
SURROGATE LEVEL	3 NO BW SMALL	2 OF 7
CONTROL LOCUS	PRINCIPAL	1 OF 2
SWITCHING/INPUT	HARD SWITCHING	1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	1 OF 4
PREVIEW MONITOR	NONE	1 OF 5
CONTROL MONITOR	NONE	1 OF 2
STORAGE FACILITY	CENTRAL ONLY	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	1 OF 3

BENEFIT: 57.99 (36 PCT OF MAX)
COST: 293000 (9 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	1 OF 3
MAG. VIDEO DISK	NONE	1 OF 2
VIDEOTAPE	BUY	2 OF 2
NUMBER OF SITES	EIGHT	2 OF 4
SURROGATE LEVEL	4 NO BW SMALL	3 OF 7
CONTROL LOCUS	PRINCIPAL	1 OF 2
SWITCHING/INPUT	HARD SWITCHING	1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	1 OF 4
PREVIEW MONITOR	NONE	1 OF 5
CONTROL MONITOR	NONE	1 OF 2
STORAGE FACILITY	CENTRAL ONLY	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	1 OF 3

BENEFIT: 60.09 (38 PCT OF MAX)
COST: 295400 (9 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	: 1 OF 3
MAG. VIDEO DISK	NONE	: 1 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	TWELVE	: 3 OF 4
SURROGATE LEVEL	4 NO BW SMALL	3 OF 7
CONTROL LOCUS	PRINCIPAL	1 OF 2
SWITCHING/INPUT	HARD SWITCHING	1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	1 OF 4
PREVIEW MONITOR	NONE	1 OF 5
CONTROL MONITOR	NONE	1 OF 2
STORAGE FACILITY	CENTRAL ONLY	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	1 OF 3

BENEFIT 93.[illegible] (58 PCT OF MAX)
COST 342200 (11 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	NONE	1 OF 3
MAG. VIDEO DISK	NONE	1 OF 2
VIDEOTAPE	BUY	2 OF 2
NUMBER OF SITES	TWELVE	3 OF 4
SURROGATE LEVEL	3 VS BW LARGE	4 OF 7
CONTROL LOCUS	PRINCIPAL	1 OF 2
SWITCHING/INPUT	HARD SWITCHING	1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	1 OF 3

BENEFIT 99.05 (62 PCT OF MAX)
COST 357800 (11 PCT OF MAX)
THE EXCESS RESOURCE IS 0

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THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    MANUAL (R/O)          : 2 OF 3
MAG. VIDEO DISK       NONE                  : 1 OF 2
VIDEOTAPE             BUY                   : 2 OF 2
NUMBER OF SITES       TWELVE                : 3 OF 4
SURROGATE LEVEL       3 VS BW LARGE         : 4 OF 7
CONTROL LOCUS         PRINCIPAL             : 1 OF 2
SWITCHING/INPUT       HARD SWITCHING        : 1 OF 4
PRIMARY MONITOR       B/W SIMPLE RASTER     : 1 OF 4
PREVIEW MONITOR       NONE                  : 1 OF 5
CONTROL MONITOR       NONE                  : 1 OF 2
STORAGE FACILITY      CENTRAL ONLY          : 1 OF 2
HARD COPY FACILITY    CENTRAL ONLY (COLOR)  : 1 OF 3

BENEFIT: 100.1  (63 PCT OF MAX)
COST:     361800  (11 PCT OF MAX)
THE EXCESS RESOURCE IS 0



THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    NONE                  : 1 OF 3
MAG. VIDEO DISK       NONE                  : 1 OF 2
VIDEOTAPE             BUY                   : 2 OF 2
NUMBER OF SITES       TWELVE                : 3 OF 4
SURROGATE LEVEL       4 VS BW LARGE         : 5 OF 7
CONTROL LOCUS         PRINCIPAL             : 1 OF 2
SWITCHING/INPUT       HARD SWITCHING        : 1 OF 4
PRIMARY MONITOR       B/W SIMPLE RASTER     : 1 OF 4
PREVIEW MONITOR       NONE                  : 1 OF 5
CONTROL MONITOR       NONE                  : 1 OF 2
STORAGE FACILITY      CENTRAL ONLY          : 1 OF 2
HARD COPY FACILITY    CENTRAL ONLY (COLOR)  : 1 OF 3

BENEFIT: 102.2  (64 PCT OF MAX)
COST:     369800  (12 PCT OF MAX)
THE EXCESS RESOURCE IS 0
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THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    MANUAL (R/O)             : 2 OF 3
MAG. VIDEO DISK       NONE                     : 1 OF 2
VIDEOTAPE             BUY                      : 2 OF 2
NUMBER OF SITES       TWELVE                   : 3 OF 4
SURROGATE LEVEL       4 VS BW LARGE            : 5 OF 7
CONTROL LOCUS         PRINCIPAL                : 1 OF 2
SWITCHING/INPUT       HARD SWITCHING           : 1 OF 4
PRIMARY MONITOR       B/W SIMPLE RASTER        : 1 OF 4
PREVIEW MONITOR       NONE                     : 1 OF 5
CONTROL MONITOR       NONE                     : 1 OF 2
STORAGE FACILITY      CENTRAL ONLY             : 1 OF 2
HARD COPY FACILITY    CENTRAL ONLY (COLOR)     : 1 OF 3

BENEFIT:  103.25  (65 PCT OF MAX)
COST:     373800  (12 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    MANUAL (R/O)             : 2 OF 3
MAG. VIDEO DISK       BUY                      : 2 OF 2
VIDEOTAPE             BUY                      : 2 OF 2
NUMBER OF SITES       TWELVE                   : 3 OF 4
SURROGATE LEVEL       4 VS BW LARGE            : 5 OF 7
CONTROL LOCUS         PRINCIPAL                : 1 OF 2
SWITCHING/INPUT       HARD SWITCHING           : 1 OF 4
PRIMARY MONITOR       B/W SIMPLE RASTER        : 1 OF 4
PREVIEW MONITOR       NONE                     : 1 OF 5
CONTROL MONITOR       NONE                     : 1 OF 2
STORAGE FACILITY      CENTRAL ONLY             : 1 OF 2
HARD COPY FACILITY    CENTRAL ONLY (COLOR)     : 1 OF 3

BENEFIT:  107.63  (67 PCT OF MAX)
COST:     391800  (12 PCT OF MAX)
THE EXCESS RESOURCE IS 0
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THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	MANUAL (R/O)	: 2 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	TWELVE	: 3 OF 4
SURROGATE LEVEL	5 VS BW LARGE	: 6 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 108.89 (68 PCT OF MAX)
COST: 403800 (13 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	MANUAL (R/O)	: 2 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	4 VS BW LARGE	: 5 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 140.98 (88 PCT OF MAX)
COST: 713800 (22 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	MANUAL (R/O)	: 2 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS BW LARGE	: 6 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 143.14 (89 PCT OF MAX)
COST: 748800 (23 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FI[illegible]	: 4 OF 4
SURROGATE LEVEL	5 VS BW LARGE	: 6 OF 7
CONTROL LOCUS	PRINCIPAL	: 1 OF 2
SWITCHING/INPUT	HARD SWITCHING	: 1 OF 4
PRIMARY MONITOR	B/W SIMPLE RASTER	: 1 OF 4
PREVIEW MONITOR	NONE	: 1 OF 5
CONTROL MONITOR	NONE	: 1 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	: 1 OF 3

BENEFIT: 143.84 (90 PCT OF MAX)
COST: 769800 (24 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	:	3 OF 3
MAG. VIDEO DISK	BUY	:	2 OF 2
VIDEOTAPE	BUY	:	2 OF 2
NUMBER OF SITES	THIRTY-FIVE	:	4 OF 4
SURROGATE LEVEL	5 VS BW LARGE	:	6 OF 7
CONTROL LOCUS	STAFF	:	2 OF 2
SWITCHING/INPUT	+ TOUCHSCREEN	:	3 OF 4
PRIMARY MONITOR	COLOR SIMPLE RASTER	:	2 OF 4
PREVIEW MONITOR	NONE	:	1 OF 5
CONTROL MONITOR	ALPHANUMERIC	:	2 OF 2
STORAGE FACILITY	CENTRAL ONLY	:	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	:	1 OF 3

BENEFIT: 149.726 (94 PCT OF MAX)
COST: 1060300 (33 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	:	3 OF 3
MAG. VIDEO DISK	BUY	:	2 OF 2
VIDEOTAPE	BUY	:	2 OF 2
NUMBER OF SITES	THIRTY-FIVE	:	4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	:	7 OF 7
CONTROL LOCUS	STAFF	:	2 OF 2
SWITCHING/INPUT	+ TOUCHSCREEN	:	3 OF 4
PRIMARY MONITOR	COLOR SIMPLE RASTER	:	2 OF 4
PREVIEW MONITOR	NONE	:	1 OF 5
CONTROL MONITOR	ALPHANUMERIC	:	2 OF 2
STORAGE FACILITY	CENTRAL ONLY	:	1 OF 2
HARD COPY FACILITY	CENTRAL ONLY (COLOR)	:	1 OF 3

BENEFIT: 151.526 (95 PCT OF MAX)
COST: 1200300 (37 PCT OF MAX)
THE EXCESS RESOURCE IS 0

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THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    PROCESSOR (R/O)       : 3 OF 3
MAG. VIDEO DISK       BUY                     2 OF 2
VIDEOTAPE             BUY                   : 2 OF 2
NUMBER OF SITES       THIRTY-FIVE           : 4 OF 4
SURROGATE LEVEL       5 VS COLOR LARGE      : 7 OF 7
CONTROL LOCUS         STAFF                 : 2 OF 2
SWITCHING/INPUT       + TOUCHSCREEN         : 3 OF 4
PRIMARY MONITOR       COLOR FRAME BUFFER    : 4 OF 4
PREVIEW MONITOR       NONE                  : 1 OF 5
CONTROL MONITOR       ALPHANUMERIC          : 2 OF 2
STORAGE FACILITY      CENTRAL ONLY          : 1 OF 2
HARD COPY FACILITY    CENTRAL ONLY (COLOR): 1 OF 3

BENEFIT: 156.5336  (98 PCT OF MAX)
COST:     1616800  (50 PCT OF MAX)
THE EXCESS RESOURCE IS 0


THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK    PROCESSOR (R/O)       : 3 OF 3
MAG. VIDEO DISK       BUY                   : 2 OF 2
VIDEOTAPE             BUY                   : 2 OF 2
NUMBER OF SITES       THIRTY-FIVE           : 4 OF 4
SURROGATE LEVEL       5 VS COLOR LARGE      : 7 OF 7
CONTROL LOCUS         STAFF                 . 2 OF 2
SWITCHING/INPUT       + TOUCHSCREEN         : 3 OF 4
PRIMARY MONITOR       COLOR FRAME BUFFER    : 4 OF 4
PREVIEW MONITOR       NONE                  : 1 OF 5
CONTROL MONITOR       ALPHANUMERIC          : 2 OF 2
STORAGE FACILITY      CENTRAL ONLY          : 1 OF 2
HARD COPY FACILITY    CENTRAL + B/W LOCAL   : 2 OF 3

BENEFIT: 158.5064  (99 PCT OF MAX)
COST:     1791800  (56 PCT OF MAX)
THE EXCESS RESOURCE IS 0
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THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ TOUCHSCREEN	: 3 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	B/W SIMPLE RASTER	: 2 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL + B/W LOCAL	: 2 OF 3

BENEFIT: 158.8196 (99 PCT OF MAX)
COST: 1819800 (57 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ TOUCHSCREEN	: 3 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	COLOR SIMPLE RASTER	: 3 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL + B/W LOCAL	: 2 OF 3

BENEFIT: 158.9132 (99 PCT OF MAX)
COST: 1830300 (57 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ DATA TABLET	: 4 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	COLOR SIMPLE RASTER	: 3 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL + B/W LOCAL	: 2 OF 3

BENEFIT: 159.2876 (100 PCT OF MAX)
COST: 1882800 (59 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ DATA TABLET	: 4 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	COLOR SIMPLE RASTER	: 3 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL ONLY	: 1 OF 2
HARD COPY FACILITY	CENTRAL+COLOR LOCAL	: 3 OF 3

BENEFIT: 159.5072 (100 PCT OF MAX)
COST: 2092800 (65 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ DATA TABLET	: 4 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	COLOR SIMPLE RASTER	: 3 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL AND LOCAL	: 2 OF 2
HARD COPY FACILITY	CENTRAL+COLOR LOCAL	: 3 OF 3

BENEFIT: 159.8204 (100 PCT OF MAX)
COST: 2722800 (85 PCT OF MAX)
THE EXCESS RESOURCE IS 0

THE ACTIVE PROJECTS AND THEIR OPTIMAL LEVELS ARE

OPTICAL VIDEO DISK	PROCESSOR (R/O)	: 3 OF 3
MAG. VIDEO DISK	BUY	: 2 OF 2
VIDEOTAPE	BUY	: 2 OF 2
NUMBER OF SITES	THIRTY-FIVE	: 4 OF 4
SURROGATE LEVEL	5 VS COLOR LARGE	: 7 OF 7
CONTROL LOCUS	STAFF	: 2 OF 2
SWITCHING/INPUT	+ DATA TABLET	: 4 OF 4
PRIMARY MONITOR	COLOR FRAME BUFFER	: 4 OF 4
PREVIEW MONITOR	COLOR FRAME BUFFER	: 5 OF 5
CONTROL MONITOR	ALPHANUMERIC	: 2 OF 2
STORAGE FACILITY	CENTRAL AND LOCAL	: 2 OF 2
HARD COPY FACILITY	CENTRAL+COLOR LOCAL	: 3 OF 3

BENEFIT: 160.04 (100 PCT OF MAX)
COST: 3209300 (100 PCT OF MAX)
THE EXCESS RESOURCE IS 0

APPENDIX C

RATIONALE FOR SCORES OF TELECONFERENCE MAU ANALYSIS

1.1 - ONE-TIME

	SQ	AUD	V12	V35
	100	97	68	0

Scores are based on the following estimated costs:

SQ - score 100 - $0 (baseline cost)
AUD - score 97 - $35,000
V12 - score 68 - $409,480.80
V35 - score 0 - $1,291,220

These costs represent equipment, software, and installation.

1.2 - ONGOING

	SQ	AUD	V12	V35
	100	98	86	0

Scores are based on the following cost estimates:

SQ - score 100 - $0 (baseline cost)
AUD - score 98 - $3.6K annual maintenance
V12 - score 86 - $24,516 annual maintenance
V35 - score 0 - $182,956 total includes $112,956 maintenance and $70K for 35 staff (@ $20K) working 10% of the time on the system.

Maintenance was assumed to be 1% of equipment costs per month.

2.1.1.1 - PREPARED

	SQ	AUD	V12	V35
	100	0	60	90

This factor refers to the availability of information which has been prepared in advance for use in a conference.

SQ, score 100, allows use of information in any format.

AUD, score 0, limits conferences to use notes on paper which are passed to conferees in advance.

V12, score 60, allows use of videotape input and gives shared viewing of graphical material including embellishment of material with notes, etc.

V35, score 90, makes available additional data sources, including optical and magnetic videodisk.

2.1.1.2 - AD HOC

	SQ	AUD	V12	V35
	100	0	80	90

This factor refers to the availability to the conferees of information generated during a conference.

SQ, score 100; face to face meetings offer the best performance in this area.

AUD, score 0; there is almost no capability for sharing ad hoc information using this medium.

V12, score 80, offers the capability to create graphical material in a shared manner.

V35, score 90, has the additional ability to mix notes with images from a video disk or other source.

2.1.2 - MEET CNTRL

SQ	AUD	V12	V35
100	0	70	70

This factor measures the ability of the leader of the meeting to control the direction of the conference, and to coordinate the inputs of the conferees. Nonverbal cues have been shown to be important in coordinating the interactions of the members of a group. Most of these cues are available in the video teleconference options, although face-to-face conferences offer still more nonverbal cues. Visual information is also important in leadership emergence.

2.1.3 - FLEXIBLTY

SQ	AUD	V12	V35
100	50	0	0

This factor refers to the ability of conferees to move freely and naturally during a meeting.

SQ, score 100. allows the greatest flexibiility.

AUD, score 50, still allows the conferee some freedom to move around the room subject to the constraints of the audio system.

V12 & V35, scores 0, all force the conferee to remain in the field of view of several cameras, thus restricting his freedom of motion.

2.1.4 - PRIVACY

SQ	AUD	V12	V35
100	0	30	30

This factor assesses the confidence that individuals may have that their conversations on the system are private.

SQ, score 100, offers the best assurance of privacy.

AUD, score 0, receives the lowest score because of the possibility of a conferee inadvertantly leaving his unit connected, allowing others to monitor a meeting. Also, higher volumes might allow monitoring from other rooms.

V12 & V35, score 30, alleviate some of the problems in AUD because of the visual link between conferees.

2.2.1.1 - FACILITY

SQ	AUD	V12	V35
0	35	40	100

This factor reflects the fact that teleconferencing offers additional conference facilities for planned meetings.

SQ, score 0, offers no help for scheduling.

AUD, score 35, links as many people as V35; however, the audio system would be appropriate for only about a third of the meetings as the video system.

V12, score 40, would be appropriate for more meetings than AUD, but only those among DASD's.

V35, score 100, offers the greatest relief for scheduling conference facilities.

2.2.1.2 - PEOPLE

SQ	AUD	V12	V35
0	35	60	100

The problem of availability of people for planned meetings is not solved with installation of teleconferencing except that it reduces travel time. The major scheduling problem is still schedule conflicts, even with teleconferencing.

SQ, score 0, gives the greatest problem.
AUD, score 35, is appropriate for about a third as many meetings as V35.
V12, score 60, helps in scheduling for DASD's only.
V35, score 100, gives the greatest benefit in this area, although much of the problem is still unsolved.

2.2.2.1 - FACILITY

SQ	AUD	V12	V35
0	75	80	100

This factor refers to the availability of facilities for important, ad hoc meetings.

SQ, score 0, offers poorest performance in this factor.
AUD & V12, scores 75 & 80, perform quite well in this factor. V12 is slightly better because its graphics capability, and becuase directors could use the site of their DASD for ad hoc meetings.
V35, score 100, offers the greatest ability in providing facilities for ac hoc meetings.

2.2.2.2 - PEOPLE

SQ	AUD	V12	V35
0	35	70	100

This factor reflects the fact that individuals will be more available for important, ad hoc meetings as they use the teleconference system (in their offices) more.

SQ, score 0, offers worst performance here.
AUD, score 35, is used about one-third as much as V35.
V12, score 70, makes DASD's more available.
V35, score 100, makes both DASD's and directors more available.

2.3.1.1 - DASD

SQ	AUD	V12	V35
0	35	90	100

This factor assesses the travel time saved through use of the teleconference system.

SQ, score 0, is the baseline.
AUD, score 35, saves less time because it is appropriate for only one-third as many meetings as V35.
V12, score 90, saves time for the DASD for many meetings mut not for some including directors.
V35, score 100, saves the greatest amount of travel time of the options.

2.3.1.2 - DIRECTOR

SQ	AUD	V12	V35
0	35	0	100

This factor assesses the travel time saved at the director level due to teleconferencing.

SQ & V12, score 0; there is no time saving at the director level for these options because the directors are not involved in them.

AUD, score 35, is appropriate for one-third as many meetings as V35.

V35, score 100, gives the greatest time savings.

2.3.2 - MEET DELAY

SQ	AUD	V12	V35
0	35	60	100

Teleconference systems reduce the effects of meeting delay because the conferee is in his office while the delay is occurring and may work on other tasks.

SQ receives the score, 0, for this factor.

AUD, score 35, solves the delay problem for the one-third of the meetings for which it is appropriate.

V12, score 60, solves the problem to a great extent for DASD's but not for Directors.

V35, score 100, offers a solution for Directors, and increases the benefit to DASD's as well.

2.4.1 - SPAN CNTRL

	SQ	AUD	V12	V35
	0	90	0	100

This factors refers to the ability of a DASD to obtain timely and accurate information from other areas. In order to accomplish this, connection of the system to the Directors is required. Thus both SQ and V12 receive the score, 0. AUD receives a slightly lower score (90) than V35 (100) because of a slight reduction of effectiveness due to the lack of graphical system.

2.4.2 - EQUL ACCES

	SQ	AUD	V12	V35
	0	90	60	100

This factor refers to the fact that teleconferencing gives all individuals equal access to the ASD and FDASD (and indeed all individuals in the system) regardless of their physical distance. Thus the 35 site sytems, AUD and V35, receive high scores (90 & 100), because equality is attained between more people. AUD is slightly lower than V35 because of the lower quality of the connection. V12 gives equality of access at the DASD level and hence also offers a benefit (score 60) in this area.

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