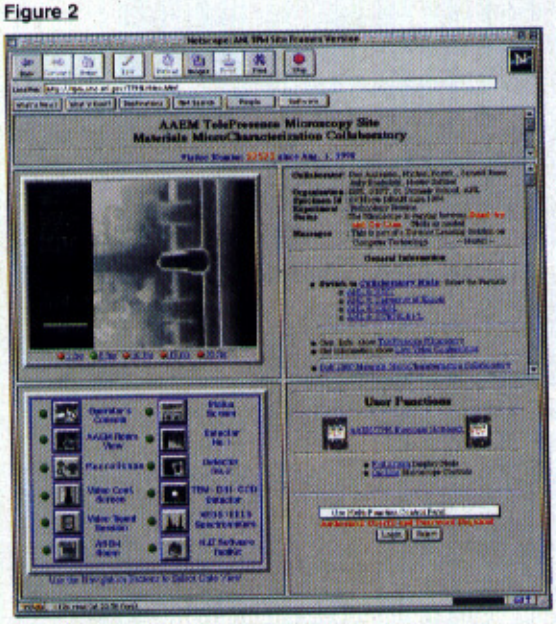
The diverse array of interactive modalities used by scientists employing in this facility (imaging, spectroscopy, remote operation, data archiving, electronic notebooks, analysis and data visualization) strains the limits of the current Internet as well as provides challenges for the Next Generation Initiative. Although the ANL TPM Collaboratory principally involves advanced electron optical instruments, the concepts embodied at this site are applicable to an entire range of scientific resources, which can be ultimately shared for the benefit of a larger community.

The philosophy of the ANL TelePresence Collaboratory is simple: create a persistent electronic space which encompasses all the "resources" of the laboratory using the Internet as the transport medium and employing platform independent software for access. Given the explosive development of the WWW and the wide distribution of browser technology, the ANL TPM site has evolved to use that interface, and the basic access to the site is provided by a state-of-the-art WWW browser (Netscape V 3 or better).

The browser acts as the principle remote user interface and provides complete site navigational controls (Figure 2). In addition, the capabilities of the collaboratory are substantially enhanced by hardware and software, which resides on servers at ANL and is transparently conferred to the user as needed. From their WWW interface, collaborators may assume either a passive or active role in online experiments.

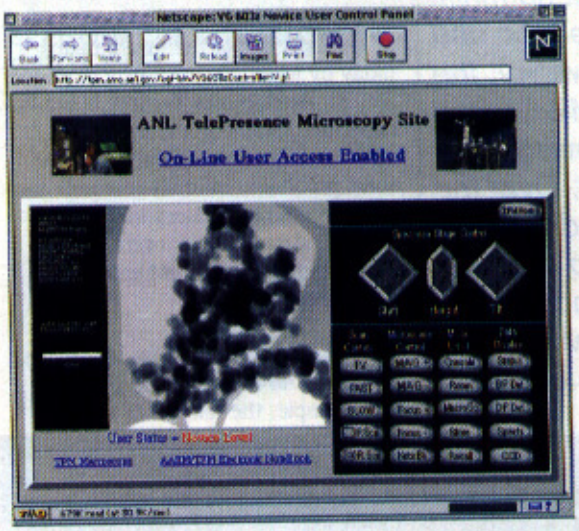
Figure 2



TelePresence Microscopy Site Navigation Interface

In a passive (observational) role the remote user has access to real-time or archived data, while in an active (participatory) role the remote users can additionally operate instrumentation directly from a secure WWW page (Figure 3). Data from the instruments can be viewed live at up to 30 fps depending upon the level of a user's connectivity and speed of their workstation, while electronic notebooks allow online storage and retrieval of text, graphs and images.

Figure 3



WWW based Remote Control Interface

Since the TPM servers employ standard Web-based protocols, we also have the ability, when necessary, to provide complete encryption of data streams, to restrict user access should confidential connections be required or to secure valuable resources from misuse and/or abuse.

Teleconferencing: The Bane of the Internet

Given the number of commercial firms developing teleconferencing software and hardware, it is illogical for us to commit any major efforts in this area. Instead, we have chosen to implement and extensively test existing protocols that provide this functionality. Both, MBone and CuSeeMe videoconferencing software are supported for this function and this accommodates, but by no means satisfies, the needs of all users.

More importantly we have found that conventional telephone calls are still occasionally needed to augment the experiments, particularly when sufficient bandwidth is not available over the Internet connection or when a Firewall is present at a remote site. In the absence of a Firewall, audio reception is one of our most vexing problems as either the remote user's CPU processing power, their Internet connection speed or the software employed can limit performance. This is a problem that may be mitigated when higher speed connections and faster CPU's are developed, but at present is being be left as a problem for others to pursue.

The issue of Firewalls is a difficult and more complicating factor particularly in the case of secure remote sites. A number of videoconferencing software programs require the opening of specific ports in Firewalls, and therefore close coordination and cooperation with site managers is absolutely required. In cases where that cannot be arranged, either a separate line outside of the Firewall must be established or a telephone utilized. Fortunately the design of all other aspects of the TPM collaboratory are transparent to Firewalls since standard HTTPD ports have been employed from the onset.

More Than Just Remote Control

TelePresence Microscopy differs significantly from conventional remote control of instrumentation using networked computers and also from simple "WebCams" which operate worldwide over the Internet today. In the former, the remote control process amounts to the relatively simple task of computer interfacing or programming a system and has been done successfully over the last decade. It does not generally afford the ability to observe and interactively control dynamic experiments such as those that deal with imaging and spectrographic systems in real-time. ➔