Preliminary Report on SSC Video Teleconferencing Needs for Detector Collaborations

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ABSTRACT

SSC detector groups are likely to have thousands of participants from around the world, including physicists, students, engineers, technicians, programmers, and other associated staff. Communication needs among these people will increase as the number of people increase. At the same time, bringing these people together for meetings will become more difficult, to the point of practical impossibility except on infrequent occasions. E-mail and the telephone can address some of the needs, but visual contact is often essential, particularly to present data, graphs, and so on. Teleconferencing (by which we mean video, throughout) is a practical and effective approach to a solution using presently-available technology, and will become more effective as the technology improves. Expenditures in support of teleconferencing will result in a net gain in efficiency and, at the same time, a net drop in overall lab costs.

I. Introduction

We discuss below our vision of the uses of teleconferencing in a modern large high energy physics collaboration.

We have examined some of the teleconferencing equipment currently available to determine a minimum set of requirements. The particular system examined was manufactured by Technical Concepts Corporation of Austin. We give a brief description of their equipment and supervisory software in order to set the stage for availability. We discuss the minimum requirements which we feel any practical system should satisfy. Finally, we discuss estimated costs, including a rough projection up to the time of turn on.

II. Uses For Teleconferencing

(a) General Collaboration Meetings

We envision that the most dramatic need comes from large-scale meetings. It costs roughly $1000 per person to attend a one- or two-day experiment meeting. In addition there is a large loss of physicists' time and efficiency due to the time required to travel, the difficulties of arranging for

the travel and of travelling, and the exhaustion resulting from the effort and the jet-lag when time zones are crossed. Due to the costs and difficulties involved, most collaboration members will be unable to attend such meetings regularly; therefore some of the utility is lost. Finally, finding a large enough meeting hall and arranging all the support for a large meeting (rental cars, hotels, refreshments, spare transparencies, etc.) places a formidable load (effort and expense) on the host institution.

With teleconferencing sites at a number of key points, no one will have to travel excessively far to attend a collaboration meeting. The logistics of setting up a multiple-point teleconference appear easily managed. Attendees at each studio will be able to follow the slide presentation in color and to respond verbally and visually to the speaker. With the use of certain equipment to be discussed in the next section, individuals at remote sites can "draw" on a screen.

(b) Sub-Group Meetings

A teleconferencing facility can make it feasible to have more frequent meetings and thereby improve communication. It therefore also becomes feasible to hold smaller meetings of subsets of the collaboration. For example, the engineers working on a particular component could meet weekly with each other and/or with the physicists.

(c) Spontaneous Meetings

Finally, it appears likely that spur-of-the-moment meetings between small groups of individuals (e.g., one-on-one) could be held. Such meetings could approximate the interaction between people working in the same building or nearby buildings. This permits rapid turnaround of engineering or physics or other technical changes in a real-time interactive mode. Given sufficient ease of use, this type of activity might turn out to be the most frequent use of teleconferencing studios at those sites with a large number of workers, such as the SSC site.

III. Technical Concepts Equipment

We describe the equipment which Technical Concepts Corp. (TCC) at Austin manufactures for teleconferencing. This is not necessarily the same as what is available from other manufacturers, but it is representative and might be the best available at the present time.

We assume that the primary need for video communication is to transmit visual information in the form of slides (transparencies) or pictures

on hard copy. Traditional lectures using blackboards can also be accommodated. Further we assume that a live presentation and interactive discussion accompanies the visual information. Otherwise one could be satisfied by FAX or even postal transmissions.

The TCC system includes, at each site:

1) A camera to show slides presented at the site;
2) Camera(s) to show the speaker or the audience or a questioner;
3) Video monitors to display the slide plus either the speaker or his audience or a questioner;
4) A high quality audio system. It suppresses background noise but picks up the speaker and any questioner;
5) A means to control the active cameras and the active microphones (preferably this is as automatic as possible);
6) A means to transmit the signals between sites. This must include a multipoint capability.
7) A PC to do data compaction and various control operations.

In addition, the TCC system includes a means to record a high-resolution picture of a slide and freeze it on one monitor. People at one or more sites have the capability to "draw" on the picture in different colors in "John Madden" style (using a hand-held stylus to cause lines to appear), allowing an interactive discussion of features shown on the slide. It is not clear whether or not this will prove extremely useful in a high energy physics context, but engineers discussing circuit diagrams or other drawings may find it essential. The value of this capability will depend on its ease of use.

TCC addresses these needs with a system of four video cameras, two monitors, and a sophisticated audio system.

Presentation of the slide can be done several different ways. One of the TCC cameras is a document camera, mounted above a flat surface and pointing down. This camera has the high-resolution "freeze-frame" capability, but can also be used to show motion. Alternately, one could mount a camera in some convenient place to view a screen. In this approach, the speaker shows his slides and gives his talk to the local audience in a normal fashion.

In either case, there would normally be one monitor dedicated to the slide being shown. The speaker's finger or pointer will show up on the monitor as he points to various features of the slide (except in freeze-frame

mode). The second monitor usually displays the audience at a remote site. In the case of more than one remote site some algorithm needs to be set up to decide which one to show. If someone remote is asking a question, it would be most natural to show that person. Alternately, the second monitor could show the speaker's face if no question is being asked. However, this is only practical if the speaker's site is fully lit, so that he is using the document camera to show his slides rather than an overhead projector with a screen.

The people at a remote site can view any given set of cameras, controlled either by themselves or by some designated person at one site. If the high-resolution freeze-frame feature is in use, one monitor would normally show that picture.

The TCC audio system is rather sophisticated. It uses echo-cancellation, which means that it "memorizes" the pattern of echoes in a room and compensates for significant changes such as people entering or leaving. An excellent audio system is essential, so that people can ask questions from a remote site and be heard everywhere. This implies some mechanism to decide which site will "get the mic". This mechanism might simply choose that voice which is loudest, the option currently available. This algorithm has its obvious advantages and drawbacks, and it may be necessary to tune it or to allow manual control from a central site.

The TCC system can be controlled by their "Pen Pal" device, which includes an electronic "pen" to point at a control tablet and choose options. These options include camera control such as pan left or right, up or down, and zoom in or out (only one site can have control of this at a time). One can also choose which cameras are displayed on the monitors. Finally, this Pen Pal is the device which is used to "draw" on the freeze-frame pictures mentioned above.

Finally, a speaker's "slides" can also be stored beforehand on the PC's disk. Then they can be recalled by the speaker in "freeze-frame" style during his talk. Using the Pen Pal, the speaker can point to different parts of the slide, "draw" on it, etc. This allows each slide to be seen in high resolution, and all sites have equal ability to view the slide.

Transmission between sites can be accomplished in several ways, depending on the band width required. The video and audio data are digitized and compacted to take maximum advantage of available bandwidth. For the video portion the compaction means that picture elements which have not changed since the last frame are suppressed. Additional compaction is also possible, depending on the algorithm chosen and the speed of the CPU doing the work. The algorithm is constantly being improved, and CPU speeds are likewise improving. New products available later this year provide improved video fidelity at low frame speeds. Therefore we can

expect frame rates and resolutions achievable with a given bandwidth to improve, although it is not clear how substantial this improvement will be before high definition TV (discussed below) becomes available.

For a two-point conference, it appears feasible to multiplex two 56-kbyte phone lines for transmission in both directions. This makes it relatively simple to connect and yields acceptable audio, frame rates, and video resolution with present-day technology. One can also "packet-share" an existing T1 (or other) computer data link, if available.

Commercial full-motion television has a frame rate of 32 frames/s. With lower frame rates the motion becomes jerky (or "fuzzed", depending on the compaction algorithm). However, this is acceptable for most teleconferencing needs, up to a point of course. For simple slide viewing with little or no motion very slow rates are acceptable. However, a speaker motioning to a point on the slide needs to have confidence that his motion will be recorded. Also, when a question is asked or a point raised, frequent hand motions are often desirable (though perhaps not essential). These requirements set lower limits on the acceptable bandwidth.

The TCC system allows any one camera to be VCR recorded at any site. This can prove useful in recording televised meetings or presentations. However, it is not clear how well that works in practice, since it might be difficult to follow any questions and answers which involve the use of different cameras. A human controller who switched the recording camera from showing the slide to showing the questioner might help, but then the people at the meeting will have difficulty following what is being done. Most likely, the only practical approach would be to record the slides plus the audio only. This would give the main part of the presentations.

Some systems (TCC did not demonstrate this capability) provide for cameras which automatically pan to a speaker in a room. This would allow a person asking a question to be shown on the monitors. Though desirable, this may be a cost which some or all of the sites may not want to bear.

The TCC system provides for communication for multi-point conferences via Digital Video Branch Exchanges (DVBXs). Each such exchange is a central node linking up to 14 sites. One or more of these "sites" can be another DVBX, allowing additional sites. Any subset of the sites can hold a teleconference, which can be simultaneous with other conferences being held by other, disjoint, subsets. The only requirement is that the bandwidths linking each member of a subset be the same.

The resolution on the freeze frame display is adequate for 12-pt type to be read, with about 3/4 of a standard sheet of paper being visible. In non-freeze frame mode, this resolution decreases to about 18 pt. This is adequate for

most purposes, but an improvement is desirable. In the future, HDTV (High Definition TV) will become available, and this may become a need in order to improve the resolution of the slides. However, HDTV will require very large bandwidths (depending on the data compaction algorithms), and so it may not be practical for some years. One must also consider how to connect HDTV sites with non-HDTV sites.

IV. Requirements

In order to satisfy the uses described in Section II, we have identified the following minimum requirements:

1) A frame speed not less than 5-10 frames/s. Some uses may require more;
2) Superior audio, including multiple microphones at each site;
3) Ease of use sufficient to permit untrained people to conduct a video meeting after a few minutes instruction;
4) Scalability from two-point conferences up to two or three dozen-point conferences. This implies one or more DVBXs or equivalent.
5) Enough linked sites within the next two years that any collaboration number can attend a short meeting without having to stay overnight away from home. This restricts the distance travelled to roughly a one-hour flight. In particular, locations containing a large number of workers (physicists plus engineers and technicians) should have high priority for obtaining a studio. Assuming that the cost of the technology will decrease, more and more sites should be linked;
6) Each site will need a minimum of two cameras, including one to display slides, plus two video monitors and multiple microphones as in 2). A PC and a controller such as the Pen Pal is also required;
7) Site design should anticipate hardware improvements, such as the eventual possible use of HDTV and/or bandwidth upgrades. This implies that some equipment may be replaced at various times.

It appears likely that two 56-kbyte phone lines connecting each site will satisfy the minimum bandwidth requirements implied by this list, at least within the continental U.S. Connection to foreign sites may involve satellites or transoceanic cables which are costly. However, it seems clear that foreign collaborators on an experiment will find these connections indispensable, and the cost will have to be borne.

V. Costs

A reasonably equipped studio costs approximately $60 K today. In addition, there is the cost of the two 56-kbyte dial-up lines. This cost includes some equipment, but the primary cost is usage. A reasonable estimate of this cost is approximately $4K/month/site. Finally, support will be needed. This will take the form of troubleshooting, consulting, arranging, and possibly other forms of support. For example, it may be necessary to employ personnel to manage (control the audio and video for) multi-point conferences. These needs will be determined by experience. For now, we assume about one FTE/10 sites.

Some of the costs may be covered by other sources. ESnet might pick up some of the line (phone) charges. Participating universities might pick up some of the charges. In particular, if a given site uses the equipment for non-SSC-related conferencing (in addition to SSC-related conferencing), it is reasonable to stipulate that at least 1/2 their site costs will be borne by them. We assume here conservatively that the SSC will buy all of the equipment used by SSC collaborations, but that an increasing fraction of the line costs will be borne by other sources, as teleconferencing becomes more popular. If other sources pay in addition some fraction of the equipment costs (as seems likely), this can be translated into extra sites.

Physics Research Division may not need to pay all the SSC costs. Although Physics Research Division will likely have the bulk of the lab-wide needs, Magnet Division will certainly have need for teleconferencing, and other divisions may have needs as well. In what follows, we assume that some of the support costs are met outside Physics Research Division.

Finally, it is conceivable that funding from the State of Texas could become available for this purpose. We will not for the present purposes assume that such funding is available.

Our funding model for FY91 and FY92 is given in Table I.

Table I
PRD Teleconferencing Costs for the Initial Setup Period

	FY91	FY92
Studios purchased in FY	15	15
Total cost to purchase	$ 900,000	$ 900,000
Dial-up line costs	$ 300,000	$ 600,000
Support personnel costs	$ 200,000	$ 200,000
Total Cost	1.4 M$	1.7 M$

Beyond FY92 we should anticipate hardware and bandwidth upgrades. For example, HDTV may become desirable, as well as an upgrade of the PC and some of the other equipment. The HDTV is apt to be expensive when first available. However, the PC should be even cheaper than at present.

We assume that the HDTV upgrade will not be done until its equipment cost is comparable to the present-day cost for a new studio. HDTV will require considerably more expensive line connections. However, we will guess that technological advances will keep line costs under $100K per site per year on average. We will assume that this upgrade occurs around FY95. In the absence of HDTV, bandwidth upgrades will still be desirable, especially if technological advances succeed in keeping the cost down. The estimated total costs for this period are given in Table II. The costs listed are the estimated total costs for the period given, not the annual costs. We do this because we cannot be sure in which year(s) the HDTV upgrades will occur, for example. If an HDTV upgrade is not effected, the hardware costs should be around the lower end of the range, since other upgrades should be less expensive.

Table II
Estimated PRD Teleconferencing Costs for Period up to Turn-on
(Costs in Millions of FY90 Dollars)

	FY93–95	FY96–00
Average number of studios	50	50–80
Total hardware costs	$ 2–3	$ 2–5
Total line costs	$ 3–5	$ 5–10
Total support cost	$ 1–2	$ 3–5

Table II also gives our projections for FY96–FY00, at which point we assume that data-taking has commenced. Obviously there are many uncertainties, so we give a range of costs. For this period, we assume the equipment costs will get cheaper with time (and probably have enhanced capability), and that regular upgrades will again be performed.

For Table II we again assume that part of the costs are borne by the remote sites. The uncertainties stem partly from the uncertainty in this factor.

VI. Conclusions

We conclude that a teleconferencing capability is essential, and that major steps toward establishing this capability for the SSC detector collaborations should be undertaken this year. As experience is gained with the test studio at the SSC and the requirements become more clear, additional studios should be established, at least in the continental U. S. It is anticipated that at least 15 and probably as many as 30 such sites will be necessary to satisfy

requirement 5) above in a reasonable way in the next two years. These sites will have to satisfy the simultaneous needs of as many as four major collaborations. It may be, therefore, that some sites will need more than one studio. It seems likely that three or four such studios at the SSC will be needed for this purpose on the same time scale. If, in addition, Magnet Division and Accelerator Division make extensive use of teleconferencing, even more studios may be necessary.

For the future, teleconferencing promises to become as necessary as photocopying and FAXing. Adequate funds should be planned. This expenditure will result in a net gain in efficiency and a net decrease in costs, *since people will have less need to travel.*