

# **NEESgrid System Overview**

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## Executive Summary

NEESgrid is the systems integration component of the NEES Collaboratory. The NEES equipment sites provide state-of-the art physical testing capabilities to the earthquake engineering community. NEESgrid enables easy, remote tele-presence access and use of those advanced facilities. It also provides data management and analysis tools for investigators, and a curated repository as a publishing mechanism for investigators designed to make it easier for future researchers to understand and use the results from the studies. NEESgrid provides access to numerical simulation software and sample output to help facilitate the use of simulation modeling in earthquake engineering. Finally, it is based in a collaborative framework built upon the concept of team-oriented research, where members share ideas and information to improve the outcome of the project. The complete NEES Collaboratory is a powerful set of information technology, numerical, and physical simulation resources intended to facilitate a revolution earthquake engineering research and practice. NEESgrid provides the scalable and extensible information technologies and services to enable the Collaboratory, now and in the future.

The System Integration Team has interacted with the NEES community over many months to better understand user requirements, and to incorporate these requirements into its system architecture specification and project plan. Between now and 2004, the Team will be demonstrating the capabilities of NEESgrid at various earthquake engineering conferences and workshops, and working prototypes will be posted for use on the project website ([www.neesgrid.org](http://www.neesgrid.org)). A key milestone in the integration of the system is a full system prototype demonstration that will be conducted in July of 2003. New features of individual components are scheduled for demonstration approximately every 3 months beginning in April 2003.

This document provides an overview of the features of NEESgrid in the context of how each feature can facilitate or enhance collaborative earthquake engineering research and practice once the NEES Collaboratory becomes operational on October 1, 2004. The document is structured to follow a stepwise approach to experimental research, discussing the specific NEESgrid features or capabilities being provided to support each step in the process. For each section, pointers to additional information resources are given that can provide details concerning any aspect of the system or its features. Readers are encouraged to use these information resources to satisfy their individual levels of interest in each topic.

The key elements of NEESgrid are:

- a powerful middleware architecture underlying the entire system that (a) supports higher-level information services accessible by end users; (b) is built upon the standards emerging from the Globus Project and the NSF Middleware Initiative (NMI); and (c) is designed to be scalable and extensible, functioning for the entire operational life of the NEES Collaboratory;
- a higher-level information services framework supported by published Application Programming Interfaces (APIs) that can scale to a large number of users, be extended easily with new services as requirements are identified or new capabilities are enabled by new technologies, and take full advantage of the underlying grid services that facilitate the access and use of NEES experimental, data, and computational resources on NEESgrid;
- reference implementations (i.e., useful, working examples) of end user interfaces that support the intended use of the Collaboratory, but which can be easily customized, extended, or replaced by NEESgrid users by taking advantage of the published APIs; and

- an operations and support organization that monitors, diagnoses, and responds to system performance issues, and which helps both end users and support personnel at Equipment Sites understand how to use and be part of the NEESgrid system supporting the Collaboratory.

This document describes a “living” system, in that improvements and changes have been made consistent with the management practices of the project. No future modifications are planned, although the document may still be updated from time to time; any comments, questions or concerns by any member of the NEES community should be provided to the author ([info@neesgrid.org](mailto:info@neesgrid.org)). All drafts will be versioned, and the website will indicate the current version of the document available for downloading.

## **NEESgrid: Building a Community Collaboratory**

The NEES community includes engineering researchers, practitioners, students and teachers; physical testing sites and their remote users; structural, geotechnical, and tsunami experts; and simulation and computational modeling experts, to name a few. However, the one theme that binds together the entire community is the desire to better understand the responses of physical systems to seismic loads in order to reduce the damage created by earthquakes.

The NEES System Integration Project (or NEESgrid) will deliver the advanced, grid-based information technology environment binding together the NEES Equipment Sites, shared data resources, shared computing environments and the members of community at large. NEESgrid is a distributed virtual laboratory for earthquake experimentation and simulation, providing an environment for researchers to develop increasingly complex, comprehensive, and accurate models of the behavior of all types of structures under seismic loading. This "collaboratory" will let researchers across the country gain remote, shared access to experimental equipment and data, will facilitate efficient communication between researchers, and will provide a powerful collaborative environment for modeling and simulation. NEESgrid provides the means for researchers or practitioners, no matter where they are, to access the latest in testing facilities, published data, simulation software, and collaborative analytical tools to support innovative research in earthquake engineering.

NEESgrid will be built using a “spiral development” approach that is characterized by iterative refinement of design requirements, features and functions and technologies used to provide them, and the active participation of engineering users (“Early Adopters”), resulting in a better version of the system with each cycle.

The Equipment Sites participating in system component test implementations leading to the release of the first version of system software supporting NEESgrid (called the “NEESgrid Early Adopter Program”) are one type of Early Adopter. In addition, other Early Adopters include engineering members of ad hoc working groups forming around each of the user services components of NEESgrid: Data and Metadata Management, Telepresence Systems, Collaboration and Visualization Environments, and Simulation.

An essential component to this approach is active and ongoing assessment of user requirements and a mechanism for incorporating changes to the system configuration. The NEES System

Integration and Consortium Development teams are developing a structured assessment of community requirements through surveys, interviews, site visits and workshops. This structured approach provides a baseline from which changes in needs can be documented over time.

In the system design of NEESgrid, a high priority was placed upon providing 1) a flexible, extensible and scalable grid-based system architecture supporting the discovery, management and high-speed movement of data and access to national research resources, e.g., NEES Equipment Sites and national high performance computing resources; 2) a data repository, including storage for testing and simulation data, associated metadata, grid extensions and other tools for managing data input and output; 3) a grid-enabled collaboration framework, including realtime and near realtime telepresence capabilities for remote participation in NEES testing activities and tools for viewing and sharing project information among researchers; and 4) a community repository of simulation software and analytical tools, including grid extensions to assist researchers in using the tools and a library of sample runs.

Rather than focusing on the development of customized user interfaces, the approach taken by NEESgrid Team is to publish the Application Programming Interfaces (APIs) that enable NEESgrid functionality and to develop *reference implementations* using the APIs that provide examples of useful, customizable user interfaces that serve critical user needs. Interfaces specifically included in the NEESgrid baseline for telepresence, data management and use, numerical simulation, and collaborative data viewing are discussed in other sections of this document in the context of their intended uses. Additional custom user interfaces may be useful to the community as a whole, and are not currently included in the NEESgrid project scope.

Detailed documentation covering the NEESgrid System Architecture, User Requirements Assessment and the NEESgrid Project Execution Plan are available (see [www.neesgrid.org/html/library\\_tech.html](http://www.neesgrid.org/html/library_tech.html)). These documents cover the designs and implementation plans for the initial deployment of NEESgrid, to be completed in 2004.

The underlying system software and extensions are based on Globus software (details at [www.globus.org](http://www.globus.org)) and the extensions, packaging and distribution mechanisms being developed under the NSF Middleware Initiative (details at [www.nsf-middleware.org](http://www.nsf-middleware.org)). These sites provide a wealth of information on the history of grid development, as well as links to sites supporting grid-based projects supporting other fields.

## Getting Started

This section summarizes the main components of NEESgrid, the NEESgrid components for accessing and using them, the research functions they support, and how to access NEESgrid software and services.

The functional research requirements used in defining NEESgrid are summarized from our current understanding of use scenarios as defined by researchers in the earthquake engineering community. Although to date practicing earthquake engineers have not been the primary focus of our user requirements assessment activities, they do represent an important component of the community, and NEESgrid's potential use by the practitioner community is discussed in a later section in this document. See the NEESgrid User Requirements Document, version 2.0

([www.neesgrid.org/NSFreview/NEESgrid\\_UR\\_Feb15.2002.pdf](http://www.neesgrid.org/NSFreview/NEESgrid_UR_Feb15.2002.pdf)) for further information on NEESgrid user requirements.

The NEESgrid system comprises two primary components: system components and information services components. System components include all software subsystems necessary for supporting grid resources, including end user access and use of those resources. Examples of grid resources are the NEES Equipment Site facilities, the NEESgrid data repository or a high performance computer at NCSA. The system components of the system are described in detail in the NEESgrid System Architecture document, version 1.0

([www.neesgrid.org/NSFreview/NEESgrid\\_SA\\_Feb15.2002.pdf](http://www.neesgrid.org/NSFreview/NEESgrid_SA_Feb15.2002.pdf)). The SI Team will conduct training workshops in late 2003 and in 2004 to train system administrators and researchers in the use of these grid components.

However, few researchers will likely interact directly with the system components of NEESgrid, unless they are developing or modifying software applications that require it. Exceptions include NEES Equipment Sites, all of which need to deploy system components on-site to support remote user access, telepresence, collaboration and data functions. These requirements are addressed through the Early Adopter Program, which will result in a software release specifically for the purpose of adding Phase I and Phase II Equipment Sites to NEESgrid. This is a separate activity under the System Architecture, Deployment and Operations component of NEESgrid.

Most users will take advantage of the grid architecture through the information services components designed to support the functional research requirements of the user community. This System Overview is focused on how end users will be able to use the NEESgrid system to enhance their ability to do productive work, collaborating with other researchers as needed.

There are four components to the NEESgrid information services: Telepresence, Collaboration and Visualization, Data and Metadata Management, and Simulation. How these components are supported by the system architecture is described in the System Architecture document; how researchers will use them to do work is not. The elements of each component are summarized in the context of the functional research requirements it is intended to support. The functional requirements are divided for this purpose into five categories: 1) collaborative project design and planning; 2) preparation, observation and monitoring of tests performed at NEES facilities; 3) use of the data repository; 4) use of the repository of community simulation codes and tools; and 5) collaborative data viewing, analysis and sharing of results.

Finally, how do users of the collaboratory access NEESgrid software and services? During the integration phase of NEESgrid (through September 2004), major components and subsystems will be prototyped and tested by Early Adopters, including participants in the Equipment Site Early Adopter Program as well as community members who have joined working groups associated with each information services component. Work group members work with SI team leaders help improve the quality and usefulness of the integrated product. For information on these working groups, including how to join them, check [www.neesgrid.org/html/contacts\\_group.html](http://www.neesgrid.org/html/contacts_group.html).

A fully functional prototype of the entire system will be demonstrated in July 2003, to be followed by a phase lasting until the completion of the project (September 2004) that is dedicated to bug fixes, required enhancements and improvements, software

packaging/distribution, user training, system acceptance testing and system transition to the Consortium. During 2004, a formal acceptance testing process will be conducted by the NEES Consortium to ensure the NEESgrid system is functional, and usable by the NEES community.

During the operational phase of NEESgrid, beginning October 2004, the anticipated software distribution mechanisms are (a) direct distribution on CDROM and DVDROM, and (b) by download from the member section of the community website ([www.nees.org](http://www.nees.org)). Required software for end users will include NEESgrid client software and up-to-date browser software, including plug-ins and any required applications needed to access system resources and information via a browser. Software distribution will also include all system documentation, APIs, manuals, and training materials developed under the project. In addition, all software needed to install and configure NEES Equipment Site implementations will be included, even though all of the NEES funded sites will have their software installed and tested prior to completion of the integration phase of NEES.

Beginning October 1, 2004, NEESgrid end users will have the choice of accessing system resources and services directly from a workstation using the NEESgrid client software, or via the member section of the community website ([www.nees.org](http://www.nees.org)). All information services component capabilities will be accessible via the web, including telepresence systems, collaboration and data viewing tools, tools for accessing the data repository, and tools for accessing the community simulation code repository.

In each of the following sections, specific deliverables representing NEESgrid tools or interfaces supporting functional research requirements are briefly summarized. The user tools and interfaces described are all grid-enabled to work with the underlying NEESgrid system architecture, and they are supported by the technologies described in the System Architecture document.

## **Collaborative Project Design and Planning**

The first stage in the research process is to take an idea and develop it informally through discussions with colleagues to formulate a study topic and research question. The next step is to discover and document what is known about the topic, including reviewing published research results and data that could be used to formulate hypotheses relating to the research question. Then, building upon what is known, the researchers decide upon a unique study that would add to the body of knowledge in the field, and begin the process of project planning. Typically, this process includes deciding with whom to collaborate, what facilities or other resources are required to conduct the study, how long it will take, and what it will cost. NEESgrid supports this phase of the research process with specific tools for data discovery, collaboration and data viewing.

**Discovery:** The metadata catalogs for the data repository and community simulation code repository will be searchable against any of their fields, and a simple search tool will be provided to end users to help them locate any testing information or information about simulation codes or modeling tools relating to the research problem. Locating published testing data and all associated metadata allows researchers planning new projects to evaluate every aspect of another study that was done independently by someone else at any one of the NEES facilities. Other

information that will be discoverable includes simulation codes or modeling tools (from the community simulation code repository), other NEESgrid participants with similar research interests (from the [www.nees.org](http://www.nees.org) member database, and from the metadata catalog), and NEES facility availability and capabilities (for NEES Equipment Sites supporting online scheduling and inventory discovery).

**Collaboration:** Support for online collaboration under NEESgrid is mediated by the Worktools and CompreHensive collaborativE Framework (CHEF) developed at the University of Michigan. These environments include a variety of resource management and information sharing capabilities. In addition to supporting asynchronous activities, the NEESgrid collaboration environment will support synchronous, or real-time collaboration through text chat, information sharing and videoconferencing. Multi-site videoconferencing sessions will be scheduled on NEESgrid using multipoint control units dedicated to that purpose that are shared by all NEES users. Videoconferencing sessions will require Polycom™ systems (or fully compatible H.323 systems) at each site, and can be conducted by themselves or in association with other collaboration tools. The NEESgrid collaboration environment also includes an electronic laboratory notebook, which can be used to document the planning and design process.

**Data Viewing:** The data repository and metadata catalog will contain information about both physical testing studies and numerical simulations that have been conducted as part of the NEES program. The NEESgrid collaboration environment will support viewing of numerical, video and simulation data from published studies using the visualization tools that are part of the CHEF environment. Capabilities will include side-by-side, time synchronized viewing of multiple perspectives on the same study, e.g., sensor data with video, or video with simulation results.

## **Setup, Observation and Monitoring of Tests at NEES Sites**

For research projects that require physical testing at NEES Equipment Sites, the next phase of the project is preparation, which can take many months. Resources need to be scheduled, specimens designed and built, and equipment and sensors calibrated. Testing is complex and expensive, and must be completed within a narrowly defined time window. So, when the tests are run they need to be monitored in real time, or near real time, to evaluate preliminary results and determine if the tests were successful. NEESgrid supports these steps in the research process with an electronic laboratory notebook, a telepresence system, and its collaboration and data-viewing environment.

**Electronic Laboratory Notebook:** The lab notebook is the key to documenting any experiment and is the thread that runs through the entire research process. When the research is completed, the lab notebook becomes the primary source for metadata defining the study. The NEESgrid laboratory notebook will help the researcher capture all data during the preparation process. These data might include notes, equipment or sensor calibration data, and video captures of the specimen preparation process and placing of sensors. This process will not be automated, but it will be under the direction of the researcher. When the tests are run, preliminary results can also be included in the lab notebook as additional notes, video clips, and/or simulation models, again at the discretion of the researcher. The laboratory notebook is not intended to be a data archive, but will be a rich source of metadata that will help people uninvolved in the study to understand



and evaluate that study for their future use. Examples of typical data that might be included in an e-Notebook are experimental notations, calibration data, data plots, and sample data tables.

**Telepresence System:** The NEESgrid telepresence system (TPS) will support tele-observation and tele-operations. TPS tele-observation is focused on real-time and near real-time viewing of multiple data and video streams during tests conducted at NEES Equipment Sites. To achieve the performance required for viewing during tests, the data are streamed from the data acquisition system simultaneously to the TPS and to the local data cache. This allows real-time viewing to be coupled with subsequent playback/review and posting of the data to the repository when the testing is completed. To review the planned features and functions of the NEESgrid TPS system under development, see <http://neestpm.mcs.anl.gov/>. (Note that this site requires a current Netscape browser for full capabilities).

**Data-viewing Environment:** The data visualization tools in the CHEF collaborative environment can be used to view multiple perspectives on testing data immediately following the tests in a side-by-side, time-synchronized format. The viewing perspectives can include numerical data, graphical representations or video data, and all perspectives are time synchronized.

## Using the NEES Data Repository

Once the testing component of a project is complete, the test data and all associated metadata are posted to the NEESgrid data repository for further analysis and for use by all authorized users. The NEESgrid Data Repository is an important grid resource for supporting collaborative research involving testing. It supports access controls to limit use to the project participants, but each participant can access the data and metadata via a common interface. Once the study is completed and the data are released by the original owner(s) for general user access, the data repository becomes an invaluable resource for other researchers modeling phenomena based on the results of multiple independent tests or developing new research hypotheses based on results from prior studies.

The key element in a data repository is the metadata catalog. The metadata define the data and the circumstances surrounding their collection. They describe the numerical data formats and the sensors used in collecting them. They describe still and motion video data, the cameras used, and the formats for viewing the resulting images. The NEESgrid team is developing a metadata model that will ultimately serve as a community standard for specifying metadata in the repository. The general approach is to capture (“ingest”) essential information about a test (i.e. the metadata, as distinct from the data) from the electronic laboratory notebook described earlier. This, coupled with other information provided by the owner of the data, completes the detailed and documented information describing how a test was conducted and its outcome. The benefits of community-wide agreement on a metadata model are facilitated data discovery and access by (a) members of the technical field that conducted the tests, and (b) members of other technical fields who may also be interested in the results. This feature is key to realizing the NEES vision of promoting cross-domain experimental or numerical simulation research activities between, e.g., structural and geotechnical earthquake engineering.

The establishment of consensus-based community data standards and specifications is a complex task. The approach taken by the NEESgrid team is to agree upon a solid and usable data model specification for October 1, 2004, based on detailed interaction with the community, its research use scenarios, and available model data sets from research conducted using different NEES facilities. This approach provides a framework for a *community-based* process for agreeing upon and documenting modifications or extensions to the standard data model during the operational phase of the NEES Collaboratory (2004-2014). This process will be managed by the NEES Consortium, and will provide important flexibility to accommodate changes in the modes and types of earthquake engineering research conducted by the NEES community.

The data repository will be established during the integration phase of NEES built upon on a rich set of APIs that will make it possible for future users of NEESgrid to develop powerful custom interfaces to NEES data and metadata. As part of the integration phase, certain reference implementations of tools and user interfaces will be provided.

**Data Streaming:** Testing data will be streamed from the local cache at the NEES Equipment Site to the repository, initially as backup storage for test data residing at the NEES Equipment Site, but ultimately to be the primary storage site for the data. This process is described in the Early Adopter Program document available at [www.neesgrid.org/html/TR\\_2002/NEESgrid\\_TR.2002-02.pdf](http://www.neesgrid.org/html/TR_2002/NEESgrid_TR.2002-02.pdf).

**Metadata Ingestion Tools:** The primary sources of metadata describing a test conducted at a NEES Equipment site are the electronic notebook and additional notes provided by the experimenters. These tools will provide the capability to excerpt information from the electronic notebook and use it to populate the metadata model. In addition, a simple free-text web form will be provided to capture additional comments from the PI or other members of the research team and insert them into the metadata model.

**Data Discovery and Access Tools:** These tools will facilitate finding physical testing or simulation data (and all descriptive metadata) of interest to a researcher that was previously published by a different researcher. They will search any element or combination of elements in the metadata catalog, and access the data for collaborative viewing or analysis in the CHEF environment.

**Curation Management Tools:** The data repository will be curated, and tools will be provided to ensure that all information is organized, classified, indexed, moved, linked, annotated, versioned, archived, and secured. The tools represent an integration of best-of-breed collection-management tools augmented with specialized tools for specific data, as required. The tools will support the activities of the repository curator, who will be responsible for verification and validation of data published in the repository.

## Using the Numerical Simulation Tools and Repository

NEESgrid will facilitate researchers' remote shared access to experimental equipment and data, will facilitate efficient communication between researchers, and will provide a powerful collaborative environment for modeling and simulation. This section describes NEESgrid components supporting research based in numerical simulation techniques.

The NEESgrid simulation effort includes several components supporting the goal of consolidating computational simulation tools from the earthquake engineering community into a community code repository of tested and capable software tools. The simulation effort is oriented towards cataloguing and testing existing software in the earthquake engineering field as a means of improving understanding, accessibility, and use of these tools by a broader community of earthquake engineers. There are many possible extensions of the simulation effort, outside the scope of the current effort, to develop new tools that demonstrate the uses of various features of the NEESgrid system in supporting simulation-based research. In addition, supporting more sophisticated simulation environments would require the integration of powerful data and model visualization capabilities, also currently outside the scope of the NEESgrid project.

NEESgrid simulation activities include gathering of community tool information, development of the community code repository, demonstration and documentation efforts on selected software tools, and identification and implementation of community-defined enhancements for key applications in the support of improved NEESgrid system usability. The grid components of the system will support secure single login access to a variety of high performance computing and storage systems available to grid users, for example through the National Center for Supercomputing Applications.

**Community Code Repository:** The NEESgrid team will design, develop, and deploy a repository of community-identified software tools, including appropriate metadata associated with each application such that the repository will support browsing and searches based on function, software quality, platform, and verification/validation criteria.

**Reference Documentation:** Community input will be coordinated to determine which applications should be utilized to develop representative content (e.g., pictures, animations, etc.) to be used as a means to educate and orient NEESgrid users, engineering practitioners and the general public on the use of the repository.

**Portal Interface:** The NEESgrid team will design and develop community-motivated software enhancements that will add value to representative community codes, e.g., developing a portal interface for an earthquake engineering simulation tool such as the OpenSEES framework ([opensees.berkeley.edu](http://opensees.berkeley.edu)).

## **Using the CHEF Framework for Analysis and Sharing of Results**

Every NEES project will generate large quantities of text, graphics, video and numerical data. NEES users need a framework for accessing, analyzing and sharing these data and analytical results. NEESgrid is providing a collaborative environment customized to serve the needs of the NEES user communities. The collaborative framework will be built upon the WorkTools environment developed at the University of Michigan, extended into a general purpose comprehensive collaborative framework called CHEF. All projects under the NEES MRE are currently using the WorkTools environment to support collaborative efforts among the different awardees and their teams. A PowerPoint presentation covering the collaboration tools effort by the University of Michigan under NEESgrid may be viewed at

[www.neesgrid.org/html/pp/CHEF052302.ppt](http://www.neesgrid.org/html/pp/CHEF052302.ppt)

In the NEES collaboratory, the CHEF environment allows earthquake engineers to configure a virtual workspace to fit their particular needs. This includes selection of specific collaboration and research tools, such as electronic lab notebook, data archive search, email archive, or visualization tools, and specification of the appearance of these tools within the collaborative workspace. In addition to the collaborative workspace, individual engineers have their own personal workspaces that they can customize to meet their own needs. A key strength of the CHEF approach is the reliance on open source technology and standards so that additional tools can be quickly integrated with existing tools.

The NEESgrid collaborative environment will support:

***Web-based Collaboration Tools:*** These tools are customizable by users and support scheduling, announcements, task management, information resource management, discussion spaces, shared presentations, notification services, email group management, email archives, and laboratory notebooks.

***Grid-enabled CHEF extensions:*** These extensions support security/authentication (useful when signing on to multiple secure resources), resource discovery (e.g. from the data repository or other data resources on NEESgrid), and directory services (e.g., for locating collaborators) for users within the collaborative environment.

***Data Viewer:*** The data viewer is designed to provide time-synchronized viewing of data from multiple perspectives, and representing multiple data types. This tool takes inputs from repository data; the user selects the experiment, the channels (data and/or video); the user chooses plot types; and the results are displayed in a tiled format showing time-synchronized plots of selected channels (or time synchronized video).

***End User Application Integration:*** The CHEF-based, NEESgrid collaborative environment supports basic and advanced application integration into the framework. Any existing application that is in the form of a web page or a web application can be easily incorporated into a personal end user space or shared with other collaborators. Advanced applications using multiple NEESgrid services and resources can be developed and integrated into the environment using well-documented, open source tools.

## **Use of NEESgrid by Practitioners**

Practitioners are frequently engaged in research and testing activities with earthquake engineering researchers. In addition, they may want to review existing data and other information resulting from similar tests conducted by non-participating researchers. Finally, they may want to consult with an academic engineer while simultaneously viewing such data. NEESgrid will support all of these uses by practitioners through the tools other capabilities described in previous sections. Examples of NEESgrid capabilities that support these activities include:

**Telepresence Systems:** Collaborating practitioners (e.g., from a state Department of Transportation) can remotely view tests conducted at NEES Equipment Sites while collaborating with their research partners to view the streaming data (from sensors and video sources) and quickly analyze the results in near real-time (CHEF).

**Electronic Lab Notebook:** Collaborating practitioners can quickly review the entire design, specimen preparation, and test setup process by accessing information from lab notebooks.

**Data Repository:** Discovery tools in the repository coupled with CHEF collaborative tools give practitioners the ability to identify and review similar or otherwise relevant results from prior tests for which they have access privileges. This includes reviewing all design and setup metadata, and even running the data and video from an experiment again to view it in simulated real-time.

## **Managing and Supporting NEES Collaboratory Operations**

Underlying the tools and interfaces described in this document is a sophisticated middleware environment architected to manage the interactions among resources and mediate the interfaces between end users and the resource grid. These resources include, e.g., the NEES Equipment Sites, the Data Repository, and various computational resources accessible by NEESgrid users. The details of the system architecture are available at [www.neesgrid.org/NSFreview/NEESgrid\\_SA\\_Feb15.2002.pdf](http://www.neesgrid.org/NSFreview/NEESgrid_SA_Feb15.2002.pdf); the system architecture specification document describes the grid services and protocols being used in the “background” to make it easy for users to conduct their research and other work.

In order to facilitate end user access and use of all the NEES Equipment Sites, a standard interface was designed to support the grid services specifically enabling the telepresence, collaboration, and data repository interfaces described above. This interface is called a NEES Point of Presence (NEES-POP), and the common services that reside on each NEES-POP are customized to the unique requirements of each Equipment Site. The end result is that the experience accessing and using one NEES Site will be very similar to the experience using another. The NEES-POP architecture is described in a document available at [www.neesgrid.org/html/TR\\_2001/NEESgrid\\_TR.2001-04.pdf](http://www.neesgrid.org/html/TR_2001/NEESgrid_TR.2001-04.pdf). Scenario-based applications of NEES-POPs at the early adopter sites are described in the Early Adopter Plan document also located in the neesgrid.org library.

A critical component of the physical dimension of the overall collaboratory is system performance, including all the NEESgrid computing, storage and networking equipment, and the national broadband Internet-2 network that ties it all together. NEESgrid provides an Operations Center that monitors the performance of all aspects of the NEESgrid and the national broadband network. The Operations Center maintains a help facility that can quickly diagnose and respond to user-generated requests.

Learning to use the physical NEES resources using remote interfaces is an important component of the NEESgrid environment. During the final year of the integration phase, the NEESgrid team will conduct user training workshops to ensure that engineers know how to take full advantage of the features of the NEES Collaboratory. Once the workshops are completed, the

training materials will be made available on-line for use by all users for the life of the NEES Program.

## **System Integration Resources Directory**

The NEESgrid website ([www.neesgrid.org](http://www.neesgrid.org)) serves as the primary information repository for the NEES System Integration Project. Here you will find all the project documents, contact information for NEESgrid Team Leaders, and news on current activities such as, for example, the Early Adopter Program. In addition, there are forms for joining the Working Groups set up by each of the technical Team Leaders. Please send comments or questions about the website to [info@neesgrid.org](mailto:info@neesgrid.org).

During the integration and testing phase of NEESgrid, tools and interfaces will be made available through the NEESgrid website for use and evaluation by the user community at large. The NEESgrid team encourages the user community to regularly visit the project website, make comments, and ask questions. This will help us to understand and be more responsive to user needs, and generally will ensure a high quality website.