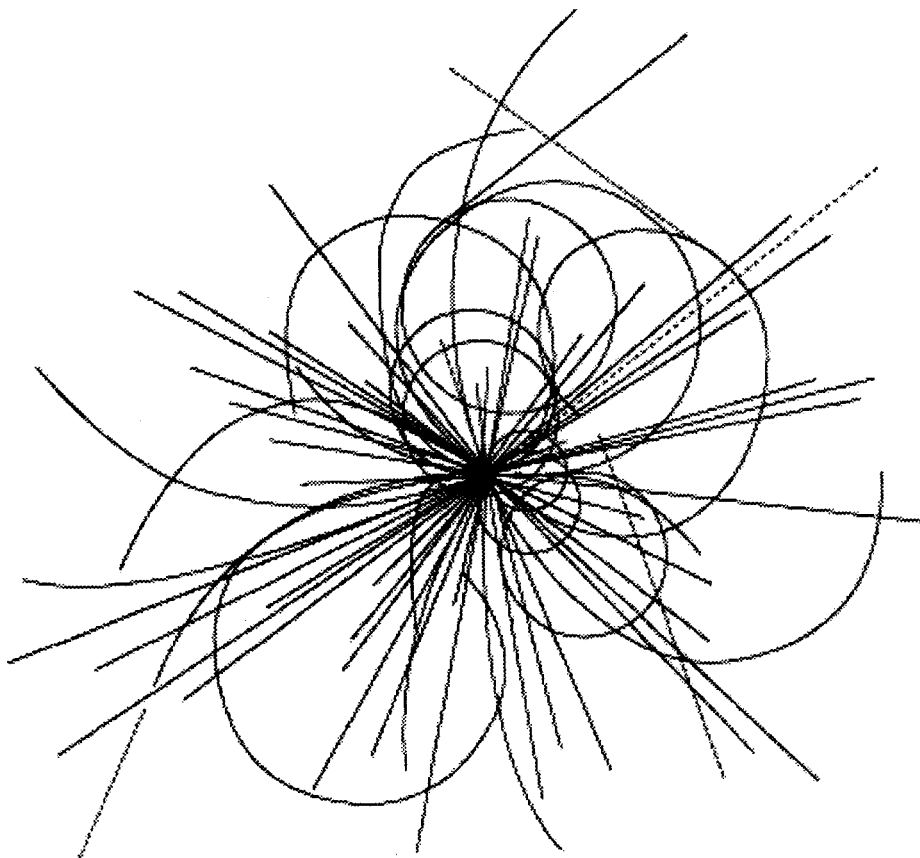


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Superconducting Super Collider Laboratory

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ESNET Requirements for Physics Research at the SSCL

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1.0 INTRODUCTION AND PURPOSE

High energy physics (HEP) research at the Superconducting Super Collider Laboratory (SSCL) is a highly collaborative affair. Scientists participating in SSC research come from a worldwide distribution of institutions. The Solenoid Detector Collaboration (SDC) currently has more than 1100 members from 20 countries. Likewise, the Gamma, Electron, Muon (GEM) collaboration members number more than 1000 from 17 countries. Roughly half of the collaborators on these experiments are from outside the U.S. Communications, in general, and data transmission, in particular, are crucial to the success of the collaborations and to the ultimate success of the SSC. The bulk of data transmission to and from the Laboratory is over the Energy Science NETwork (ESNET). The location of the SSCL and its current connections to the ESNET backbone by four T1 lines are shown in Figure 1. The purpose of this document is to describe the anticipated network capacity needed to provide adequate communication among these widespread collaborations.*

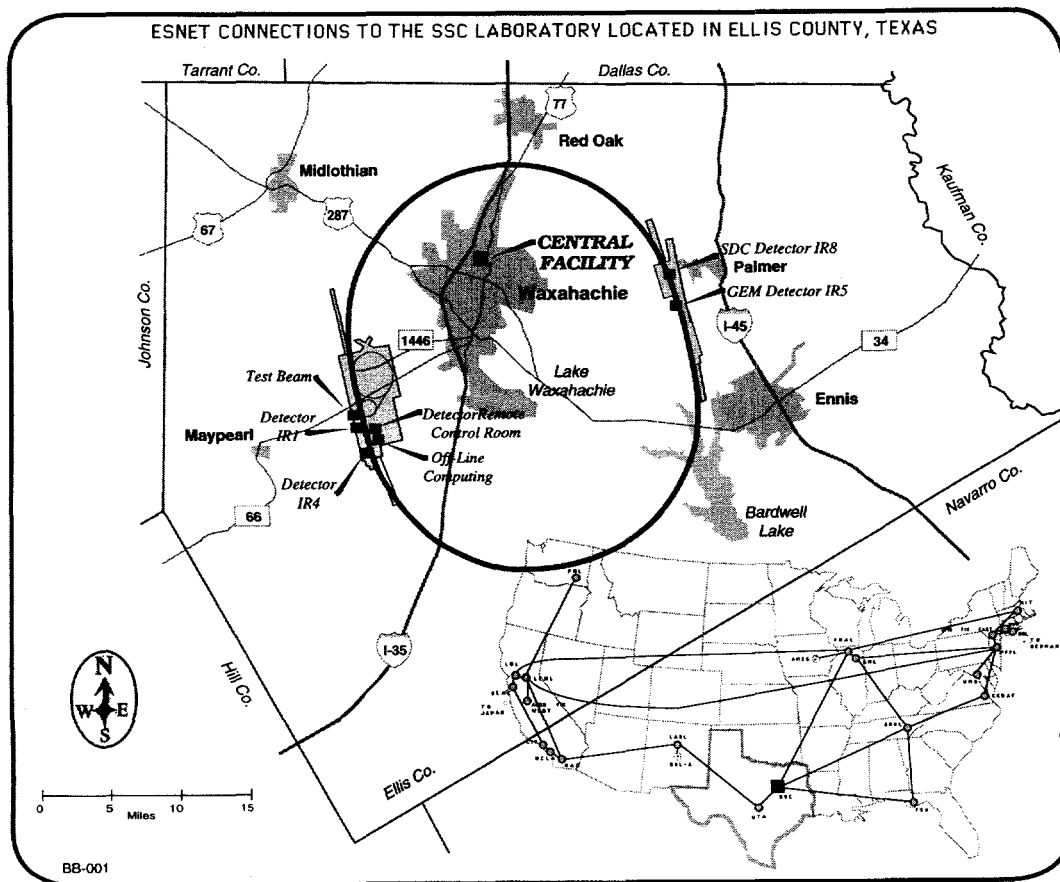


Figure 1. ESNET Connections to the SSC Laboratory.

* Another set of data communications requirements deals with the need to transmit detector data locally within the SSCL site. These requirements are described in another document.

2.0 BACKGROUND

Wide area network (WAN) requirements of the collaborations vary from simple interactive sessions such as e-mail on the low end of the spectrum to the transmission of large amounts of bulk data from the SSCL to the collaborations' regional analysis centers.

The GEM and SDC detectors are being designed to collect and store data at a rate of several gigabits per second (Gbps). The collaborations will analyze much of the detector data at the SSCL and therefore will not require a broadcast of the many petabytes of data to each of the collaborating institutions. Nevertheless, the transmission of reduced samples of data to several regional analysis centers represents a major bandwidth requirement after the SSC becomes operational. At this time, several sources of network transmission over ESNET can be identified, and models for the anticipated ramp-up of the usage can be constructed. The current and anticipated uses of ESNET include:

- Interactive sessions. These sessions currently include users logged into the Physics/Detector Simulation Facility (PDSF) at the SSCL. Some of these sessions are x-window based and some are simply line mode ASCII transmissions. Interactive sessions include activities such as editing, debugging, and e-mail.
- Studio video-conferencing. Since the beginning of the SSCL video-conferencing has been a key form of communication for its distributed collaborations. The Laboratory and its collaborators have established eight video-conferencing studios to date. The savings in travel costs and the increased communication capabilities have shown that video-conferencing is very worthwhile.
- Desktop video-conferencing. Vendors of workstations and PCs are now providing inexpensive video boards and interfaces. With the addition of inexpensive CCD cameras, desktop video-conferencing becomes an extremely attractive alternative to travel/commuting and studio video-conferencing. The usage of desktop video-conferencing coupled with multimedia capabilities and shared white boards should greatly enhance the effectiveness of collaborating scientists throughout the 1990s.
- Multi-media communication. The transmission of digitally recorded graphics, video, and audio segments for memos, reports, and mail is a powerful method of communication. Essentially all computer vendors are now providing multi-media capabilities for their equipment.
- Regional analysis centers. Laboratories such as Fermilab (FNAL), Argonne (ANL), Oakridge (ORNL), and Brookhaven (BNL) are major collaborators on SDC and GEM. A considerable amount of analysis will take place at these labs and at associated universities. Some large fraction of the many petabytes (10^{15} bytes) of SSC data will be transmitted to these centers.
- Remote control centers. SDC (and possibly GEM) is planning to provide real-time access to the on-line monitoring control and calibration systems of the experiment at several remote centers.
- Test beam data. Detector prototypes will be tested in 1995 and 1996 at Fermilab and at other labs. It is expected that data will be recorded at rates of about 3–5 Mbytes/s, requiring the storage of many terabytes of data. It is planned to transmit this data over ESNET to the SSCL for storage and analysis.
- Other experimental data. Physicists from the SSCL are collaborating on both the CDF and $D\bar{0}$ experiments at Fermilab. Summary data from both experiments is routinely transmitted to the SSCL. Also, physicists in the SSCL Computing Department generate $D\bar{0}$ Monte Carlo data that is transmitted to Fermilab.

Each of these uses of ESNET is expected to grow at rapid rates and can easily saturate the current capacity of the T1 backbone.

Ever-increasing bandwidths will be required throughout the development and operation of the SSC. Delays in the improvement of the ESNET to T3, OC-1, and OC-12 capabilities would cause a tremendous detriment to the capability of producing timely, high-quality research from the SSC.

3.0 MODEL OF NETWORK USAGE

It is anticipated that the SSC requirements for ESNET will grow rapidly from current rates of 1 Mbps or so to rates in excess of several Gbps. To plan for those needs and to determine the impact they may have on the national information infrastructure, we have developed a model that attempts to estimate the growth over a period of 10 years. The model is based on the uses of the network described in the previous section, the number of participating scientists and their distribution, and the predicted data collection and analysis requirements for SSC detectors.

3.1 Assumptions

A number of simplifying assumptions have to be made in order to predict the growth of network usage. These include:

- **Schedule.** The main factors in determining the schedule for large data-transmission requirements are the startup of test beam activities at FNAL and at the SSCL, and the beginning of the SSC operation. These dates are assumed to be FY 1995, FY 1997, and FY 2000, respectively. Other requirements, such as desktop televideo, simply start now and basically increase with time.
- **Media.** It is assumed that all of the data transmission described in this note will be over ESNET or follow-on networks in the national information infrastructure, such as NREN. While it is conceivable that some of this traffic may be carried by commercial or FTS telephone circuits, that assumption is not made here.
- **Interactive usage.** User accounts on the PDSF currently number about 500 and on SSCVX1 about 1500. Nearly one-half of these accounts are external users. The number of external accounts is expected to grow to about 1500–2000. Typically, about 10–20% of the users are actively using the systems during the day. Much of the network activity is simple command line input and transmission of small amounts of data, but an ever-increasing amount of the traffic is x-window based. It is assumed that eventually all interactive usage will be x-based, requiring a bandwidth of 40–100 KB/s per session.
- **Studio video-conferencing.** It is assumed that studio video-conferencing traffic will grow linearly or slightly faster throughout the development of the SSC. It is anticipated that the bandwidth per channel (128 Kbps) will remain constant and that video quality will be improved over the years by improved compression algorithms.
- **Desktop video-conferencing.** It is expected that traffic from desktop video-conferencing will grow exponentially for the next few years. Depending upon the frame rate and the compression algorithms being used, a two-way session may require a bandwidth of 30–100 Mbps. It is assumed that this mode of communication will eventually become the preferred mode rather than telephone or e-mail.
- **Multi-media.** Multi-media usage is likely to grow exponentially for the next few years but increase at a slower rate of growth thereafter. A typical multi-media transmission might be a memo with an enclosed video, graphics, or audio clip of perhaps 1–100 MB of data. Eventually several thousand people are likely to transmit multi-media messages. Multi-

media transmissions are likely to replace or become what is currently e-mail communication.

- Regional centers. It is assumed that about 10% of the detector data collected at the SSCL will be transmitted to the collaborations' regional centers.
- Remote control centers. It is assumed that data equivalent to about 10 x-window sessions and 5–10 televideo sessions will be transmitted to each of four regional control centers during the operation of the SSC.

3.2 Predictions

The predicted usage and growth of ESNET by the SSCL and its collaborators is summarized in Table 1 and is graphically represented in Figure 2. In this model the network traffic is eventually dominated by transmission of data to the regional analysis centers and the remote control centers following the startup of the SSC experimental program. Second to those combined uses is the desktop video-conferencing, which is assumed to be a key factor in providing the daily communication necessary to plan, design, configure, install, and run the experiments. Transmission of data from the test beams to the SSCL represents the dominant requirement in the near term (FY 1995–97).

TABLE 1. ESTIMATED ESNET BANDWIDTH REQUIREMENTS (Mbps).

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Studio Video-conferencing	0.5	0.8	1.0	2.5	5.0	10	20	30	40
Desktop Video-conferencing	10	20	40	100	500	1000	1500	2000	2500
Multi-Media	0.5	0.5	0.7	2.0	10	40	60	75	100
Bulk Data-Regional Centers	1.0	5.0	10	15	40	100	200	400	500
Remote Control Centers	0	0	100	200	400	800	1600	3200	4000
Interactive Sessions	10	20	30	40	50	40	30	20	10
Test Beam and Test Bed	1.0	50	100	100	150	150	150	150	150
Other Experiments	4.0	0.5	0.5	5.0	5.0	0.5	0.5	5.0	5.0
TOTALS	27	97	282	465	1160	2141	3561	5880	7305

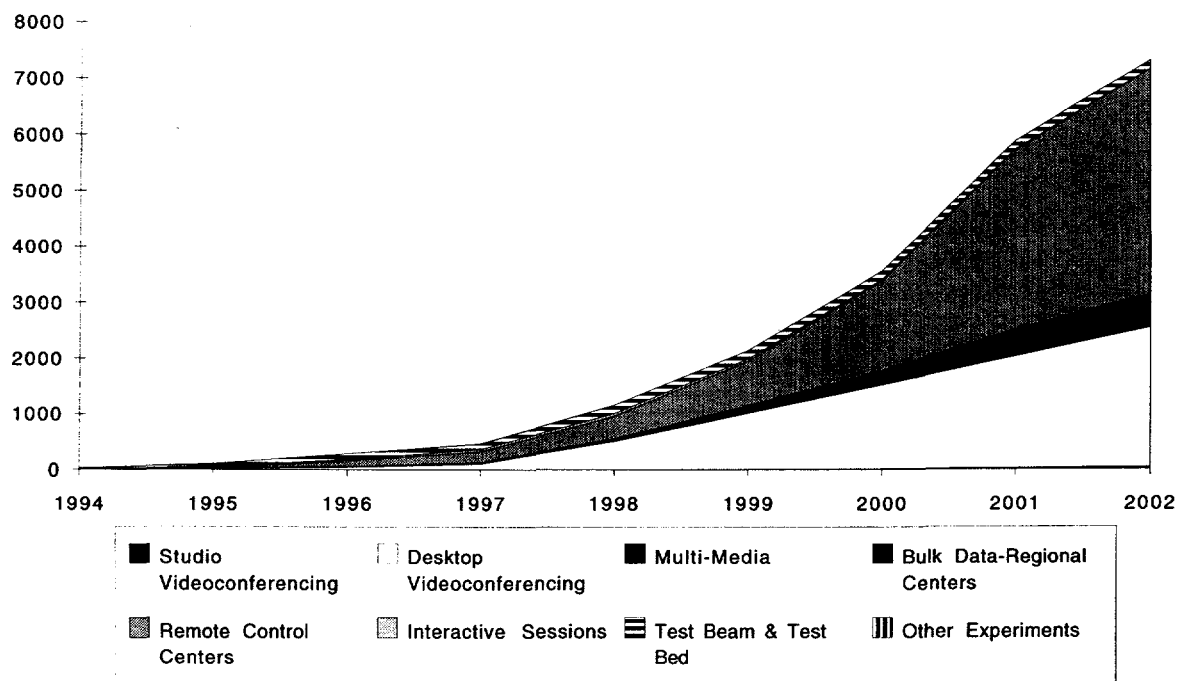


Figure 2. Physics Communications Requirements in MB/s.

4.0 CONCLUSIONS

The SSCL currently has four T1 connections at 1.5 Mbps each to ESNET, as shown in Figure 1. It is likely that T1 bandwidth will meet the communications needs for perhaps the next year or so. Early in 1995, both GEM and SDC are scheduled to begin test beam operation at FNAL. The bulk of this data will be transmitted back to the computing "ranch" at the SSCL for storage and analysis. At that time it is anticipated that the Laboratory and in particular the Physics Research Division will need the equivalent of three or more T3 lines at 45 Mbps each. At least one of these will be dedicated to the Fermilab test beams. By 1997 the bandwidth requirement is expected to grow to the OC-12 level (622 Mbps). Based on this model it is anticipated that early in the next century the Laboratory will require a network backbone capable of supporting traffic in excess of OC-48 rates (2.4 Gbps).