NEESgrid: A Distributed Virtual Laboratory for Advanced Earthquake Experimentation and Simulation

A component of the George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES) Program

Project Execution Plan

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1.0 Project Execution Overview

The Project Execution Plan (PEP) presents the top level technical, cost, and schedule baselines and project management for the "NEESgrid: A Distributed Virtual Laboratory for Advanced Earthquake Experimentation and Simulation," project, hereafter referred to as "NEESgrid," submitted in accordance with National Science Foundation (NSF) proposal CMS-0117853. This project is a component of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), a Major Research Equipment (MRE) project at NSF, and is also part of the National Earthquake Hazards Reduction Program. This project will design, construct, implement, test, and make operational a high performance Internet network that enables a truly synergistic national simulation resource for research and education that will support collaborative experimentation, modeling, and simulation for the earthquake engineering community[1].

The focus of NEES systems integration is to integrate tools that will enable earthquake engineering simulation (both physical and numerical) in order to develop increasingly complex, comprehensive, and more accurate models of how the nation's infrastructure responds to earthquake loadings[2] utilizing large-scale/near full-scale structural and soil models, extensive data bases, and advanced and integrated simulation and visualization tools. The systems integration effort will provide a common access framework for connecting to and using the 15 NEES equipment sites. Capabilities available to NEES system users include teleobservation and teleoperation; tools supporting publication to and use of a curated data repository; access to computational resources and open source analytical tools; and collaborative tools supporting experiment planning, execution, analysis and publication. Therefore, NEESgrid will integrate experimental, archive, and numeric simulation sites into a scalable, extensible system.

This PEP sets forth the organization, systems, and plan for managing the NEESgrid project that are in effect on February 28, 2003. This document is a revision of the PEP submitted on February 15, 2002, and accepted by NSF. The PEP for the overall NEES system integration component will be revised, as required, to incorporate lessons learned, changes in baselines (technical scope, cost, and schedule), and new project development and/or other arrangements among the participants. Revisions, as they are issued, will be acknowledged by all participants, and will supersede in their entirety previous versions. These project plan modifications will be administered via the change management practices presented in Section 8 of this document. These revisions will reflect new information on user requirements and experiences with implementing NEESgrid technical strategies. Such new information will assist the project participants in determining the order in which to undertake the development and deployment efforts in the plan, managing risk, and ensuring that the integration effort meets its objectives and deliverable schedule.

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[1] Within the scope of this document, the term "earthquake engineering community" is intended to include not only researchers in the various disciplines of earthquake engineering, but also to encompass practicing engineers (e.g., bridge engineers concerned with seismic response, foundation engineers responsible for dynamic soil response, etc.) and professional researchers and practitioners in related fields such as seismology and structural dynamics.

[2] Examples of such earthquake-induced loadings include tsunami effects, seismic soil response, dynamics of buildings, bridges, and lifelines response, nonstructural response, etc.

The following project management elements are included in this document:

! Project description (Section 2, page 11);

! Project organization (Section 3, page 25);

! Project work breakdown structure (WBS, Section 4, page 32);

! Project cost elements (Section 5, page 35);

! Project implementation elements (Section 6, page 38);

! Project standards required for contract management (Section 7, page 41), configuration control (Section 8), and appropriate technical standards for documentation, software development, and other essential components of this project (Section 9, page 48); and

! Reporting and review requirements (Section 10, page 49).

To provide additional detail in support of the narrative document, these appendices are included with this execution plan:

! Appendix A. Current diagram describing the Work Breakdown Structure for the project to Level 3;

! Appendix B. Detailed WBS Outline describing tasks to Level 4, and

! Appendix C. Gantt Chart for complete WBS including component milestones

The NEESgrid project cannot readily be managed via a single project-management technique, because this systems integration enterprise includes substantial hardware and software components, each of which must be handled appropriately to reflect best-practices management principles for real-world and virtual systems integration efforts. Throughout this document, dual-track processes for administration of the NEESgrid system are presented, in order to reflect this composite hardware/software project architecture.

This project execution plan is one of five central NEESgrid project documents that provide the framework for successful implementation of the NEESgrid system:

1. The NEESgrid Project Execution Plan (PEP) document, which provides the project-management view of the project, and hence reflects the work breakdowns structure and schedules for NEESgrid implementation;

2. The NEESgrid User Requirements (UR) document, which provides high-level requirements specification for the NEESgrid system;

3. The NEESgrid Systems Architecture (SA) document, which provides a vision for the proposed architecture of the Grid components of NEESgrid, and which technically defines the architecture and the information services that it provides;

4. The NEESgrid System Baseline Description which describes the technical systems and components of NEESgrid in greater detail than found in the PEP; and

5. The NEESgrid Acceptance Testing Plan, which will be developed in concert with the Consortium Development Team to provide the agreed upon schedule and technical tests that will be used to validate that the criteria provided by the NEES Consortium for their formal acceptance of the NEESgrid system have been met on or before September 30, 2004.

Documents 1 through 3 described above were provided to NSF and published on the neesgrid.org website as part of an integrated set of deliverables on February 15, 2002. The User Requirements and System Architecture documents stand alone as documents describing current requirements and system baselines, but they have been referenced in the Project Execution Plan (revision dated February 15, 2002), and are incorporated herein by reference. A draft version of the System Baseline Description was provided to NSF on January 31, 2003. The Acceptance Testing Plan is a future activity that is included in the tasks and milestones associated with section 4.4 of the WBS (Appendix B).

The points of contact for different aspects of the NEES System Integration Project, NEESgrid, are provided in Table 1, below.

Table 1. SI Points of Contact

SI Project Contact	Responsibility	SI Project Contact	Responsibility
Dan Reed *National Center for Supercomputing Appli cations* *UIUC*	Project Director; overall SI project direction and strategies; interface with NEES PIs and NSF; public spokesperson for SI project	*Tom Prudhomme* *NCSA/UIUC*	Deputy Project Director; Chairs the CCB; Overall responsibility for management and coordination of the project
Cristina Beldica, *NCSA/UIUC*	Project management; monitoring, reporting, logistics and fiscal management functions	*Carl Kesselman,* *Information Sciences Institute,* *University of Southern California*	NEESgrid system architecture design and development; Early Adopter Program; leads System Components efforts
Tom Finholt, *Collaboratory for Research in Electronic Work,* *University of Michigan*	Collaboration and visualization tools, user requirements, project assessment; leads Outreach efforts	*Randy Butler,* *NCSA/UIUC*	Leads NEESgrid Operations efforts; system deployment, operations and user support
Dan Abrams, *Department of Civil and Environmental Engineering,* *UIUC*	Interface with CDT Collaboratory Vision work group, strategies for demonstrations and participation in community events	*Joe Futrelle,* *NCSA/UIUC*	Data and metadata management efforts; standards, specifications, formats, tools and the curated data repository

Nestor Zaluzec, Electron Microscope Collaboratory, Argonne National Laboratory	Passive teleobservation and active teleoperations environments for NEESgrid	*Jean-Pierre Bardet, Department of Civil and Environmental Engineering, USC*	Assists team with design and execution of integrated demonstrations to document uses of NEESgrid in research
Kim Mish, School of Civil Engineering and Environmental Sciences, University of Oklahoma	Numerical simulation repository and tools, risk assessment analysis and configuration management; Acceptance Testing Plan development		

1.1 Ongoing Refinement of User Requirements and System Architecture

Fundamental to the nature of the NEES Program is the need to accommodate change over the lifespan of the effort, both during the construction phase (2001-2004) and the operational phase (2004-2014). In assessing user community requirements, using our understanding of requirements to define a system architecture and delivering a working system, we need to accept from the beginning that neither the user needs nor the technologies upon which our system is built will remain stable over the next 14 years. Further, we need to follow a balanced approach to addressing both the needs that stem from current practices, which need to be supported in the short term, and innovative ideas for new research approaches that may be implemented during the construction phase of NEESgrid or later on in the lifespan of the NEES Program.

In building system design specifications based on our user assessment efforts, it is important to understand that there is no single right answer, but rather two essential objectives: 1) a stable, extensible and scalable architecture that can survive until 2014+, and 2) a working, useable, and cost effective system that can be delivered on or before September 30, 2004. Satisfying both of these objectives simultaneously is not simple. Some components of the system can or should have the ability to be easily changed in order to accommodate changes in practices or research paradigms. Other components cannot or should not change, but rather must be designed with an architecture that will provide a stable platform for supporting innovative end user environments and novel research paradigms. Technical decisions made today in designing and building NEESgrid need to be continuously evaluated. Changes in either the constraints identified by users, or boundary conditions defining the realm of the community and its work, will have to be addressed through modifications of the system design and execution plan.

In response to this need and the evolutionary nature of this problem – how to architect NEESgrid in an environment defined by constantly changing conditions – we initiated a multifaceted and ongoing user assessment activity, which was designed to give us both useful data and also a deeper understanding of the work done in the earthquake engineering community. From the perspective of the NEESgrid project, the sole purpose of this activity is to better address and meet the objectives stated above: designing a stable, lasting, useful, and cost effective solution. We included both formal and informal components that we believe will provide an ongoing process for evolving the user requirements information we require to architect and build our system, and provide a methodology for continuing the process once the collaboratory is transitioned to the Consortium in 2004. The various components of our activities are described

in the User Requirements Assessment document included in the February 15, 2002 NEESgrid deliverables.

The formal components described in this document reflect a discipline for defining an initial baseline of current practices in the use of information technology supporting the conduct of earthquake engineering research and practice. Through a repetitive data gathering effort, the formal mechanisms also make it possible to periodically evaluate changes to this baseline while NEESgrid is being built and after it is in operation. In essence, this effort will document the community transformation that is NSF's stated purpose for the NEES MRE. The definition of this essential baseline was a primary goal of the effort behind the User Requirements Assessment document.

Its other purpose was to stimulate thinking by members of various sectors in the community about how a grid-based collaborative environment might make new types of research possible, and what features such an environment would need to support it. This activity provides a motivation to demonstrate innovative uses of NEESgrid, which in turn stimulates changes in current practices that will ultimately be documented through the formal evaluation process.

Over and above the efforts of the User Requirements Assessment team to stimulate thinking on innovative but feasible uses of NEESgrid, the System Architecture (SA) Team conducted detailed technical evaluations of six of the ten Phase I Awardee sites. The purpose of these evaluations was to determine sites that were technically ready to participate in an initial software prototype deployment effort called the Early Adopter Program. Under this program, three sites were selected to stand up early prototypes of NEESgrid system and information services components and to provide feedback to the SI team on usability in supporting actual research scenarios. The result of this effort was the alpha release of the NEESgrid system in February 2003. This software will be debugged and further tested with the early adopters as well as other sites that are ready to participate in the iterative development process for subsequent software releases as described in the WBS and in Table 8. The scenarios identified by the Early Adopter Program participants are included in the System Architecture Specification document.

The link between the formal user requirements baseline and the system architecture specification has two major components. Firstly, the System Architecture Team was involved in the development of the formal instruments used to collect baseline data. Secondly, once the results were analyzed, the SA Team evaluated their specification and determined that all of the current practice requirements could be accommodated by the architecture, and that future requirements would be met assuming a conservative trend in new technology performance over the next 10 years. The scenarios defined by the participating sites as part of the Early Adopter program are by definition possible to demonstrate and, once demonstrated, the capabilities were integrated into the general release system software.

In summary, the user requirements effort is both multi-layered and iterative. CREW is responsible for conducting, analyzing, and communicating the results from the formal surveys and site visits. This effort defines the baseline for current practice and will be used to document changes to this baseline. The current assessment of user requirements represents at least an initial response by virtually every component of the NEES community, and includes input from users and practitioners in addition to representatives from the NEES equipment sites. The SA team is actively engaged with the NEES experimental facilities in defining NEESgrid scenarios,

which in turn define prototyping objectives for initial system deployment efforts. The other technical teams are also actively engaged in working with the NEES experimental facilities to evaluate telepresence or data scenarios, and with other members of the research community to investigate scenarios to define NEES collaboration tools or simulation tools. Finally, the NEES SI Project Director and Deputy Project Director for Technology actively engage with members of the Experimental Site teams, the Consortium Development Team, and other researchers in the field to better understand the nature of the work that NEESgrid has the potential to enable. The purpose of all these outreach activities is twofold: first, scenarios are generated assisting the NEESgrid technical teams in delivering a stable, useable, and cost-effective system; and secondly, the discussion and prototyping of the scenarios involves users in taking advantage of the capabilities of NEESgrid, so the formal user requirements assessment mechanisms can document the success of the project.

1.2 NEES Project Overview

The NEES Program is a MREFC project in the NSF Directorate for Engineering, Division of Civil and Mechanical Systems. The goal of the NEES Program is to provide a networked, national simulation resource of geographically distributed, shared-use next-generation experimental research equipment installations, with teleobservation and teleoperation capabilities. This national resource will provide the infrastructure and framework to shift the emphasis of earthquake engineering research *from* current reliance on physical testing *to* integrated experimentation, computation, theory, databases, and model-based simulation. NEES will integrate experimental facilities, computational resources and tools, collaborative communications technologies and tools, and a curated data repository system, all developed to facilitate collaboration and broad community participation in earthquake engineering research and education. Through NEES, the earthquake engineering community will be catalyzed to use its advanced experimental capabilities to test and validate more complex and comprehensive analytical and computer numerical models that will improve the seismic design and performance of our nation's civil and mechanical systems. NSF plans that NEES construction will be completed by September 30, 2004, and will be operational through September 30, 2014.

1.3 NEESgrid Project Management Overview

NEES is unlike traditional NSF MREs in a number of ways, and the project management of the NEESgrid Systems Integration component must reflect these differences. Conventional NSF MREs begin with a set of community needs that are expressed via a consortium, and the project deliverables can be sequentially identified, designed, developed, and deployed using the traditional waterfall systems engineering approach shown in Figure 1 below.

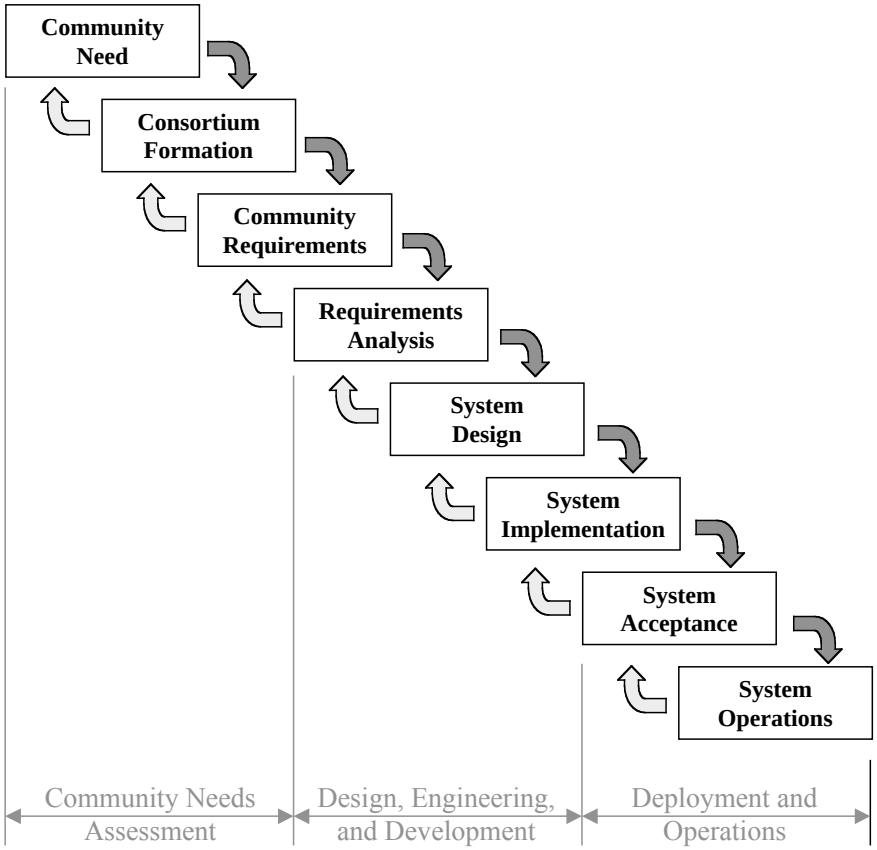


Figure 1: Traditional (Waterfall) MREFC Project Development Model

The NEES program began with the funding of various equipment sites, followed by systems integration and community-development efforts. This reversal of sequence on the NEES MREFC must be reflected in the NEESgrid project management plan; in particular, the differences between NEES and more conventional MREFCs must be studied to learn which project management techniques are appropriate to NEESgrid, and which techniques must be extended, modified, or replaced. The salient differences between NEES and other big-science NSF MREFCs include:

- The NEES MREFC is a heterogeneous collection of equipment sites found in geographically and professionally diverse settings;

- ! The NEES MREFC includes both hardware (i.e., equipment at NEES awardee sites) and software (i.e., content developed at NEES sites and computer science tools disseminated within the Systems Integration effort) components, each of which requires distinct project management techniques; and
- ! The NEES MREFC ends with formation of the consortium that will take delivery of the system, instead of the more traditional approach of starting with a community-based consortium that guides the development and management of the MRE.

The cumulative effect of these differences is that NEESgrid project management techniques must necessarily be different from those found in conventional MREFCs. Project management efforts on NEESgrid will more closely resemble those found in development of software systems than project planning and execution techniques appropriate for construction of scientific experiments. The fact that the consortium is funded at the end of the NEES MREFC implies that a community consensus on NEES system requirements will not be known *a priori*, and will in fact have to be deduced over the lifespan of the project. These characteristics make NEESgrid a natural candidate for modern *architecture-first* iterative project management techniques that have proved successful in software systems design [Royce, 1998], as shown in Figure 2below.

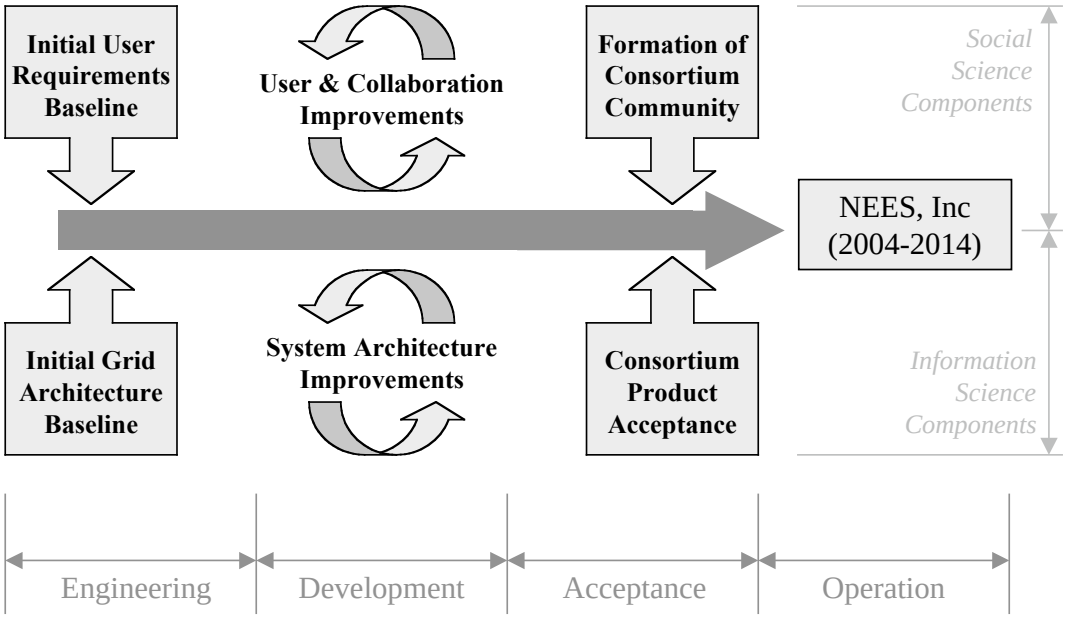


Figure 2: NEESgrid Project Development Model

In an architecture-first approach to project execution, an initial balance is forged among requirements, architecture, and project planning efforts, so that these tasks can begin simultaneously, and so that these three essential project components can be improved concurrently. This initial balance is expressed in the NEESgrid project as a collection of the three baseline documents (PEP, UR, and SA), and the evolution of these project documents reflects the incremental, iterative strategy of NEESgrid project execution.

The advantage of an architecture-first approach is that the resulting system can be made much more responsive to the real needs of the community, and that these requirements are discovered and developed continuously over the NEESgrid project lifecycle. Since many of the actual user requirements of the NEES program are *a priori* unknown (in part because they will evolve under the aegis of the consortium over the consortium's lifespan from 2004 through 2014), it is essential to permit discovery of community requirements, and to promote a flexible systems architecture that is sufficiently extensible so as to be able to accommodate evolutionary improvements over time.

The primary disadvantages of an architecture-first approach are that:

(a) This approach requires considerable project management oversight, including flexible program execution plans and a heavy reliance on change and configuration management;

(b) A successful implementation needs to be jump-started with a proposed initial systems architecture that is demonstrably feasible; and

(c) The systems acceptance criteria are dynamic and evolve in concert with the user requirements.

The additional project management burden required to manage change is developed later in this document. The initial systems architecture is based on successful utilization of Grid solutions that have already been developed and deployed for scientific research. Criteria for systems acceptance and the metrics for satisfying those criteria will be developed by the NEES Consortium Development effort. These criteria and metrics will be formalized through a process of discussion and negotiation between the NEES CD and NEES SI projects until both parties agree.

These project management elements are developed in detail in the following sections of this document. As is always appropriate when developing an iterative project model, these project documents must be viewed as "works-in-progress", with initial baselines presented as initial project deliverables, and with the evolution of the content of these project documents guided under a change and configuration control process.

1.4 Acceptance Testing

Systems testing to meet community-derived acceptance criteria is an integral part of any successful systems design and integration effort. Informal component and system tests conducted by the technical teams are implicit in the iterative demonstration and software release plan for NEESgrid. This section addresses the formal acceptance testing aspects of NEESgrid, comprising component tests and system-level tests that are designed to satisfy the acceptance criteria and metrics agreed to by both the CD and SI projects and facilitate system transition to the Consortium. Overall, the suite of tests, criteria and metrics for system acceptance will cover the entire feature suite of the NEESgrid project.

Component tests require individual software and hardware components of NEESgrid to provide baseline functions that can be verified by community tests, and validated as necessary system function that can be linked to one or more user requirements. Component tests will be conducted

in both controlled conditions where external influences (e.g., network quality-of-service) can be minimized, and also under service conditions at representative NEES equipment sites.

System-level tests provide the ultimate measure of acceptance for NEESgrid, as they stress both a collection of NEESgrid components and the associated network and software fabric that enables the interaction among the components used in the larger systems design. Systems tests for NEESgrid begin in July 2003, and various large-scale tests of actual NEESgrid systems functions will be designed and executed to demonstrate to the community that the NEESgrid system is sufficiently robust and reliable to be utilized for large-scale engineering research and practice.

Agreed upon acceptance metrics are an essential element of quality assurance, and are necessary for designing component and system-level tests which, if completed successfully, demonstrate that the system is acceptable for use by the community of NEES stakeholders. Initial formulation of acceptance criteria and metrics are necessarily the responsibility of the Consortium Development Team or Consortium. It is important that the acceptance criteria, and metrics for evaluation be initially developed independently from the system integration effort to ensure that they are unbiased in their representation of NEES stakeholder interests. Once the criteria and metrics have been established by the Consortium (or Consortium Development Team), they must be agreed upon by the System Integration Project Director, and specific testing scenarios established by the SI team based on their analysis of user requirements coupled with input from the CDT and the NEES Equipment Sites.

The Project Management team will coordinate the conduct of formal acceptance tests (under WBS 4.2.4), and the Technology Management team will document test results (under WBS 4.4.4). Tests will be conducted for all operational components of the NEES System, including the connections to individual equipment sites to enable teleobservation, teleoperation and links to the NEES data repository; connections to high performance networks and existing high performance computers and data storage networks; and all software specifically integrated into the NEESgrid pool of resources. This resource pool includes both software developed by the NEESgrid team and other codes in general use by the earthquake community, for example, OpenSees, which have been specifically integrated into code and simulation data repositories supported by NEESgrid. In addition, specific testing scenarios for demonstrating the ability of the NEESgrid system to connect the various classes of physical sites to the NEES Collaboratory (e.g., shake tables, centrifuges, wave tanks, large-scale systems, and field testing sites) will be provided in the Acceptance Testing Plan document, based on acceptance criteria and metrics provided by the NEES Consortium (or CDT).

Following the workflow schema described above, the System Integration team will work with the CDT and Consortium leadership to formalize the criteria and metrics developed by the Consortium on behalf of the NEES community, and to establish scenarios and specific tests that both parties agree will satisfy the initial criteria and metrics and which can be used by the SI team for acceptance testing. A draft Acceptance Testing Plan will be published by the SI team in June 2003, and this plan will be used to conduct the first system-level test to be undertaken in July 2003. Based upon the results of these tests, final acceptance criteria and metrics will be established by the Consortium and agreed to by the System Integrator for use by the SI team in developing specific scenarios and tests to be conducted during the final stages of the project construction phase (June through August 2004) and which will serve as the formal acceptance

tests for the NEESgrid system. The Acceptance Testing Plan document will be published in its final form by March 31, 2004. Acceptance testing conducted by the SI team will be completed by August 31, 2004.

2.0 Science Plan

This section outlines the core scientific and engineering objectives of the NEES Systems Integration project. Because success of the overall NEESgrid enterprise requires successful component efforts in a wide range of physical science, social science, and engineering venues, these individual aspects of the overall NEES effort are outlined below.

2.1 Introduction

NEES system integration provides a synergistic, collaborative access-and-use framework linking individual NEES experimental equipment sites and community resources (data, models, simulation codes and other software tools) to be shared by the broadest definition of the earthquake engineering community. The general intent of the SI project is to remove distance and location near major experimental facilities as barriers to research progress, innovation, and education in earthquake engineering, thus providing opportunities for full earthquake engineering community participation in the many facets of NEES, as well as K-12 academic infrastructure and the general public.

NEESgrid serves three subgroups of earthquake engineering researchers and practitioners, namely:

- The structural engineering community, generally concerned with the behavior of above ground and buried infrastructure systems subjected to seismic effects, including structures (e.g., buildings, bridges, dams, tunnels) and nonstructural components;
- The geotechnical engineering community, generally motivated by the response of foundations and soil masses (e.g., earth dams, soil liquefaction, slope stability) during earthquakes; and
- The tsunami community, concerned with the estimation of the hazard and mitigation of tsunamis, which occur in response of earthquakes occurring on the ocean floor.

NEESgrid must readily handle the similarities and differences of each of these communities, so that the development of new cross-disciplinary communities of earthquake engineers can be fostered while preserving the unique and productive attributes of these existing communities.

2.2 Objectives and Scope

Constructing a large-scale distributed system such as NEESgrid poses many challenges from the information technology perspective. NEES is a national simulation resource for a diverse user community, each component having its own set of specific application requirements. Viewed from the perspective of an integrated system, NEESgrid must be able to scale up to tens of experiment sites, hundreds of user sites, and thousands of users distributed across the entire

country, and eventually, internationally. Current and future applications (e.g., teleobservation tools, design and analysis packages, etc.) that utilize NEESgrid services will be written in a variety of programming languages and may incorporate commercial software components, and thus the various NEESgrid system components must provide for interoperability, extensibility, and scalability of user-deployed applications over the lifespan of the NEES project. These goals promote the use of industry standards within the NEESgrid system, and care must be taken to avoid one-off or stovepipe solutions within the NEESgrid system design and implementation. Furthermore, there may be stringent performance requirements in terms of response times (e.g., for teleobservation and teleoperation), in the volumes of data that the system must handle, and in the amount of computation needed to support advanced simulation studies.

Experience in designing, building, and maintaining large-scale distributed systems supports the approach taken in this plan: identify and exploit common needs across NEESgrid applications and produce system elements that can be reused from application to application, eliminating the need to start from scratch every time a new application is developed.

The NEESgrid design is based on distributed systems technology referred to as Grid technology. Grids follow the principle of layered system architectures, a principle that has proven particularly successful in the design and development of the Internet. At its lowest level, a grid consists of a core set of services with well-defined protocols that form a foundation for constructing higher level and more application-specific tools and services. This layered architecture addresses requirements for common NEES infrastructure, while supporting the development of higher-level capabilities to support the applications of specific earthquake engineering domains.

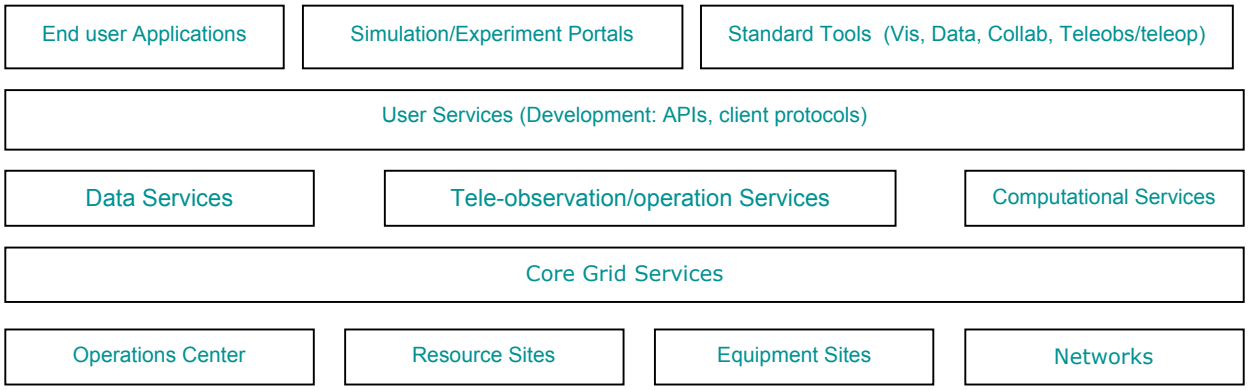


Figure 3: Main Elements of the NEESgrid System Architecture

Figure 3 shows the structure of the NEESgrid system architecture. Similar with other Grid-based systems, the NEESgrid architecture is layered, starting from a set determined by physical resources. These are the experimental equipment sites, the resource sites, the users, campus and wide area networks, and an operation center. The resource sites host the data repositories and/or computer systems to be used for running simulations. The operation center provides various forms of monitoring and diagnosing facilities for NEESgrid as a whole.

At the foundation of this architecture is a small set of core common Grid services providing capabilities that cut across essentially every aspect of NEESgrid operation. Building on these

basic services are more specialized collections of services addressing requirements in data management, teleobservation/teleoperation, computation, and collaboration. Each individual collection forms a *Services Package* that is installed on Grid resources. Each services package is used in turn to construct the higher-level end-user services and tools (teleobservation/operation, collaboration, simulation, and information management) that are required by the NEES community.

The major elements of this architecture are as follows:

- *Core grid services* provide basic security, information, and resource management functions that are used by virtually all services packages. These capabilities comprise authentication and authorization mechanisms for remote access to compute or experimental resources, resource discovery for determining the location and characteristics of the linked resources, and resource monitoring mechanisms for monitoring the status of those resources.

- *Data management services* relate directly to the management of NEESgrid experiment data. The tools in this category enable metadata generation or extraction, data transferring into repositories and the associated access control and indexing, data discovery, and uniform resource access.

- *Teleobservation and teleoperation services* provide standard protocols for exchanging control and status information between equipment sites and remote sites. The services in this package are used to construct the high-level teleobservation and teleoperation tools discussed in the following section.

- *Computation and simulation services* include access to compute resources and simulation codes. These services are used to construct the high-level simulation services and tools described in the following section.

The NEESgrid system architecture defines a set of software services and packages that, collectively, address the capabilities listed above. In developing the NEESgrid, we will use Grid services provided by the Globus Toolkit, and we will leverage software packaged under the recently funded NSF Middleware Initiative (NMI) project. Globus and other NMI software releases will evolve over the next three years as a result of other funded R&D projects and standards activities in the Global Grid Forum, Internet Engineering Task Force, and elsewhere, and through commercial adoption of, and support for, the technology. Consequently, subsequent NEESgrid releases will benefit from the changes in the code base and the introduction of new services, while the underlying conceptual framework of the NEESgrid architecture will remain intact. Thus, we expect to minimize risk by ensuring that NEESgrid is an instance of the more broadly deployed, commercially supported production Grid infrastructure that we expect to see emerging in this timeframe.

One of the goals of NMI is to have middleware infrastructure supported at the campus level. If NMI is successful on this front, NEESgrid will not rely on infrastructure that is deployed only for the purpose of earthquake engineering activities, but rather on supported campus wide infrastructure that is common with the broader scientific community on campus. This outcome is further reinforced by the fact that NMI is being targeted for the broad scientific community.

A further advantage of basing the NEESgrid architecture on NMI is that we can focus NEESgrid development activities on software and services that are unique to the requirements of the earthquake engineering community, further increasing the likelihood of successful adoption by the earthquake engineering community.

The core capabilities needed in the NEESgrid system were derived from the analysis of the current user requirements (UR document) and a series of proposed operation scenarios. Both the requirements and the accuracy and depth in assessing them are expected to increase during the life of the project. The conceptual framework of building the system based on a generic set of tools ensures the flexibility and adaptability of the architecture. The details of the system architecture will be optimized for earthquake engineering community requirements based on input from earthquake engineers prior to and during the design, development, and deployment of NEESgrid. This input will be obtained through an ongoing user requirements analysis, coupled with direct interaction with the NEES equipment sites, application developers, engineering members of the NEESgrid team, and through other NEESgrid outreach activities that are aimed at gaining the requirements of the larger earthquake engineering community as a whole.

An implementation of the NEESgrid architecture results in several specific sets of interfaces, services and software components. For end users, there will be programming interfaces and tools that use underlying NEESgrid services and protocols to perform application-specific functions. These interfaces and tools are the primary means by which the high-level system capabilities described in the next section are implemented. Equipment sites as well as compute and storage resource providers will be able to implement services and interfaces that provide access and control of the physical resources located at their sites.

Implementation of these services will by aided by various means, including:

- *User requirements efforts* aimed at gathering accurate community requirements for the NEESgrid system;
- *Early-adopter efforts* intended to provide a technology-savvy subset of equipment sites with early versions of the system components in order to shake out design and implementation problems before general distribution of the grid technology;
- *Shadow adopter efforts* that will provide early-adopter technology and expertise to a broader range of sites than can be handled using standard early-adopter techniques; and
- *Public dissemination* of results from all technology adoption efforts, so that the technology, documentation, expertise developed in the requirements gathering, early adopter, and shadow adopter efforts can be quickly and cost-effectively disseminated throughout the earthquake engineering community.

Finally, management services will be defined to support the operation and maintenance of the NEES system.

This project will utilize these various technology adoption processes to develop and refine working prototypes during the second year of operation, and will achieve a fully operational NEES System by September 30, 2004. The prototypes will include NEES equipment sites that have become operational with sufficient lead-time to be incorporated into the prototypes.

2.2.1 Scientific Scope and Objectives

The scientific purpose of the NEESgrid effort consists of two broadly-defined components, one involving the physical sciences that govern the response of physical systems to earthquakes, and the other involving the social science principles that form the underpinning of community-building, and collaborative research, and deployment of research advances. In addition to these components, the systems integration effort forms the bond that links these two scientific components. Through NEESgrid, scientific understanding is improved by leveraging the collective knowledge of the community, the social science understanding of the nature of collaborative work, and the ability of information technology to facilitate collaborative knowledge sharing. By integrating three disciplines to create the underlying architecture of NEESgrid, the overall benefit to the earthquake engineering community is maximized. The integrated system is by design more powerful, useable, and appropriate to the needs of the community than any other combination of the components implemented independently of one another.

These integrated and synergistic capabilities will permit earthquake engineering researchers and practitioners to gain insight and understanding of earthquake testing and simulation, while minimizing the community effort required to utilize and maintain the system.

2.2.2 Technical Scope and Objectives

The technical objectives of the NEESgrid effort are diagrammed in the following tables (Tables 2 through 5), which present brief descriptions of WBS Level 3 (deliverable) components. Delivery dates are presented for each deliverable, including when the processes that support these activities extend through incremental revisions over the project lifespan.

Note that delivery dates are for final completion of each L3 deliverable, and that intermediate milestones toward these deliverables are reflected in the Work Breakdown Structure provided in Appendices B and C.

These NEESgrid deliverables combine and interact to produce these cumulative outcomes:

1. Deployment of a national experimental simulation resource incorporating support for collaboration, telepresence, data archiving, curation, and discovery, and based on a proven scalable systems architecture.
2. Management and administrative oversight to insure that the NEESgrid system is responsive to the community's immediate and near-term needs and is extensible to support the long-term needs of the NEES consortium.
3. Documentation and dissemination efforts intended to demonstrate and promote the use of the NEESgrid system to both simulation content producers and to a wide range of content consumers, including those in educational and practice venues.
4. Assessment and evaluation measures to insure responsiveness of the evolution of the NEESgrid system to real community needs
5. Support for numeric simulation capabilities using community codes that have been consistently characterized in terms of capability and software quality, with extensions to capability (e.g., portal enhancements) identified and directed by the community.
6. Phased deployment of the system so that all content consumers and producers will be considered and accommodated over the lifespan of the project, using established principles of new technology adoption.

Table 2. Baseline System Capabilities: System Components

Deliverable	Description	Date
1.1 System Configuration and Design		
1.1.1 System Requirements Specification	Development of initial baseline for systems architecture, scenario-driven system requirements, and capabilities	2/15/2002
1.1.2 NEESgrid Early Adoption	Communications and visits with candidate early adopter (EA) sites, oriented towards (a) determination of EA sites and (b) EA needs assessment	2/15/2003
1.1.3 NEESgrid Security Enhancements	Ongoing development and deployment of security capabilities specific to NEESgrid community needs	6/30/2004
1.1.4 Access to Experimental Apparatus and Instruments	Development at the interface of the NEESgrid system and the remote experimental sites, including scheduling, discovery, use, etc.	6/30/2004

Deliverable	Description	Date
1.1.5 Access to Simulation Codes	Development, deployment, and support for the simulation tool archive, as well as community-identified numeric simulation capabilities (e.g., portals)	6/30/2004
1.1.6 Access to Data	Development at the interface of the system and data/metadata management components, including data transport, control, replication, etc.	6/30/2004
1.1.7 Collaboration Support	Ongoing system development in support of collaborative capabilities, VTC, the CHEF framework, etc.	6/30/2004
1.1.8 Documentation	Ongoing documentation efforts, culminating in final versions of documents that satisfy documentation acceptance criteria	9/30/2004
1.2 Deployment, Operations and Community Support		
1.2.1 NEESgrid Development and Deployment at Early Adopter Sites	Initial deployment in support of EA sites, including demonstration of prototype NEES-POP capabilities	1/31/2003
1.2.2 NEESgrid Systems Software Distribution	Refined support and operations for EA sites, including NEES-POP consulting and broader range of adopter sites	6/30/2004
1.2.3 NEESgrid Systems Operations	Ongoing deployment and operations of the NEESgrid system, targeted towards a smooth transition to Consortium acceptance in 2004	9/30/2004
1.2.4 User Support and Training	Support and training for NEESgrid users, local NEES-POP administrators, and other system stakeholders	6/30/2004

Table 3. Baseline System Capabilities: Information Services Components

Deliverable	Description	Date
2.1 Telepresence Mode Services		
2.1.1 Telepresence Management System for Remote Observation	Telepresence application development, deployment, and demonstration for remote viewing of experiments	10/15/2003
2.1.2 Telepresence Management System for Remote Operation	Telepresence application development, deployment, and demonstration for remote operation of experiments	6/30/2004
2.1.3 Documentation	Ongoing documentation efforts, culminating in final versions of documents that satisfy documentation acceptance criteria	9/30/2004
2.2 Collaboration and Visualization		
2.2.1 Prototype Collaborative Environment.	Development and demonstration of prototype virtual environment for support of geographically-distributed collaborations	1/31/2003
2.2.2 Visualization Support for Collaboration Tools	Addition of representative scientific visualization support (e.g., coordinated display of experimental data results) within the prototype collaborative tool.	10/15/2003
2.2.3 Adaptation of CHEF for Collaborative Services on NEESgrid	Adaptation of the CHEF collaborative framework to support deployment on NEESgrid	6/30/2004
2.2.4 Documentation	Ongoing documentation efforts, culminating in final versions of documents that satisfy documentation acceptance criteria	9/30/2004

Deliverable	Description	Date
2.3 Simulation Tools and Frameworks		
2.3.1 Community Simulation Tool Archive	Library of software used within earthquake engineering community, including metadata representations of capabilities, software quality measures, supported platforms, etc.	6/30/2004
2.3.2 Repository of Sample Community Code Results	Library of representative analysis results (both input and output) from the community simulation tool archive, suitable for use in demonstration, education, outreach, and PR	6/30/2004
2.3.3 Usability Enhancements for Community Codes	Community-identified improvements to codes from the simulation tool archive intended to improve specific NEESgrid capabilities, e.g., portal adaptation	6/30/2004
2.4 Data and Metadata Management		
2.4.1 Recommended Standards for Data and Metadata Models and Representations	Establish teams to characterize, develop, document, and disseminate data and metadata standards.	6/30/2003
2.4.2 Specification for NEESgrid Data Services Architecture	Identify and develop appropriate data services, including data access, transport, discovery, and archival.	6/30/2003
2.4.3 APIs for Data Harvesting, Management and Access	Development and documentation of Applications Programming Interfaces (APIs) for data access and harvesting	10/15/2003
2.4.4 Curated Data Repository	Develop and deploy a curated repository for community data, including early-adopter prototype efforts and scenario-driven design for improved capabilities.	6/30/2004
2.4.5 Documentation	Ongoing documentation efforts, culminating in final versions of documents that satisfy documentation acceptance criteria	9/30/2004

Table 4. Baseline Deliverables: Community Outreach and Partnership Development

Deliverable	Description	Date
3.1 User Requirements Assessment		
3.1.1 Site Technical Surveys	Phased annual surveys of technical capabilities for NEES equipment sites	12/31/2003
3.1.2 Practice Surveys	Phased annual surveys of practitioner needs and capabilities	3/31/2004
3.1.3 Visits to NEES Equipment Sites	Travel to various NEES equipment sites for purposes of discovering, documenting and disseminating site needs and capabilities	12/31/2003
3.1.4 Virtual Tours of Equipment Sites	Electronic documentation (e.g., video recording) of the NEES equipment sites, and dissemination of this content	12/31/2003
3.1.5 Publication of User Requirements Document	Ongoing documentation efforts, culminating in final versions of UR documents that satisfy documentation acceptance criteria	2/15/2004
3.2 Community Building		
3.2.1 Engage EER Community to Collect SI input	Continuing efforts in support of discovery and documentation of research and simulation needs within the NEES community	9/30/2004
3.2.2 Build Consensus with CDT on SI Issues	Ongoing activities supporting communications and coordination at the interface of the NEESgrid and Consortium Development teams.	9/30/2004
3.2.3 Facilitate NEESgrid Transition to Consortium	Efforts on behalf of successful transfer of NEESgrid technology to the NEES consortium, including estimation of resources required for operations.	9/30/2004
3.2.4 Promote Practical Examples of the Uses of NEESgrid	Plan, execute, evaluate and document demonstrations on representative sample applications of NEESgrid involving EA sites and the Consortium development team	6/30/2004

Table 5. Baseline Deliverables: Management

Deliverable	Description	Date
4.1 NEESgrid Management		
4.1.1 Outreach to NEES Equipment Sites	Conduct visits and other data-gathering activities with various NEESgrid equipment sites	6/30/2002
4.1.2 Advisory Activities and Program Reviews	Create advisory boards (e.g., EAB) to provide NEESgrid management team with community guidance, technical review, and programmatic expertise	3/31/2004
4.1.3 Technical Outreach to Resource Providers and NEESgrid Users	Creation of working groups intended to promote communications between NEES MREFC stakeholders	12/31/2002
4.1.4 Participation in NSF-Sponsored NEES Events	Provide communications between NEESgrid team and NSF-funded NEES workshops relevant to SI scope.	9/30/2004
4.2 NEESgrid operations		
4.2.1 Project Management	Oversight of NEESgrid project, including coordination of all components of the enterprise	9/30/2004
4.2.2 Fiscal Accountability and Recording	Generation, verification, and dissemination of all fiscal information, including auditing records and project reports to NSF	9/30/2004
4.2.3 Communications and Community Outreach	Communications, education, and outreach activities between NEESgrid personnel and earthquake engineering community	9/30/2004
4.2.4 Project Documentation and Transition Management	Ongoing documentation of system and its capabilities, oriented towards insuring a smooth transition to Consortium management in 2004	9/30/2004

Deliverable	Description	Date
4.3 NEESgrid Assessment and Evaluation		
4.3.1 Evaluation of NEESgrid Acceptance and Use	Phased assessment of NEESgrid capabilities, based on site visits and broad user surveys	4/30/2004
4.3.2 Technical Performance Evaluation	Evaluation of NEESgrid performance metrics	8/31/2004
4.4 Technology Management		
4.4.1 Change Control	Protocols and processes for oversight, and management of NEESgrid project documents	6/30/2004
4.4.2 Configuration Management	Protocols, processes and tools for record-keeping of configuration status for all NEESgrid components	6/30/2004
4.4.3 Technology Risk Mitigation	Ongoing assessment/mitigation strategies for risks associated with project baseline changes or failure of any key project component	6/30/2004
4.4.4 Acceptance Testing	Formulation and documentation of specific scenarios and tests to satisfy acceptance criteria and metrics provided by the NEES Consortium	8/31/2004

2.2.3 Project Scope and Objectives

The NEES System will give researchers remote access to a curated repository of experimental and simulated datasets, user-developed simulation software, and models for use in model-based simulation and visualization. The SI project team will work extensively with the earthquake engineering research community, under the coordination of the NEES Consortium Development awardee and the NEES Consortium, when established, to define procedures for collecting, processing, retrieving, and disseminating data sets and user-developed simulation software and will implement these procedures to produce the curated repository for the NEES System. The SI team will be responsible for design, deployment, curation, and operation of this data repository through September 30, 2004.

The NEES System will form an integrated, networked national simulation resource that facilitates collaboration among scientists and engineers, including educators, students, practitioners, and public sector organizations, both within the U.S. and abroad. There is expected to be continued growth in the size of the NEES user community and in the community's utilization of NEESgrid. Users will continue to require new levels of connectivity and communications, mass storage, speed, system memory, and systems integration services.

The SI project team will be expected to plan for and monitor these changes in usage at each NEES equipment site and throughout the NEES System. To incorporate the experimental, collaborative, computational, modeling, and archival needs of the earthquake engineering research community, the SI team will interface extensively with this community through outreach and training activities to design, promote, and facilitate use of the NEES System through September 30, 2004. The SI team will also monitor and evaluate the performance of the NEES System and its use through September 30, 2004. These SI team milestones for outreach, training and evaluation are provided in the WBS under sections 1.2, 3.2 and4.3 (Appendix B).

Developing the NEES System includes establishing the configuration of the three main software layers: the *programming interfaces* for NEES equipment at the host equipment sites; the *middleware* needed to facilitate networked collaboration, including database query and retrieval interfaces; and an *application development and operation environment*, including a networked numerical simulation and visualization capability. Software, including embedded software and processors, for the NEES research equipment will have to be adapted to enable teleobservation and teleoperation participation during experimental testing. This is a collaborative process between the sites and the SI team, but the ultimate responsibility for these enhancements to the on-site environments rests with experimental testing sites. The overall system design is the responsibility of the SI team, and must be flexible to adapt to and support both the changing external networking and data storage environments, and the evolving requirements of the NEES collaboratory.

A key user requirement and one of the objectives of the Project is to create a flexible, extensible and web-accessible interface to all of the tools and capabilities provided through NEESgrid. To address this requirement a collaborative framework is being integrated into NEESgrid based upon the web-accessible Worktools and CHEF software environments developed at the University of Michigan. The CHEF framework allows each of the individual component interfaces and all of the NEESgrid tools to be integrated in a manner that allows access to the full suite of NEESgrid capabilities from a single web-accessible portal. This integrated portal interface is not a specific deliverable of the project, but is a natural consequence of using the CHEF framework to access component tools and interfaces. Therefore, the implementation of CHEF services into NEESgrid is a deliverable under WBS 2.2, and each of the system and information components of the WBS will use CHEF as the framework for delivering their tools and services to NEES users. However, there is no specific WBS entry for an “integrated user interface.”

2.3 Project Description

This project develops and makes operational NEESgrid, a national-scale distributed virtual laboratory for advanced earthquake engineering. NEESgrid will be an Internet-based virtual laboratory, national in scope, that links together diverse institutions and resources to enable teleobservation, teleoperation, collaboration, data access, and the coupling of experiment, simulation, and data. Our goal is to provide a software environment and tools that support sharing and integrated use of scarce resources, including expensive equipment, datasets, simulation codes or human expertise. NEESgrid comprises the following components:

Experimental facilities enhanced with specific technologies enabling collaborative planning and *teleobservation* of experiments as they are taking place, *network management* to enable remote archiving and integration of experimental data with simulation capabilities, and *control interfaces* to enable teleoperation where appropriate.

Information Management systems that enable the curation and sharing of data and metadata located in centralized and distributed repositories, including storage systems at experimental facilities and other remote sites, enhanced with data management software to enable rapid and controlled publication of, and subsequent remote access to, experimental and simulation data.

Simulation systems and associated software repositories that enable a wide range of earthquake engineers to exploit powerful simulation codes at high speeds, whether on centralized supercomputers or on high-end clusters at user sites.

User sites, with *NEESgrid-enabled user desktops* that provide individual users throughout the community with access to the experimental, collaborative, simulation, and data archive capabilities of the entire collaboratory.

Support node(s), which a) maintain *online knowledge bases* that contain tutorial and other information concerning the effective operation of the many components of NEESgrid and which b) operate *help desk(s)* that provide access to assistance with the technologies that underlie NEESgrid, whether collaborative tools, data archives, or the underlying networks.

Our goal is to produce, via effort in three principal areas, an operational national simulation resource that can be turned over to the NEES consortium for subsequent operation during FY 2005 – FY 2014.

- *Development and ongoing refinement of a set of detailed user requirements* that identify both functionality and performance needs in each of a set of key areas. An expert team with extensive experience in understanding the needs of scientific communities will perform this requirements analysis, working in close collaboration with the earthquake community, the NEES Consortium Development Team and, in particular, with sites funded under the NEES Earthquake Engineering Research Equipment solicitations (Phases 1 and 2).
- *Definition and integration of a set of hardware and software technologies* to be deployed at each of the NEES Equipment sites, coupled with a collaborative framework for accessing NEESgrid resources and services. This infrastructure will leverage existing grid infrastructure developed and deployed by members of the NEESgrid team and will also exploit existing NSF-funded compute and storage resources at NCSA.
- *Development of a support infrastructure* including online knowledge bases and help desk capabilities, with the goal of ensuring that the NEESgrid collaboratory is directly usable by all earthquake engineers.

We will achieve this goal through the delivery of software to provide desired capabilities in the areas of data (including a curated data repository), instruments (teleobservation and teleoperation), collaboration, computation, grid and user services, and a software framework that facilitates the development and/or incorporation of community-based end user applications.

In the fully deployed system, software will be physically implemented at the NEES Equipment Sites and at the NEESgrid network operations center (NOC). The NOC is located at NCSA for the duration of the NEES System Integration Cooperative Agreement. All NEESgrid users will be able to access capabilities, tools and services through the CHEF-enabled web portal. Software supporting security, teleobservation, teleoperations and data transport will be enabled at the Equipment Sites. In addition to core grid services, softwaresupporting CHEF services, data management/curation services and data discovery services will be deployed to Equipment Sites. Core grid services, CHEF services, data management/curation services and data discovery services will be mirrored at the NEES NOC. In addition, the central data repository, numerical simulation code and simulation data repositories will be implemented at the NEES NOC. User interfaces and portals will be maintained at the NOC along with other repositories containing, e.g., documents and source code for NEESgrid components.

3.0 Institutional Roles and Responsibilities

This section provides information on organizations participating in the project, their roles and responsibilities. The System Integration project is one of three integral components of the NEES program.

3.1 Institutional Roles

The key organizational participants are:

1. The University of Illinois at Urbana-Champaign, and
2. The National Science Foundation Division of Civil and Mechanical Systems

The legal entity for the cooperative agreement pertinent to the operation of the NEESgrid Project is The Board of Trustees of the University of Illinois, Champaign, Illinois. The University of Illinois at Urbana-Champaign (UIUC) is responsible for the execution of this project. The UIUC Office of Grants and Contracts has responsibility for the managing the execution of the NEESgrid project Cooperative Agreement, on behalf of the University of Illinois. The NEESgrid Principal Investigator (Project Director) is the Director, National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign, and reports to the Vice Chancellor for Research. The Project Director in turn has appointed a full-time Project Manager at UIUC, and a Deputy Project Director whose responsibilities include oversight, technical management and coordination for NEESgrid.

Within the National Science Foundation (NSF), the Division of Civil and Mechanical Systems (CMS) has responsibility for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and general oversight monitoring of all awards under NEES. The NSF NEES Program will provide project funds, pending availability of funds, and provide general oversight monitoring.

3.2 Responsibilities

3.2.1 University of Illinois at Urbana-Champaign

The University of Illinois at Urbana-Champaign will utilize existing expertise in its Department of Civil and Environmental Engineering (UIUC-CEE) and the National Center for Supercomputing Applications (NCSA) to complete the design, development, and implementation of NEESgrid. In addition, UIUC will subcontract certain aspects of the effort to other nationally recognized organizations. The subcontracting organizations are:

1. The University of Michigan (UM)
2. The University of Chicago (for Argonne National Laboratory, ANL)
3. The University of Southern California (USC)
4. The University of Oklahoma (OU)

Each of these subcontracting organizations is responsible for the completion of specific tasks as described in the WBS. The effort subcontracted to the University of Michigan will be carried out by the Center for Research in Electronic Work (CREW), a unit of the School of Information. The Mathematics and Computer Science Division of Argonne National Laboratory will carry out the effort conducted under the auspices of The University of Chicago. The Department of Civil and Environmental Engineering (USC-CEE) and the Information Sciences Institute (ISI) will conduct work subcontracted to the University of Southern California. The School of Civil Engineering and Environmental Science (OU-CEES) will conduct the work subcontracted to the University of Oklahoma.

Figure 4, below, shows the functional organization of the NEESgrid project, including overall project leadership, leadership of major divisions within the project, and team leaders representing participating institutions. This is a highly distributed team-oriented project, and to improve overall management efficiency and responsiveness, the functional divisions are intended to follow the major subcontracting relationships as much as possible. Therefore, overall project leadership is the domain of NCSA. OU-CEES is responsible for integration of the Numerical Simulation effort, and for establishing project management systems for risk mitigation, configuration management and change control. NEESgrid Operations and Project Management are also the domain for NCSA's participation. System Design and Development is led by the Information Sciences Institute at USC, but is a highly distributed team including participation by Argonne National Lab, NCSA and OU. The Collaboration & Community effort is led by CREW at the University of Michigan, and includes integration of collaboration tools that will facilitate access to all system functions and coordination of all community outreach functions.

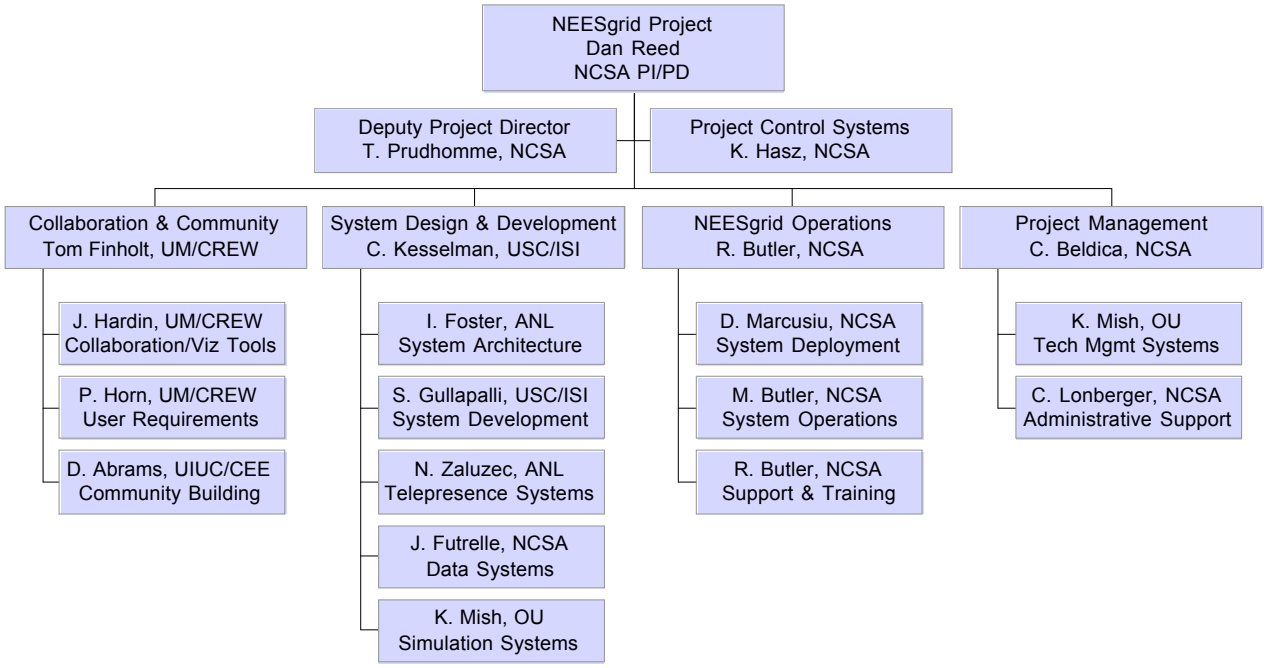


Figure 4: NEESgrid Project Organization and Personnel

The responsibilities of UIUC in the overall leadership, management and conduct of the NEES Systems Integration project are, in collaboration with its subcontracting partners, to:

1. Develop and submit to NSF major technical scope, cost, and schedule baselines to be used in the design, development, and implementation of the NEESgrid project;
2. Prepare the Project Execution Plan for NEESgrid, keep it current, and submit any subsequent revisions to NSF for review and approval;
3. Manage the project in accordance with the specifications in the WBS;
4. Conduct an annual review and interim design reviews of the NEESgrid project;
5. Conduct project design reviews per the project schedule with active participation by members of the earthquake engineering community;
6. Prepare and transmit to NSF required quarterly and annual reports documenting fiscal and programmatic details of the project;
7. Prepare and disseminate technical reports on the NEESgrid web site per the project schedule documenting NEESgrid progress;
8. Monitor and report use of the web site by the earthquake engineering community; and
9. Manage subcontract relationships to ensure timely adherence to schedules and report requirements required by NSF.

3.2.2 National Science Foundation

The responsibilities of NSF in the overall oversight of the NEES System Integration project are to:

1. Approve major technical scope, cost, and schedule baselines to be used in the design, development, and implementation of the NEESgrid project;
2. Approve the Project Execution Plan and any subsequent revisions;
3. Review the NEESgrid Project on an annual basis and perform other reviews as necessary;
4. Participate as an observer in all NEESgrid project major design reviews;
5. Review performance against approved technical specifications, budget levels, and schedule milestones, and provide oversight with the awardee to make necessary changes or take corrective action; and
6. Review and approve quarterly interim progress reports and annual progress reports submitted by the awardee.

3.3 Internal and External Management and Advisory Functions

The NEESgrid Project is complex and needs both internal and external advisory mechanisms to ensure a) timeliness and technical quality in system integration activities, b) relevance and usability of the interfaces and resources provided to the community, and c) effective synergy with the other NEES program components. Functional relationships among SI project components, its advisory groups, other NEES Program components and the community at large are depicted in Figure 5, below. The relationships described in Figure 5 show multiple points of contact between the SI Project and both the NEES Program components and the community-at-large. These relationships have been established over the first six months of the project, and any team leader from the SI project is encouraged to engage in collaborative relationships with the NEES Experimental Sites, the NEES Consortium Development Team, or the community-at-large if it will in some manner improve the overall product delivered by the SI project or benefit the overall NEES Program.

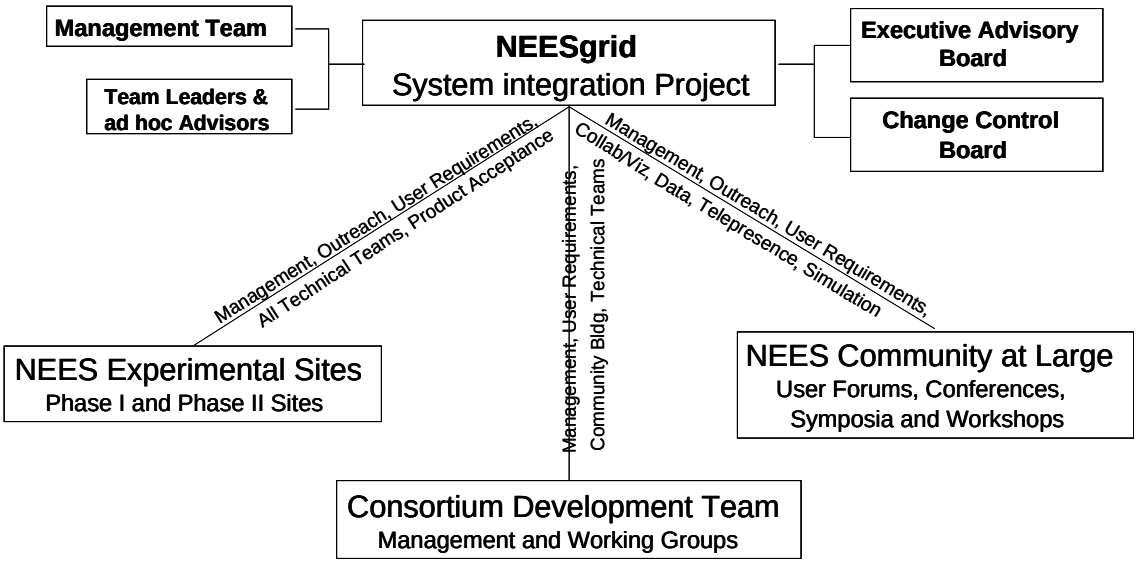


Figure 5: NEES System Integration Project relationships with Advisory Groups, NEES MREFC Components and the Community-at-Large

3.3.1 NEESgrid Management Team

NEESgrid management functions are coordinated through the Management Team. This team is led by the Project Director and includes all project Co-PIs. The Management Team advises the Project Direction who has final decision-making authority for the project. The Project Director also coordinates formal communication between the NEESgrid Project and the Equipment Site PIs, Consortium Development Team PI and the National Science Foundation.

The technical and outreach project teams report to the four major project component leads (Figure 4), and are responsible for meeting milestones and completing NEESgrid deliverables in the areas of information service components, system components, community outreach components, and management and operations, as described in the SI Work Breakdown Structure (WBS) that is provided as part of this Project Execution Plan. The Management Team, combined with the technical and outreach team leaders and other ad hoc advisors, as needed, serves as the *internal advisory group* for the NEESgrid project.

3.3.2 Executive Advisory Board

An Executive Advisory Board (EAB) advises the NEESgrid Project Director. The NEESgrid EAB is selected from outstanding national leaders in earthquake engineering research and information technology. Members who are earthquake engineers represent the diverse interests of that community, and members from the IT community represent the technical fields that are central to the NEESgrid system architecture and user interface components. Current membership on this Board includes two structural engineers (Frieder Seible and Andrei Reinhorn), one geotechnical engineer (Bruce Kutter) and one coastal engineer specializing in

tsunami research (Harry Yeh). On the IT side, the Board includes a grid computing expert (Bill Johnston), a large-scale cyberinfrastructure expert (Dan Atkins), a collaboratory expert (Jim Myers), a network infrastructure and visualization expert (Tom DeFanti), and a data systems expert (Sara Graves).

The role of the EAB is to make recommendations for positive change or improvement in project scope or direction to the Project Director. The EAB meets twice each year for the following tasks:

- To review and make recommendations on NEESgrid technical directions, strategies and project management;
- To recommend strategies for improving communications with the community and with the National Science Foundation; and
- To advise the Project Director as needed on overall administrative issues.

3.3.3 Change and Configuration Management Teams

The Change Control Board (CCB) provides a formal review mechanism for making changes to the WBS and baselines, including changes to design or configuration specifications for NEESgrid components. The roles of the CCB include:

- To insure that each proposed change to any of the project baselines receives due consideration by all relevant stakeholders within the NEES MRE;
- To evaluate all proposed changes on the basis of appropriate technical, cost, and schedule criteria; and
- To insure that only authorized changes are implemented.

The CCB members reflect the diversity of expertise required to evaluate proposed changes to the NEESgrid technical, schedule and cost baselines. In addition to the NEESgrid Project Manager, members include the four Management Team members responsible for system development, system deployment, community/collaboration and technology management systems. Members representing earthquake engineering community interests include the two earthquake engineer Co-PIs, one member from the Consortium Development Team. Finally, one member represents the perspective of the EAB. The Deputy Project Director chairs the Change Control Board so that proposed changes to the NEESgrid project elements will receive attention at the highest technical management levels of the project.

In reviewing changes proposed by the Management Team, the CCB may solicit advice and other input from other members of the EAB, the technical team leaders, members of the information technology community-at-large, and members of the earthquake engineering community-at-large. The CCB will meet as needed, as scheduled by the Deputy Project Director, and will conduct most of its ongoing work via electronic collaborations such as e-mail. Once a proposed change has been reviewed and approved by the CCB, the CCB Chair will recommend the changes to the Project Director for final approval and communication of the change(s) in baseline to NSF.

3.4 Project Communications

The NEESgrid Project is conducted as a cooperative agreement between NSF/CMS and UIUC. For the NEESgrid Project to progress rapidly, NSF needs to be fully informed of progress, plans, issues, problems, solution, and achievements in a timely manner.

NEESgrid project communications include the following three components:

- Internal project communications,
- Communications with the NSF NEES Program Office, and
- Communications with the earthquake engineering community and the general public.

Internal project communications internally includes Management Team and technical team leader meetings, staff meetings for each technical team, communication with the EAB and its members, communication with the CCB, and staff meetings of the project Management Team. Typically, these communications will be handled using electronic mail and attachments, but other electronic media may be used. Meetings will be summarized electronically to capture issues presented, discussion comments, and actions taken. All meeting summaries and internal electronic communications regarding the NEESgrid project will be archived to document the issues, the decisions taken, and the internal management or decision-making processes followed in executing the project. Communications between the management team and the CCB will be handled separately from other communications, and a formal record will be kept documenting changes to the WBS and baselines requested by the Management Team, CCB meeting summaries, and actions taken. Overall, the definitive source for information on policies and procedures for project participants is the NEESgrid Project Manager.

Project communications with NSF includes various reports, as described in Section 10, and listed in Table 9. In addition, changes to the WBS approved by the CCB and the Project Director will be formally submitted to NSF for acceptance. In general, the Project Manager will provide quarterly updates to NSF on the master NEESgrid Project Execution Plan. Action on and transmittal of formal communications are performed promptly. On most issues, informal communication between NSF and UIUC will have occurred prior to formal communications to minimize surprise and delay and maximize success.

A public website (http://www.neesgrid.org) has been established to serve as the primary communications interface between the SI effort and the earthquake engineering community. This website provides a single point of contact to access all web content specific to the SI component of the NEES Program, including all associated system and client software, portals, analytical tools, and repositories.

The standards used in the development of materials for the website, and for print and other media, will be those used by the NCSA Communications Division for development and dissemination of NCSA program materials. NCSA has a long history of creating high quality printed materials, state-of-the-art websites, and actively promoting scientific successes in the popular press.

3.5 Records Management

Records are divided into program documents and materials, and financial records. All program documents and materials will be archived in electronic form and maintained at the NEESgrid project management office at NCSA for the duration of the project. Program documents and materials include all official correspondence (electronic or paper format) among NEESgrid participants, between the NEESgrid Management Team and its advisory boards, and between the NEESgrid Management Team and NSF. The WBS and all changes proposed and approved by NSF are included in these materials.

All program documents and materials will be published on the neesgrid.org website and made generally available, barring intellectual property or other concerns that will be discussed with NSF on a case-by-case basis. Upon completion of the project, copies of all project materials will be provided to the NEES Consortium as documentation for the detailed progress of NEESgrid implementation during the systems integration phase of the NEES MREFC.

The Office of Grants and Contracts (OGC) at the UIUC will maintain all financial records. The OGC is responsible for financial accounting and adherence to regulations and acceptable business practices for the entire University of Illinois system. The OGC will comply with reasonable requests for financial information regarding NEESgrid made by NSF.

4.0 Project Work Breakdown Structure

A standard Work Breakdown Structure (WBS) has been developed to describe and account for all components of the project. The NEESgrid enterprise is organized in multiple nested levels of increasing detail (e.g., see the overview in Appendix A, and the WBS outline details in Appendix B). The NEESgrid project WBS organizes the technical content of the project and is the basis for project management, cost estimating, scheduling, project cost and schedule control, and human resource requirements. In this section, the first three levels of the WBS are described.

Level 0 (L0) represents the entire project. At level 1 (L1), the project is divided into four components representing the primary division of labor:

1. System Components,
2. Information Services,
3. Community Outreach, and
4. Management.

While the project is managed as an integrated whole, each of these four components is presented separately in the following sections.

In level 2 (L2), the primary activity areas are defined. Each level 2 activity is assigned to a technical, outreach or management team, and each team has a team leader. Level 3 (L3) of the WBS identifies key deliverables for each technical, outreach or management team effort, and a few dozen separate deliverable items are identified in the WBS. Finally, WBS level 4 (L4)

elements include project component milestones with completion dates leading to accomplishment of each deliverable (L3) task.

4.1 Work Plan (WBS Levels 1 and 2)

The Work Breakdown Schedule (described in detail in Appendix B) for this project is divided into five levels, as described above. The responsibilities assigned to project teams in each level 1 component are given in the following four sections.

4.1.1 System Components

The System Components task includes all system design, development, deployment, operations and support activities in NEESgrid. This effort comprises two project teams:

1. System Design and Configuration; and
2. System Deployment, Operations and Support.

The System Design and Configuration team is responsible for specifying system requirements to meet defined user needs using the Architecture-First model presented in the Project Management Overview section of this document. This team is assigned the tasks related to configuring or modifying existing middleware (or in certain cases, developing new required components) to meet those requirements. Upon completion, the software products from this team are transferred to the Deployment, Operations and Support Team. The deployment component of this team is responsible for packaging, testing, validating, and distributing the NEESgrid System and client software releases and updates. The operations component is responsible for establishing, monitoring and troubleshooting NEESgrid System components including computing, storage and network resources. The support component is responsible for training and consulting for system support personnel at provider sites and users of NEESgrid services. In addition, the support component is capable of providing consulting support for optimization and use of simulation and numerical analysis codes that might experience improved performance running on grid-accessible HPC platforms, or that might provide critical assistance to NEES sites.

4.1.2 Information Services Components

Information Service Components include all integration activity in developing high-level end user interfaces for NEESgrid users. This effort comprises four project teams:

1. Teleobservation and Teleoperation (Telepresence),
2. Collaboration and Visualization,
3. Simulation Tools, and
4. Data and Metadata Management.

Each of these teams will work closely with the system design and development team to ensure proper function and interoperability of their tools and interfaces with the underlying middleware tools and services in NEESgrid. They will also work with the systems deployment and

operations team to assist them in packaging their work products into the NEESgrid client software releases for testing and distribution.

These teams include the following:

1. The Teleobservation and Teleoperation team is responsible for delivering a passive telepresence management system supporting participation in NEES experiments by remote users, and an active teleoperation management system supporting remote control of experiments, as appropriate given safety and performance issues.

2. The Collaboration and Visualization team is responsible for delivering a collaboration environment supporting experimental design and data analysis, including data visualization tools and visualization pipelining.

3. The Simulation Tools team is responsible for delivering a web-accessible database of user codes, as well as relevant content (e.g., representative analyses from the community code base, searchable representations of community code capabilities, etc.) for evaluating the suitability of the community codes for application in research and practice venues.

4. The Data and Metadata Management team is responsible for establishing data and metadata standards for the NEES repository, for establishing a curated repository, and for providing the tools to be used by the NEES community to populate the repository with data and metadata.

4.1.3 Community Outreach Components

The Community Outreach components of NEESgrid are responsible for the effective communication between the NEESgrid team and the different disciplines within the earthquake engineering community. This effort comprises three components, each of which will be implemented in concert with the Consortium Development team.

1. The user requirements analysis component is focused on assisting the system specification definition activity with user requirement specifications that are determined through direct interaction with the different segments of the earthquake engineering community.

2. The community building effort is focused on developing active partnerships with the Consortium Development team, NEES Consortium, the NEES equipment sites (through direct contact coupled with a partnership with the NEES Site Council), and with specific industrial and practicing partners that are relevant to the systems integration aspects of NEES, promoting practical examples of the uses of NEESgrid.

4.1.4 Project Management and Operations

Four activities are included in the NEESgrid management effort:

1. The NEESgrid Management Team and Executive Advisory Board component includes high-level management and decision making for the project, plus the internal and external review activities that actively involve the EAB.

2. NEESgrid Project Management and Operations includes the day-to-day adherence of project teams to delivery schedules, fiscal management, and reporting to NSF and communications with the earthquake engineering community.

3. The Project Assessment and Evaluation effort collects, analyses, and publishes reports summarizing usage statistics, community valuation and validation, and technical performance results from semi-annual and annual reviews.

4. The Technology Management effort supports processes and strategies for implementation of a project management model supporting iterative systems design and integration.

5.0 Cost Baseline

This section provides an overview of cost estimates, baseline funding agreements, contingency management and project staffing.

5.1 Basis of Cost Estimate

Cost estimates for this project include personnel, equipment, travel, and services required to perform the tasks necessary for completion of the L3 deliverables in the WBS. In addition, these estimates reflect our knowledge of management and support costs gained from prior experience conducting projects of this complexity, scope and magnitude.

Personnel costs represent the largest proportion of the cost estimate. For NEESgrid project staff currently employed by UIUC or one of its subcontractors, estimates are based on the average fully loaded salary (i.e., including fringe benefits and indirect costs) necessary to replace that individual's experience and expertise at his/her institution. For personnel to be recruited, an average fully loaded salary for each type of position to be filled is used to estimate cost, specific to the institution with responsibility for completion of the task.

5.2 Funding Profile

Table 6 provides overall baseline funding estimates for the entire project for each of the WBS level 1 components. Contingency funds are incorporated into these estimates, as discussed in section 5.3, below.

Table 6. NEESgrid Cost Baseline for Full Project (2001-2004) to Level 1

WBS L 1	*Description*	*Total Cost ($M)*
1	System Components	$ 3,665,000
2	Information Services Components	3,099,659
3	Community Outreach and Partnership Development	1,005,740
4	Management	2,229,601
	Total	$ 10,000,000

Table 7 documents the funding obligations to UIUC and its subcontractors for each year of the project to level 1 of the WBS, with contingency funds included in the numbers for each level 1 project component.

Table 7. Project Obligation Profile Including Contingency to Level 1

WBS L 1	*Description*	*Year 1 8/1/2001 to 7/31/2002*	*Year 2 8/1/2002 to 7/31/2003*	*Year 3 8/1/2003 to 7/31/2004*	*Year 4 8/1/2004 to 9/30/2004*	*Total*
1	System Components:	993,000	1,267,000	1,321,097	83,903	3,665,000
2	Information Services Components	900,860	1,106,813	1,056,986	35,000	3,099,659
3	Community Outreach and Partnership Development	320,393	330,065	327,832	27,450	1,005,740
4	Management	937,878	645,860	560,814	85,049	2,229,601
	Totals by Project Year	$3,152,131	$3,349,738	$3,266,729	$231,402.	$10,000,000

5.3 Contingency Management

NEESgrid, as with any systems engineering project, must manage technical, schedule and cost contingencies in mitigating project risks and ensuring project completion that is on-time, on-budget and in-scope. NEESgrid project management uses the strategies described in this section to manage the risks inherent to the project. Using these strategies allows project management to modify whichever baseline (technical, schedule, or cost) most effectively addresses the contingency in a manner that keeps the project on track.

NEESgrid is a multi-institution endeavor that must remain flexible in order to succeed. However, the formality of university-university contracting policies and procedures requires that each and every change to the *cost* baseline impacting an institutional partner generate a formal contract modification to be executed by each institution. This is a cumbersome process. We contend that this may be necessary in order to ensure the success of the project, but from a management perspective it is the least flexible mechanism available to us in tackling any problem that faces the project. Further, since personnel costs are the largest proportion of our budget, making changes to the cost baseline impacts personnel and can have negative consequences to a project partner, which we choose to avoid.

Therefore, our strategy for managing contingencies is to first evaluate possible changes to the technical or schedule baselines as the preferred approach to address the need. For example, a change in the technical scope or schedule for a L4 task may be all that is needed to solve the problem. If the problem requires changing, removing, or adding a deliverable, changes may be needed in the L3 schedule and costs. However, in either case the changes can be made by transferring work assignments or modifying work schedules within the project team at a given partner institution. Changes of this type made to L3 costs need to be reflected in the WBS, and managed by the CCB, but these changes need not require any inter-institutional transfer of funds. If none of these strategies – technical modification of scope, schedule modification, or intra-institutional cost contingency – address the problem, then we must consider other modifications to the cost baseline, which require the formal transfer of funds among project participants.

Each of these strategies has its own unique cycle time, which reflects the time lag required to effectively make changes, and therefore the management flexibility. The key is to closely monitor progress, so problems can be identified and dealt with as early as possible. Once a problem has been identified, possible changes to the technical or schedule baselines will be discussed by the Change Control Board within days and a decision forwarded to NSF for final acceptance of the change. Due to the nature of the work involved in NEESgrid, i.e., software engineering, is highly probable that the technical personnel involved in the activity in question, or another available technical expert in the same organization, can begin working in a new technical direction or on a new schedule immediately. Managing in this manner provides the project with a great deal of essential flexibility.

However, there must be a process and mechanisms for modifying the cost baseline for the project, for cases where such a change is necessary. Further, this process must reflect the time cycle and administrative effort required to make these changes. Therefore, our strategy for managing cost contingencies will address cost issues as part of the annual project planning and review. Each year, funds will be allocated to each subaward institution based on the WBS

current at the time. Any required changes to the cost baseline will be undertaken as a result of this process, and formal subaward modifications will be initiated as necessary to reflect these changes. So, as part of each annual review, each cost element of the WBS for the coming year will be reviewed in the context of necessary modifications to the technical and schedule baselines, and performance to date by each participant responsible for a given activity.

In the review process, each participant needing to address a contingency will prepare an application to the CCB which includes proposed modifications to the scope of work, the WBS, technical, schedule, and cost baselines necessary to address the need. All requests for application of contingency funding will undergo formal review by the NEESgrid Change Control Board, and the board will make its recommendations to the NEESgrid Project Director. In each case, the Project Director shall issue a written decision memorandum on the request.

The results of this process will be formally recorded as changes in the NEESgrid Cost Baseline. Application of contingency will be reported at WBS level 3 in the quarterly and annual reports to NSF. NSF will be notified separately of any contingency allocation in excess of $50,000; otherwise all contingency allocations will be reported in the quarterly and annual progress reports.

5.4 Staffing

Wherever possible, each of the technical, outreach and management team leaders is using existing staff to fulfill task obligations to NEESgrid. This strategy allows us to initiate the project with minimal staffing dependencies, and allows us to more exactly estimate costs. Certain key activities require the recruitment of new staff. Since the project began in August 2001, several key personnel have been recruited including a Project Manager at NCSA, a Senior Technical Manger at ISI and technical staff at CREW. For other open positions, recruitment will continue until acceptable candidates are identified. The Project Director will also be discussing open recruitments with relevant team leaders to expedite activity or determine if there is a better way to meet the project requirements. Any open recruitments, which are potentially jeopardizing completion of milestones and deliverables, will be discussed by the Management Team to decide if action needs to be proposed to the Change Control Board.

6.0 Implementation Plan

6.1 Schedule Baseline

Table 8 describes major project milestones leading to the successful completion of this project.

Table 8. Major NEESgrid Project Milestones

Milestone	*Description*	*Date*
Project Initiation	NSF Project Funds Received by UIUC	8/23/2001
Project Management and Design Documentation	Project Execution Plan, System Architecture and User Requirements Documents delivered to NSF	2/15/2002

First NSF Site Review	First annual NSF site visit and review focused on project management and system design	3/11/2002
Conduct First NEESgrid Prototype Demonstration	Early Adopter demonstration of major system components applied to a research problem conducted at a NEES Equipment Site	11/14/2002
First NEESgrid Software Release	Initial release of integrated software package to support basic system functions, including source code, documentation and installation instructions	1/31/2003
Second NSF Site Review	Second annual NSF site visit and review focused on software features, system development and deployment schedules, and transition planning	3/20/2003
Publish Draft Acceptance Testing Plan	Draft of an acceptance testing plan document to be used with the full NEESgrid system prototype tests in July 2003 and which will form the basis for the formal acceptance testing plan	6/30/2003
Conduct Demonstration of Full NEESgrid System Prototype	System-level tests using an earthquake engineering research problem of working prototypes of all NEESgrid components that will be included in the final system	7/31/2003
Second NEESgrid Software Release	Second release of integrated software package supporting all system functions as demonstrated, including bug-fixes from initial release, source code, documentation and installation instructions	10/15/2003
Publish Final Acceptance Testing Plan	Protocols, procedures, criteria, metrics, scenarios, tests and schedules for formal acceptance testing of NEESgrid software to be used in conducting final system acceptance testing	3/31/2004
Third NSF Site Review	Third annual NSF site visit and review focused on final system features, deployment progress and schedules, and progress on system transition	3/31/2004
Final NEESgrid Software Release	Final release of integrated software package supporting all system functions including bug-fixes and refinements to second release, source code, software documentation and installation instructions	6/30/2004
Conduct Final System Demonstration	Demonstrate system features and uses at 13th World Conference on Earthquake Engineering in Vancouver, Canada	8/15/2004
Complete System Acceptance Testing	Complete testing of each system component to meet criteria for acceptance by NEES Consortium	8/31/2004
Complete System Transition to NEES Consortium	Transfer of all project documentation, system documentation, software source code, executables, and repositories to NEES Consortium	9/30/2004

6.2 Critical Path Analysis

A schedule for the entire NEESgrid project is found in Appendix C, in the form of a Gantt chart for the project displayed down to WBS Level 3. This schedule represents an attempt to cast the *incremental architecture-first* project management plan for NEESgrid into a standard format used successfully for *typical deterministic non-incremental* projects (i.e., sequential instead of concurrent, and with UR information known in detail a priori instead of subject to substantial discovery over the project lifespan). Because incremental software development project management techniques are commonly ill-suited to Gantt[3] representations and the project networks that arise from them (e.g., the Critical Path Diagram represented by highlighting critical tasks on the most-detailed Gantt project representation), it is essential to realize that NEESgrid project network diagrams will not look like those found in conventional hardware-oriented projects.

However, software systems engineering projects such as NEESgrid still possess a critical path that is essential to discern from the project dependencies (i.e., a sequence of tasks whose timely completions are critical to the project schedule), and *it is essential to examine the project dependencies in order to gain an optimal scheduling plan to insure that the project is executed on time and on budget.*

For the NEESgrid project, these critical tasks arise in the following high-level sequence:

(1) Initial planning activities, which include WBS-specified tasks such as development of project plan, user requirements, and systems architecture baselines, developing connections within the community, and identifying early adopter sites. This set of tasks also can be extended to include critical tasks for the MRE, which are not specified in the NEESgrid WBS, including aiding the equipment sites in development and implementation of plans for local network architecture that will connect the sites to the national network fabric.

(2) Deployment of prototype components in support of the early-adopter and shadow-adopter programs, including development and dissemination of NEESgrid-specific data models, formats, and services, early versions of telepresence tools, prototype reference

[3] The fundamental problem of casting an iterative software development model into a Gantt format is that the various iterations (e.g., release versions) of the software products are not well-suited to scheduling deterministically, e.g., some more stable components may progress more slowly through versions compared to others that are responsive to less-well-understood requirements. In addition, where the requirements are subject to discovery over the project lifespan (i.e., new-technology projects such as NEESgrid, where both the social/community vision and the technological/shared-resource architecture are new models for research and practice in the community served), it may be desirable to cease iterative development on some stable components in order to reallocate resources to other identified tasks, or to develop new tasks that arise from scientific or technical opportunities (e.g., new software or hardware that can be added to the project, or changes in suppliers caused by key vendors of equipment going out of business or entering NEES-related markets). In all of these evolutionary venues, deterministic sequential representations such as the Gantt chart will only work well at the higher levels of project detail, e.g., WBS/L2. Hence scheduling and project networking methods that depend upon the lower-level details at L3 and L4 may not be well-suited to the NEESgrid project plan.

implementations of NEES-POP hardware and software, and other systems components deployed in support of the early-adopter program

(3) Continuous delivery of improved features identified by the full range of NEES stakeholders, developed by the NEESgrid team, and with this discovery/deployment process mediated by the change control processes of the NEESgrid project, and reviewed by the various NEESgrid advisory groups (e.g., the EAB, NSF, the CREW assessment effort, the CD team, etc.)

The first task requires approximately six months, the second will consume nine to twelve months, and the third occupies the rest of the project's duration. These are the three main collections of tasks that must be executed in this particular sequence in order to insure that a functional system that is responsive to the real needs of the community is delivered late in 2004. As the project proceeds and the early-adopter efforts aid in discovery of more detailed project requirements, more accurate project networks will be developed for use within the NEESgrid project, and at the interface with the CDT, where scheduling tasks in 2003 and 2004 will greatly affect system quality at delivery.

7.0 Subcontract Management

This section describes the subcontracts required to execute this project and specific reporting requirements imposed upon the subcontractors necessary to assist the Project Management team in its activities.

7.1 Subcontracts

The execution of this project requires expertise and other resources from four academic institutions in addition to the University of Illinois at Urbana-Champaign. These institutions are:

- The University of Michigan (School of Information),
- The University of Southern California (Information Sciences Institute and Department of Civil and Environmental Engineering),
- The University of Chicago (contractor for the Argonne National Laboratory, Division of Mathematics and Computer Science), and
- The University of Oklahoma (School of Civil Engineering and Environmental Science).

The University of Illinois Office of Grants and Contracts will execute subcontracts with each of these institutions that will describe the terms and conditions governing the conduct of activities undertaken by employees of each subcontracting institution. The University of Illinois has extensive experience negotiating and managing subcontracts resulting from large NSF-funded projects, and specifically has active subcontracts with each of the institutions described above.

7.2 Reporting requirements

Each of the NEESgrid subawardees invoices UIUC on a monthly basis. This allows the Project Manager to integrate subaward and UIUC expenditures, and to stay abreast of overall project expenditures monthly for management purposes.

In addition, on a quarterly basis the project management office at NCSA will receive from each project technical and outreach team leader an updated project plan including partial progress against milestones and deliverables, keyed to the WBS. These reports are used to update the NEESgrid master project plan and to generate quarterly and annual progress reports due to NSF.

8.0 Baseline Control

A mechanism for controlling baselines and specifications is presented in this section.

8.1 Overview

The project baseline includes a technical baseline (Section 4), a cost baseline (Section 5), and a schedule baseline (Section 6). All three aspects will evolve and be monitored by the NEESgrid Project Manager, as the project progresses. The cost and schedule baselines presented in Sections 5 and 6, respectively, are based on the technical baseline and proposal CMS-0117853 submitted to NSF.

If necessary (e.g., due to significant changes to the funding profile), UIUC or NSF may initiate and propose rebaselining the project at any time. Rebaselining involves updating cost and schedule plans to reflect the best current estimate for the current, approved configuration given the currently projected funding profile. The revised baseline will then be used to track subsequent cost and schedule performance estimates. Cost estimates are based on only the most up-to-date baseline and approved technical scope.

The cost and schedule baselines will be implemented and controlled through the following measures:

! All project work will be defined, organized, and implemented in accordance with the WBS.

! Project performance will be measured against cost and schedule baselines at level 2 of the WBS.

! A Change Control Board will manage changes to the baseline in a manner conforming to the NEESgrid change management process.

The NEESgrid Project management will exercise technical control by:

! Organizing work according to the WBS.

! Maintaining the controlled technical baseline to specific technical objectives and to establish design specifications and criteria for the component systems.

- Creating system designs that meet the design criteria and satisfy the cost and schedule constraints.
- Reviewing proposed designs (using both technical and fiscal criteria, and with review performed under the aegis of the associated advisory or control board) prior to issuance of subawards.
- Implementing the institutional QA plan and establishing specific QA plans as required by Q2 as part of the risk mitigation strategy.
- Implementing and continuously executing a change control system.
- Implementing procedures to assure the proper authorization and technical integrity of the statements of work, procurement documents, and accompanying documents.
- Supervising the development of component systems and testing them at appropriate points (e.g., upon delivery for deterministic components, or during walkthroughs for higher-risk components) to assure that design specifications and criteria are met.

Baseline management for mature technology components is effected through the project's configuration management component, with a formal mechanism utilized for (1) identifying areas where change is required, (2) characterizing the events that cause changes to be desired, (3) outlining the process for effecting the change, and (4) gaining the required authority (e.g., from the funding agency, or from a technical advisory board) for realizing the change. The various components of baseline management are presented below.

There are three primary areas where baselines must be identified and managed in this project:

- Business and cost baselines, which will be in the form of a cooperative agreement between NSF and UIUC and as subcontracts between UIUC and subaward organizations, which may require more formal approval to create or modify;
- Technical baselines, which are expressed as agreements outlining the technical work to be performed (e.g., the WBS expression of the roles and responsibilities of the collaborating organizations); and
- Schedule baselines, which detail the sequence and duration of the various component tasks that define the overall systems integration project.

In each of these venues, a baseline modification procedure will be developed during Q2, as part of the Change Control Process and Project Execution Plan development process.

8.2 Risk Mitigation for NEESgrid

New technologies always involve risk. Because the NEES program is integrating many new technologies, project management effort must be expended to identify and mitigate the associated risks. A NEESgrid risk assessment and risk mitigation plan is a component of the Technology Management activities under WBS 4.4. This document is maintained separately from the PEP, and it is updated periodically to reflect changes in the risk profiles for project components. The first version of the NEESgrid Risk Assessment and Risk Mitigation Plan will

submitted to NSF on or before March 1, 2003. Once accepted by NSF, the document will be posted on the neesgrid.org website.

Three general areas of risk are inherent in the NEESgrid project:

- *Reliance on grid technologies*: The risk in using grid technologies in the core components of the system architecture is that these technologies may not continue to be developed or supported during the operational lifetime of the NEES program (2004-2014).

- *Data and metadata systems that support the curated data repository*: The risk in the strategy for building a curated repository for NEES data and metadata based on user derived standards and specifications is that the objectives may be too complex to be completed during the construction phase of the NEES program (2000-2004).

- *System usability*: The risk in building an integrated system based on advanced software technologies that are unfamiliar to most members of the earthquake engineering community is that at the end of the construction phase the system will be functional, but not sufficiently useful to the community to be adopted.

These risk elements cannot be addressed in a manner that reduces risk to zero; however, specific NEESgrid architectural design and implementation strategies are intended to maintain each at an acceptable level.

- *Reliance on grid technologies*: There is no guarantee that grid technologies will continue to develop and be supported for the operational lifetime of NEES, but every indication is that they will. Members of the NEESgrid project team are leaders in the grid computing community, and are actively involved in specific initiatives designed to provide a stable but evolving grid computing environment for use by a wide range of science and engineering communities. These initiatives include the NSF Middleware Initiative, the TeraGrid Project (another MREFC), the Global Grid Forum, the UK e-Science Grid, and the European Data Grid, to name a few.

  The software implemented in NEESgrid adheres to the standards being established by these initiatives and to the direction for development that is being followed in efforts driven by a broad based community of software engineers and applications specialists. Moreover, a large number of national and international science projects are committed to use of Grids as their underlying infrastructure.

  However, the strongest indication that the grid middleware approach will persist is the high level of investment in these technologies by large corporations. IBM, HP, SUN, Microsoft and other major computing vendors have committed billions of dollars to commercial Grid software development, deployment, and support. This trend greatly increases the likelihood that the grid technologies underpinning NEESgrid will become commercially supported during the operation phase of NEES.

- *Data and metadata systems that support the curated data repository*: The greatest element of risk in the data systems and repository approach in NEESgrid is that the

community is highly multidimensional, with each dimension having specific data requirements. Hence, building a repository based on a single, flexible structure and high-level specifications is challenging. However, the challenge is to staff, direct and focus the effort so three outcomes are achieved: 1) a working repository exists that is both accessible and useful to the end user community, and 2) the tools for modifying and extending the repository exist and expertise is accessible to the community for improving the structure and function of the repository based on new information relating to user data requirements, and 3) a community-based process exists to plan and implement such changes that maintains smooth operation of the repository.

From a construction perspective, the primary risk is that the data problem is unbounded, and developing an unbounded solution is neither practical nor achievable. Conversely, developing a narrow solution for a subset of the community will disenfranchise other critical NEES constituencies. NEESgrid strategies for mitigating these risks and accomplishing the desired outcomes include 1) interacting closely with the diverse components of the community to ascertain the similarities and differences in their data system requirements, 2) increasing the expertise in data systems and their management both on the project technical team and on the Executive Advisory Board, 3) developing a bounded specification for the 2004 data/metadata system based on community needs, and 4) working with the CDT/Consortium to define a community-based process for improving and extending the 2004 system during the operational phase (2004-2014).

- *System usability*: There is always a risk that the system or elements of the system will not be sufficiently useable by the community to be adopted. Strategies employed by NEESgrid to mitigate this risk include: 1) iterative development and deployment that focuses on community-relevant demonstrations, software releases and training activities with each iteration; 2) publication of mock-ups and working prototypes of tools for general access by the community, and 3) a formal acceptance testing program to satisfy specific component and system-level criteria developed by the NEES Consortium (or CDT) and agreed to by the SI team. Feedback from the November 2002 demonstration provides strong evidence that this process is working effectively. Addressing system usability risks includes usability of the grid-based software elements of the NEESgrid system, a concern that is sometimes raised by members of the earthquake engineering community.

Risk profiles and mitigation strategies are discussed in additional detail in the NEESgrid Risk Assessment and Management Plan developed and maintained as a component of the Technology Management activities in WBS 4.4. The first version of this document will be published on or before March 15, 2003, as noted in the milestones for WBS 4.4.3.

8.3 Change Control

Management of change is of preeminent importance in iterative project management. The NEESgrid project change control is effected by maintaining a centralized repository of information that represents the current state (e.g., progress, financial health, configuration, etc.) of the project, the various directions that individual components are working in, and other project management information (e.g., contingencies, portfolio diversification strategies). This

centralized repository serves both as a means to provide a uniform view of the project for all the project participants, and as a history of the project's evolution, both planned (e.g., schedule baselines) and unplanned (e.g., changes arising from new requirements or from risk mitigation).

Task 4.4.1 is reserved for the deployment of the Change Control Board (CCB). The CCB is chaired by the Deputy Project Director, and populated with representatives from the Management Team, Executive Advisory Board, and the Consortium Development Team. In addition to these members, the CCB may seek additional information on proposed changes to the project baselines from other sources within the Information Technology and Earthquake Engineering Communities.

The change control processes include oversight of the Configuration Management (CM) system of the NEESgrid project. Configuration management includes the following items:

- Project baselines, including project documents, technical baselines, and schedules;
- Software components, including the Grid components configured via GridCVS within the NMI Project software repositories; and
- All project documents, including drafts of all documents identified as WBS L4 milestones for the various NEESgrid deliverables.

Documentation of deliverables is shown in the NEESgrid project schedule as milestones associated with final deployment of various WBS L3 tasks. These document efforts will be ongoing throughout the NEESgrid project lifecycle, and draft versions of all such documents will be configured items that will be checked into the NEESgrid document repository, so that all NEES stakeholders can view the current state of each project document.

8.4 Funding Control

The NEESgrid Project maintains a project obligation plan that is revised as required to adapt to changes in the funding profile. The total obligation plan is the sum of individual plans prepared by task in the WBS.

Each fiscal year during the project, it is expected the NSF, pending availability of funds, will approve a specified amount of the funding for the NEESgrid Project. This funding will be provided to UIUC following the annual site visit merit review and based on progress to date and plans for the next year. These plans will include risk assessment and contingency plans based on risk. In the interest of optimizing progress and project success, it is the policy of UIUC to obligate all funds in the year they are received to perform activities or to procure items included in the approval baseline.

A parallel accounting structure that allows funds to be allocated to specific WBS elements has been created. This structure provides a system by which both awardee accounting and project fiscal management requirements can be met.

Based on monthly updates from UIUC and its subcontractors, updates of expenses and obligations are generated for use by the Project Manager and Management Team. The overall fiscal status of the project is reported quarterly to the NSF.

If, towards the end of the fiscal year, the total obligations fall short of the available funds, the NEESgrid Project Director will have the management freedom to accelerate priority tasks for procurements planned for the subsequent fiscal year. This process does not change the total project contingency since the estimated for all tasks has not been changed.

If the cost trend is unfavorable, i.e., planned tasks are requiring more funding than estimated, the NEESgrid Project Director will act to reduce costs by exploring and implementing cost-saving alternatives. Total costs for all work planned for the fiscal year will be compared with the funding available. If the total estimate for the planned work exceeds the available funding, the Project Manager will coordinate with the technical and outreach team leaders to identify and prioritize tasks or procurements that can be rescheduled for the subsequent fiscal year while minimizing the impact on project milestones. Any significant impacts on major project milestones will be discussed with the NSF NEES Program Director.

Rescheduling project tasks to manage the required funding does not directly affect contingency since the estimate at completion for the task remains the same. Contingency is affected by changes in the estimate at completion reflecting cost overruns or underruns. Contingency may also be affected slightly by the change in escalation rate when a task is rescheduled to a different fiscal year.

On an annual basis, the NEESgrid Project prepares a revised estimated of the cost to complete the project. This estimate is based upon updated cost information from subawards, approved changes to the technical baseline, cost-saving plans and approaches developed by the NEESgrid Project Director in the collaboration with the Management Team, and on known or projected revisions to the funding profile. With this information, NSF will evaluate the progress and scope of the project. If the estimate-to-complete exceeds the current funding baseline, the Project Director will develop a plan, approved through the Change Control Board, to enable NEESgrid Project completion and submit this plan to NSF for approval.

8.5 Performance Measurement and Corrective Actions

The performance of all project technical, outreach, and management teams will be measured by their adherence to the plan, meeting all approved milestones according to the agreed upon timelines and within the allocated budgets. In addition, the Project Manager will monitor progress toward milestones, and evaluate on a monthly basis whether any project components are at risk. The Project Manager will present this assessment to the Management Team for discussion and action, if appropriate. If action is required, a change request will be prepared by the Management Team and proposed to the Change Control Board.

8.6 Meetings and Reviews

Internal management meetings will occur on a bi-weekly basis during the term of this project. The purpose of these meetings is to monitor project performance at each level in the WBS and to identify as early as possible any changes in risk profiles or other aspect which might require a change in the technical, cost, or schedule baselines.

Internal management meetings include:

- Management Team meetings, conducted by the Project Director;
- Technical and Outreach Team meetings, conducted by the Team leaders. The technical teams and their leaders are defined at level 2 in the WBS.

The Executive Advisory Board meets formally on a semi-annual basis, coinciding with the internal reviews conducted each October and the annual NSF project reviews conducted each March. In addition, on an *ad hoc* basis members of the EAB will be invited to join meetings of the Management Team or the technical teams to contribute their expertise and perspectives.

The Change Control Board serves to consider proposals by the Management Team for changes to project baselines. It is not scheduled to meet on a regular schedule, but stands ready to consider any proposals made as soon as a meeting of its members can be arranged.

We anticipate frequent interactions with the NSF NEES Program Office. It is essential to the success of the project that an open line of communication is maintained between NSF and the Project Director. In addition, on an annual basis NSF will convene a formal project merit review to perform a detailed evaluation of project performance, project management, desired or necessary changes to project baselines, and other assessment reports prepared by the NEESgrid Project participants. Participants in the annual reviews will include external reviewers invited by NSF, the NEES Program Director and other NSF staff, the NEESgrid Project Director, NEESgrid Deputy Project Director, NEESgrid Project Manager, Management Team, and other NEESgrid Project staff.

9.0 Standards, Quality Assurance, and Safety

Relevant standards for the systems integration project are presented in this section, including background material on software project management and software quality assurance, two topics which are more tightly related in the abstract world of software development than they are in more concrete projects such as construction or manufacturing.

9.1 Standards

Codes and standards proven through established engineering and software practice to be appropriate to the system under consideration will be incorporated into performance specifications for the design of each major system of NEESgrid. An integral part of the preliminary design of each major system will be the selection of the appropriate codes and standards to govern design, development, testing and operation of the system. This selection is subject to review by UIUC through the design review process. The selection of codes and standards will be tailored for each major system specification in accordance with the function of the system and accumulated engineering experience with similar systems development projects.

When established codes and standards are not applicable or available, a NEESgrid Project Standard or Specification will be formulated by the appropriate standards subcommittee, based on the best technical information available, and communicated to project participants.

In the realm of software and digital content generation (e.g., from data gathered at experimental sites), existing industry standards will be utilized where feasible. Software development models will follow established industry practice (e.g., CMM), and data models generated for archiving and retrieval of experimental and simulation data will utilize established standards appropriate to the content (e.g., XML).

In all cases, preference will be given to deployment of COTS technology, either as an initial prototype implementation intended to mitigate risk, or as a long-term solution intended to minimize costs.

9.2 Quality Assurance

Ultimately responsibility for the guidance and oversight of quality assurance (QA) at UIUC rests with the Project Director. Formulation and implementation of the QA program is the primary responsibility of the NEESgrid Project Manager.

It is the policy of UIUC that all activities be performed at a level of quality appropriate to achieving the scientific, technical, operational, and administration objectives of the NEESgrid system. This concept is adhered to in design, development, test, calibration, operation, procurement, finance, personnel, security, and other activities. Concept, design, programmatic, and administrative reviews are an essential component of QA at UIUC.

In general, the QA strategies used by the NEESgrid project are derived from those used by NCSA in its software development and deployment projects (e.g., Teragrid, Oscar, NMI, HTTPD), by ISI/ANL (e.g., Globus, NMI, AG), and by the University of Michigan (e.g., Worktools, CHEF). In the development and integration phases of the project, ISI has oversight of QA activities based on its role in coordinating software integration across technical teams. For final deployment and release QA responsibility resides with NCSA.

The QA objectives are to implement the checks and balances required for achieving the scientific, technical, operational, and administrative objectives of NEESgrid.

10.0 Reporting and Reviews

10.1 Reporting Schedule to NSF

Table 9 lists periodic reports due to NSF during the course of the NEESgrid project and the due dates for these reports. The following subsections describe the reports required by NSF.

Table 9. Reporting Schedule to NSF

Type of Report	Due Date Each Year
Quarterly Interim Progress	June 30
Quarterly Interim Progress	September 30
Quarterly Interim Progress	December 31
Annual Progress	March 31
GPRA - Performance Data Report – Estimate	TBA by NSF
GPRA – Performance Data Report – Actuals	TBA by NSF

10.1.1 Quarterly Interim Progress Reports

The NEES grid project quarterly interim progress report will be prepared and submitted to NSF via FastLane. The quarterly interim progress report will cover baseline technical scope, cost, and schedule progress during the quarter just completed minus one month, e.g., the quarterly report due on September 30 will cover the months of June, July, and August.

This report is prepared in accordance with the Cooperative Agreement and at a minimum will consist of the following:

- Summary of work accomplished during the reporting period, including major technical accomplishments and interactions with other NEES program awardees.
- Progress toward technical baseline achievement.
- Financial status report and other financial information, including actual or anticipated underruns or overruns.
- An assessment of project status relative to the baseline schedule and milestones.
- Change Requests approved by the Change Control Board during the reporting period and their affect on key milestones, contingency, or technical performance parameters.
- Changes in organizational structure or personnel.
- Summary of risk management during the reporting period, including a review of current or anticipated problem areas, use of contingency funds, and corrective actions taken.
- Status of action items affecting NEESgrid/NSF responsibilities.
- Any other actions requiring NSF notification.

The financial information in the quarterly report will include a summary at the reporting level of the WBS level 2, of costs and obligations and a comparison with available funding. The forecast and actual completion of project level milestones will also be compared with the planned milestone completion dates presented in this plan. Performance data will include comparisons of "earned value" for work completed with a time-phased budget baseline and with actual costs accumulated to provide a "dollar" measure of the ahead- or behind-schedule position and the overrun/underrun status of each reporting level of the WBS. This data will be presented graphically to show trends at the top level of the WBS. A narrative "variance report" will discuss the causes and corrective actions to address significant variances from the Project Execution Plan.

10.1.2 Annual Progress Report

In lieu of a fourth quarterly progress report, the NEESgrid project annual progress report due on March 31 will be submitted via FastLane, and include all information that would be submitted in the quarterly progress report in the form of an annual progress report. The annual reporting period will be March 1 – February 28. The annual report will be prepared in accordance with the Cooperative Agreement and will contain, as a minimum, the following information:

- Summary of overall progress, including results to date, and comparison of actual accomplishments with the proposed goals of the period.
- Summary of work performed during the succeeding year, and any other pertinent information.
- Technical, financial, schedule, risk management, and contingency allocation information similar to that given in the quarterly progress report will be included in the annual report, including progress against baselines, summarized for the annual reporting period.
- Summary of changes to the NEESgrid technical, cost, and schedule baselines, approved in the NEESgrid Change Control process.
- Indication of any current problems or favorable or unusual developments.

The annual report will discuss past year achievements in terms of technical scope, cost, and schedule and compare these achievements against those in the Project Execution Plan. Significant staffing changes, costs, and schedules will be presented for each WBS level 2 and comparisons will be made to the Project Execution Plan cost and schedule baselines.

Changes to the NEESgrid technical, cost, and schedule baseline approved in the NEESgrid Change Control process will be identified, and these changes may represent modifications to the cost and schedule information presented in this Project Execution Plan. Any other changes in the Project Execution Plan will be similarly considered in the Change Control process, as the Project Execution Plan is a controlled document with the overall NEES project baseline. These changes will be fully reported in the annual progress report review and approval by NSF in accordance with the terms and conditions in the Cooperative Agreement. The annual progress report will include an estimate of funds remaining unobligated at the end of the annual reporting period and the plan to spend these funds during the next period. The annual progress report will include a

statement of the NEESgrid project calendar for the next project year for meetings of advisory committees, workshops, and internal and NSF reviews.

10.1.3 GPRA Reporting

As a requirement under the Government Performance and Results Act (GPRA), NSF is required to report on the Federal Performance Goals for Facilities. The awardee is required to submit, via FastLane, Performance Data Reports related to the GPRA performance goals. This may include the collection and submission of specific data related to the NSF GPRA requirements, including information on costs, project schedule, and annual project milestones. The Awardee will be required to submit estimates for the current fiscal federal year on a date TBA by NSF and data for the preceding fiscal federal year are due on a date TBA by NSF.

10.1.4 NSF Reviews

NSF will conduct annual reviews of the NEESgrid project, covering technical and management issues. NSF will provide the project with the review protocol and criteria prior to the review, with adequate time to agree on the agenda and to prepare the necessary presentation material. There will be continuity of membership on these review committees.

10.2 Project Documentation

The NEESgrid project activities for technical, outreach and management teams will be fully documented using a variety of mechanisms. First, the neesgrid.org website supports email archiving, and all project related email will be archived on the site server. A copy of the Project Execution Plan, including all revisions and updates will be maintained on the website. All reports and white papers generated by the project team will be posted to the website.

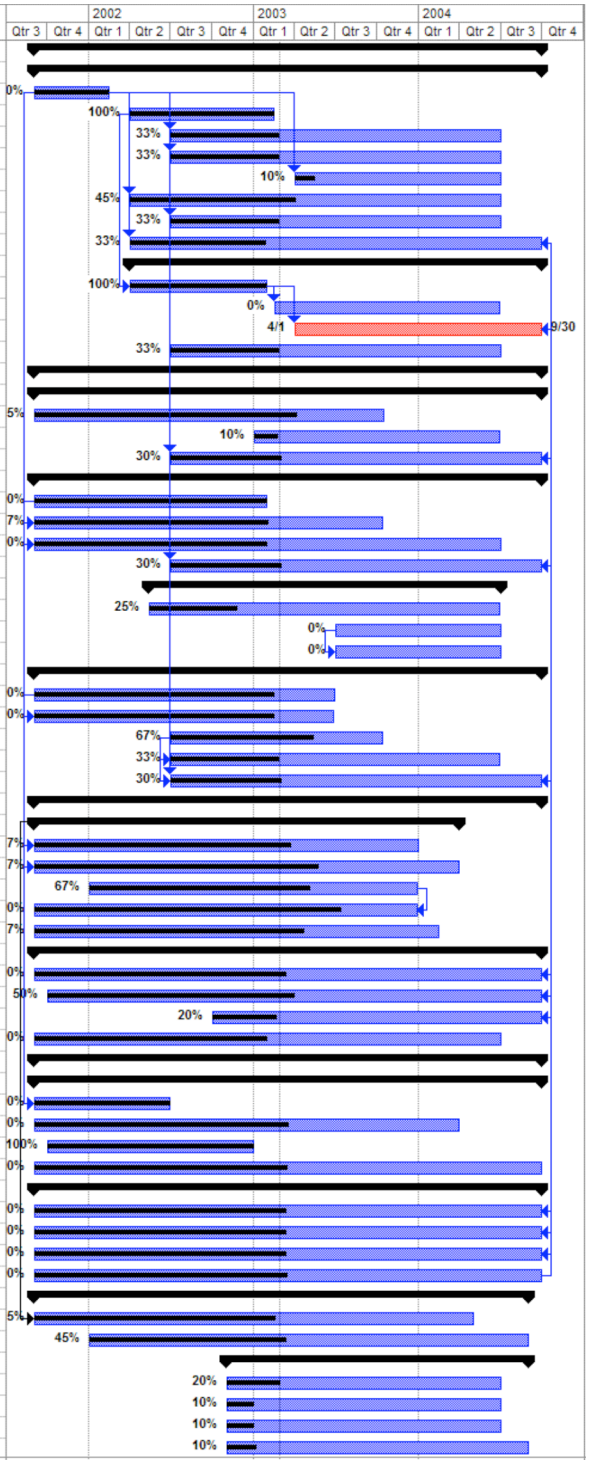
Copies of all technical specification and other documentation will be maintained by the team leaders and updates will be posted to the website as needed. All software products and training information will be distributed via the neesgrid.org site.

10.3 Technical Reports

As part of the NEESgrid project it is expected that technical reports will be generated to document the implementation and performance of new concepts in software engineering for complex science and engineering communities. Copies of all technical reports generated by the NEESgrid Project team will be posted on the website.

Appendix A. WBS to Level 3

ID	% Complete	Task Name
1	36%	1. System Components
2	40%	1.1 System Configuration and Design
3	100%	1.1.1 System Requirements Specification
4	100%	1.1.2 NEESgrid Early Adoption
5	33%	1.1.3 NEESgrid Security Enhancements
6	33%	1.1.4 Access to Experimental Apparatus and Instruments
7	10%	1.1.5 Access to Simulation Codes
8	45%	1.1.6 Access to Data
9	33%	1.1.7 Collaboration Support
10	33%	1.1.8 Documentation
11	26%	1.2 Deployment, Operations, and Community Support
12	100%	1.2.1 NEESgrid Development at Early Adopter Sites
13	0%	1.2.2 System Software Distribution
14	0%	1.2.3 System Operations
15	33%	1.2.4 User Support and Training
16	47%	2. Information Services Components
17	41%	2.1 Telepresence Mode Services
18	75%	2.1.1 Telepresence Mode Services
19	10%	2.1.2 TPM System for Remote Operation
20	30%	2.1.3 Documentation
21	57%	2.2 Collaboration and Visualization
22	100%	2.2.1 Prototype Collaborative Environment
23	67%	2.2.2 Visualization Support
24	50%	2.2.3 Adaptation of CHEF
25	30%	2.2.4 Documentation
26	13%	2.3 Simulation Tools and Frameworks
27	25%	2.3.1 Community Simulation Tool Archive
28	0%	2.3.2 Repository of Sample Codes
29	0%	2.3.3 Usability Enhancements for Codes
30	56%	2.4 Data and Metadata
31	80%	2.4.1 Standards for Data and Metadata
32	80%	2.4.2 Specification for Data Services Architecture
33	67%	2.4.3 APIs for Data Harvesting, Management
34	33%	2.4.4 Curated Data Repository
35	30%	2.4.5 Documentation
36	57%	3. Community Outreach and Partnership
37	70%	3.1 User Requirements Assessment
38	67%	3.1.1 Site Technical Surveys
39	67%	3.1.2 Practice Surveys
40	67%	3.1.3 Visits to Equipment Sites
41	80%	3.1.4 Virtual Tours of Equipment Sites
42	67%	3.1.5 Publication of User Requirements Document
43	44%	3.2 Community Building
44	50%	3.2.1 Engage EE Community
45	50%	3.2.2 Build Consensus with CDT on SI Issues
46	20%	3.2.3 Facilitate Transition to Consortium
47	50%	3.2.4 Promote Examples of Use
48	46%	4. Management
49	67%	4.1 NEESgrid Management
50	100%	4.1.1 Outreach to NEES Equipment Sites
51	60%	4.1.2 Advisory Activities/Program Reviews
52	100%	4.1.3 Technical Outreach to Users
53	50%	4.1.4 Participate in NSF-sponsored Events
54	50%	4.2 NEESgrid Operations
55	50%	4.2.1 Project Management
56	50%	4.2.2 Fiscal Accountability and Reporting
57	50%	4.2.3 Communications and Community Outreach
58	50%	4.2.4 Project Documentation and Transition Mgmt
59	50%	4.3 NEESgrid Assessment and Evaluation
60	55%	4.3.1 Evaluation of Acceptance and Use
61	45%	4.3.2 Technical Performance Evaluation
62	12%	4.4 NEESgrid Technology Management
63	20%	4.4.1 Change Control
64	10%	4.4.2 Configuration Management
65	10%	4.4.3 Technology Risk Mitigation
66	10%	4.4.4 Product Acceptance



Appendix B. Detailed WBS Outline to WBS/L4

1	**System Components: Design, Development, Deployment, Operations, and Support**	**ISI** **Carl Kesselman**	!	!
	!		!	!
1.1	**System Configuration and Design**	**ISI/ANL** **Carl Kesselman and Ian Foster**	!	!
	!		!	!
1.1.1	***System Requirements Specification***	***ISI/ANL*** ***Kesselman/Foster***	***9/1/2001***	***2/15/2002***
	Publish System Architecture Document			2/15/2002
	!		!	!
1.1.2	***NEESgrid Early Adoption***	***ISI*** ***Kesselman/Foster***	***4/1/2002***	***2/15/2003***
	Publish Early Adoption Plan			5/17/2002
	Demonstrate Basic System Functionality			11/14/2002
	Document EA Outcomes			2/15/2003
	!		!	!
1.1.3	***NEESgrid Security Enhancements***	***ISI/ANL*** ***Kesselman/Foster***	***7/1/2002***	***6/30/2004***
	Demonstrate Core Grid Security Components			11/14/2002
	Integrate Basic Security into Release 1.0			1/31/2003
	Demonstrate System-wide, Multi-site Security			7/31/2003
	Implement System Security in Release 2.0			10/15/2003
	Implement Refined Authorization Tools in Final Release			6/30/2004
	!		!	!
1.1.4	***Access to Experimental Apparatus and Instruments***	***ISI/ANL*** ***Kesselman/Foster***	***7/1/2002***	***6/30/2004***
	Demonstrate NEESgrid Streaming Data Services (NSDS) at Early Adopter Site			11/14/2002
	Implement Standard NSDS (OGSA TP4) in Release 1.0			1/31/2003

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Demonstrate NSDS Extensions to Support Multi-site Hybrid Experiments			7/31/2003
	Implement Extensions in Release 2.0			10/15/2003
	Implement Standard Device Independent NSDS in Final Release			6/30/2004
	!		!	!
1.1.5	***Access to Simulation Codes***	***ISI/ANL Kesselman/Foster***	***4/1/2003***	***6/30/2004***
	Demonstrate Information Services in Support of Numerical Simulation Code Repository and Data Management			7/31/2003
	Implement Basic Simulation Information Services in Release 2.0			10/15/2003
	Implement Services Supporting Usability			6/30/2004
			!	!
1.1.6	***Access to Data***	***ISI/ANL Kesselman/Foster***	***4/1/2002***	***6/30/2004***
	Demonstrate Core Grid Services Supporting Data Movement and Access Control			11/14/2002
	Implement Basic Data Services in Release 1.0			1/31/2003
	Demonstrate Enhanced Access Control Services			7/31/2003
	Implement Enhanced Access Control Services in Release 2.0			10/15/2003
	Implement Community Access Control Services in Final Release			6/30/2004
	!		!	!
1.1.7	***Collaboration Support***	***ISI/ANL Kesselman/Foster***	***7/1/2002***	***6/30/2004***
	Demonstrate Core Grid Services Integrated into Basic CHEF Collaboration Environment			11/14/2002
	Implement Integrated Services in Release 1.0			1/31/2003
	Demonstrate Integrated Collaboration Services			7/31/2003
	Implement Integrated Services in Release 2.0			10/15/2003

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Implement Grid-enabled Integrated Collaboration Services in Final Release			6/30/2004
	!		!	!
1.1.8	***Documentation***	***ISI/ANL*** ***Kesselman/Foster***	***4/1/2002***	***9/30/2004***
	Deliver System Documentation and User Guides to Consortium			9/30/2004
	!		!	!
1.2	**Deployment, Operations and Community Support**	**NCSA** **Rob Pennington**	**!**	**!**
	!		!	!
1.2.1	***NEESgrid Development and Deployment at Early Adopter Sites***	***NCSA*** ***Randy Butler***	***4/1/2002***	***1/31/2003***
	Deploy NEES POPs at Early Adopter Sites			7/31/2002
	Deploy Early Adopter Software at Sites			12/31/2002
	Release NEESgrid System Version 1.0			1/31/2003
	!		!	!
1.2.2	***NEESgrid Systems Software Distribution***	***NCSA*** ***Randy Butler***	***2/15/2003***	***6/30/2004***
	Deploy System Software and NEES POPs to Full System Demonstration Sites			6/30/2003
	Package and Release NEESgrid System Version 2.0			10/15/2003
	Deployment of System Hardware and Software to all NEES Sites			6/30/2004
	Package and Distribute Final Relase of NEESgrid System Software			6/30/2004
	!		!	!
1.2.3	***NEESgrid Systems Operations***	***NCSA*** ***Michelle Butler***	***4/1/2003***	***9/30/2004***
	Establishing NEESgrid Monitoring and Support Services, Including Help Desk			8/1/2003

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Establish Compute, Storage Monitoring and Security Production Services			8/1/2003
	Publish System and Administrative Documentation			12/31/2003
	Transition NEESgrid Operations to Consortium			9/30/2004
	!		!	!
1.2.4	***User Support and Training***	***NCSA*** ***Randy Butler***	***7/1/2002***	***6/30/2004***
	Conduct User Training on User Tool Integration into the Collaborative Framework			4/30/2003
	Conduct Administrator Training Based on Release 2.0			12/31/2003
	Conduct User Training on Using NEESgrid to Access Experimental Facility Resources			3/31/2004
	Conduct Final Administrator Training			3/31/2004
	Conduct User Training on Using the Data and Simulation Code Repositories			6/30/2004
			!	!
2	**Information Services Components**		!	!
	!		!	!
2.1	**Telepresence Mode Services**	**ANL** **Nestor Zaluzec**	!	!
			!	!
2.1.1	***Telepresence Management System for Remote Observation***	***ANL*** ***Nestor Zaluzec***	***9/1/2001***	***10/15/2003***
	Publish Telepresence System Specification			3/31/2002
	Demonstrate Passive Telepresence System in Thin WWW Client (TWC)			11/14/2002
	Implement Passive Telepresence TWC System in Release 1.0			1/31/2003
	Implement final Passive Telepresence TWC System in Release 2.0		!	10/15/2003

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
			!	!
2.1.2	***Telepresence Management System for Remote Operation***	***ANL*** ***Nestor Zaluzec***	***1/1/2003***	***6/30/2004***
	Demonstrate Multi-site Passive Telepresence TWC supporting simple Pseudodynamic Control			7/31/2003
	Implement Multi-site Passive Telepresence TWC and simple controller in Release 2.0			10/15/2003
	Demonstrate Active Telepresence TWC System with LabView Based Control Support			4/30/2004
	Implement Active Telepresence TWC System with Genralized Control Support in Final Release			6/30/2004
	Implement Telepresence TWC System Integrated with Grid Information Services compatible with CHEF Collaboration Support in Final Release			6/30/2004
	!		!	
2.1.3	***Documentation***	***ANL*** ***Nestor Zaluzec***	***7/1/2002***	***9/30/2004***
	Deliver final Telepresence System Specifications, Software Documentation and User Guide to Consortium			9/30/2004
			!	!
2.2	**Collaboration and Visualization**	**UM** **Joseph Hardin**	!	!
			!	!
2.2.1	***Prototype Collaborative Environment***	***UM*** ***Joseph Hardin***	***9/1/2001***	***1/31/2003***
	Demonstrate Prototype Collaborative Environment for NEESgrid based on UM Worktools at Early Adopter Sites			11/14/2002
	Implement Worktools-based Environment in Release 1.0			1/31/2003
	!		!	!

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
2.2.2	***Visualization Support for Collaboration Tools***	***UM*** ***Joseph Hardin***	***9/1/2001***	***10/15/2003***
	Demonstrate Synchronized Multi-channel Data Viewer at Early Adopter Sites			11/14/2002
	Implement Basic Data Viewer in Release 1.0			1/31/2003
	Demonstrate Advanced Data Viewer and Visualization Pipeline in CHEF Framework			7/31/2003
	Implement Integrated CHEF Viewer and Pipeline in Release 2.0			10/15/2003
	!		!	!
2.2.3	***Adaptation of the Comprehensive Collaborative Framework (CHEF) for Collaborative Services on NEESgrid***	***UM*** ***Joseph Hardin***	***9/1/2001***	***6/30/2004***
	Implement Completed NEESgrid Adaptation of CHEF in Final Release			6/30/2004
	Deploy CHEF as Integrated User Interface Environment for NEESgrid in Final Release			6/30/2004
	!		!	!
2.2.4	***Documentation***	***UM*** ***Joseph Hardin***	***7/1/2002***	***9/30/2004***
	Deliver CHEF Specifications and User Guide			9/30/2004
			!	!
2.3	**Simulation Tools and Frameworks**	**OU** **Kim Mish**		
			!	!
2.3.1	***Community Simulation Tool Archive***	***OU*** ***Kim Mish***	***5/15/2002***	***6/30/2004***
	Demonstrate Prototype Archive			7/31/2003
	Implement Prototype Archive in Release 2.0			10/15/2003
	Implement Operational Archive in Final Release			6/30/2004
	!		!	!

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
2.3.2	***Repository of Sample Community Code Results***	***OU*** ***Kim Mish***	***7/1/2003***	***6/30/2004***
	Demonstrate Prototype Repository			7/31/2003
	Implement Prototype repository in Release 2.0			10/15/2003
	Implement Operational Sample Output Repository in Final Release			6/30/2004
	!		!	!
2.3.3	***Usability Enhancements for Community Codes***	***OU*** ***Kim Mish***	***7/1/2003***	***6/30/2004***
	Demonstrate Prototype Usability Portal			7/31/2003
	Implement Prototype Portal in Release 2.0			10/15/2003
	Implement Operational Usability Portal and Tools in Final Release			6/30/2004
			!	!
2.4	**Data and Metadata Management**	**NCSA** **Joe Futrelle**		
			!	!
2.4.1	***Recommended Standards for Data and Metadata Models and Representations***	***NCSA*** ***Joe Futrelle***	***9/1/2001***	***6/30/2003***
	Publish Recommended Standards for Metadata, Data Models and Representation			6/30/2003
	!		!	!
2.4.2	***Specification for NEESgrid Data Services Architecture***	***NCSA*** ***Joe Futrelle***	***9/1/2001***	***6/30/2003***
	Publish Specifications for the NEESgrid Data Services Architecture			6/30/2003
	!		!	!
2.4.3	***APIs for Data Harvesting, Management and Access***	***NCSA*** ***Joe Futrelle***	***7/1/2002***	***10/15/2003***
	Demonstrate Basic Data Harvesting, Management and Access Functionality			11/14/2002
	Implement Basic Data Harvesting, Management and Access APIs in Release 1.0			1/31/2003

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Demonstrate Advanced Data Harvesting, Management and Access Functionality in Multi-site Test			7/31/2003
	Implement Advanced APIs in Release 2.0			10/15/2003
	!		!	!
2.4.4	***Curated Data Repository***	***NCSA*** ***Joe Futrelle***	***7/1/2002***	***6/30/2004***
	Demonstrate Basic Repository Functionality			11/14/2002
	Implement Basic Repository in Release 1.0			1/31/2003
	Demonstrate Operating Data Repository			7/31/2003
	Implement Operating Repository in Release 2.0			10/15/2003
	Populate Operating Data Repository with Sample Data			6/30/2004
	Implement Bug-fixes and Enhancements to Repository in Final Release			6/30/2004
	Deliver Data Repository to Consortium			9/30/2004
	!		!	!
2.4.5	***Documentation***	***NCSA*** ***Joe Futrelle***	***7/1/2002***	***9/30/2004***
	Deliver Data Systems Documentation and User Guide to Consortium			9/30/2004
			!	!
3	**Community Outreach and Partnership Development**	**UM** **Tom Finholt**	!	!
			!	!
3.1	**User Requirements Assessment**	**UM** **Tom Finholt**	!	!
	!		!	!
3.1.1	***Site Technical Surveys***	***UM*** ***Tom Finholt***	***9/1/2001***	***12/31/2003***
	Publish Results from Year 1 Technical Survey			11/30/2001
	Publish Results from Year 2 Technical Survey			11/30/2002

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Publish Results from Year 3 Technical Survey			11/30/2003
	!		!	!
3.1.2	***Practice Surveys***	***UM*** ***Dan Horn***	***9/1/2001***	***3/31/2004***
	Publish Results from Year 1 Baseline Practice Survey			1/31/2002
	Publish Results from Year 2 Baseline Practice Survey			1/31/2003
	Publish Results from Year 3 Baseline Practice Survey			1/31/2004
	!		!	!
3.1.3	***Visits to NEES Equipment Sites***	***UM*** ***Tom Finholt***	***1/1/2002***	***12/31/2003***
	Visits to Phase I and Phase II Sites			4/30/2003
	Follow-up Visits to Sites			12/31/2003
	!		!	!
3.1.4	***Virtual Tours of Equipment Sites***	***UM*** ***Tom Finholt***	***9/1/2001***	***12/31/2003***
	Video Tours of Phase I and Phase II Sites			12/31/2002
	Follow-up Tours			12/31/2003
	!		!	!
3.1.5	***Publication of User Requirements Document***	***UM*** ***Tom Finholt***	***9/1/2001***	***2/15/2004***
	Publish Baseline User Requirements Document			2/15/2002
	Publish User Requirements Update			2/15/2003
	Publish User Requirements Update			2/15/2004
	!		!	!
3.2	**Community Building**	**UIUC** **Dan Abrams**	**!**	**!**
	!		!	!

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
3.2.1	***Engage EE Community to Collect SI Input***	***UIUC*** ***Dan Abrams***	***9/1/2001***	***9/30/2004***
	Ongoing Outreach Through Direct Interaction with NEES PIs and Participation in National and International EE Meetings			
	!		!	!
3.2.2	***Build Consensus with CDT on SI Issues***	***UIUC*** ***Dan Abrams***	***10/1/2001***	***9/30/2004***
	Ongoing Interaction with CDT Members through Monthly Meetings between the SI and CD Teams			
	!		!	!
3.2.3	***Facilitate NEESgrid transition to Consortium***	***UIUC*** ***Dan Abrams***	***10/1/2002***	***9/30/2004***
	Ongoing Interaction with CD Team Members Responsible for Developing the 10 year NEES Operating Proposal			9/30/2003
	Development with CD Team of System Acceptance Criteria and Tests			3/31/2003
	!		!	!
3.2.4	***Promote Practical Examples of the Uses of NEESgrid***	***USC*** ***Jean-Pierre Bardet***	***9/1/2001***	***6/30/2004***
	Publish Results to Date			3/31/2003
	Publish Results to Date			3/31/2004
			!	!
4	**Management**	**NCSA** **Dan Reed**		
				!
4.1	**NEESgrid Management**	**NCSA** **Tom Prudhomme**	!	!
	!		!	!
4.1.1	***Outreach to NEES Equipment Sites***	***NCSA*** ***Tom Prudhomme***	***9/1/2001***	***6/30/2002***

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Visit Selected NEES Equipment Sites			6/30/2002
	!		!	!
4.1.2	***Advisory Activities and Program Reviews***	***NCSA*** ***Tom Prudhomme***	***9/1/2001***	***3/31/2004***
	Conduct Executive Advisory Board Meeting			1/21/2002
	Conduct Annual NSF Program Review			3/12/2002
	Conduct Executive Advisory Board Meeting			8/9/2002
	Conduct Executive Advisory Board Meeting			2/12/2003
	Conduct Annual NSF Program Review			3/21/2003
	Conduct Executive Advisory Board Meeting			8/15/2003
	Conduct Executive Advisory Board Meeting			2/15/2004
	Conduct Annual NSF Program Review			3/31/2004
	!		!	!
4.1.3	***Technical Outreach to Resource Providers and NEESgrid Users***	***NCSA*** ***Tom Prudhomme***	***10/1/2001***	***12/31/2002***
	Conduct Integration Workshop on Requirements			12/31/2002
	Establish Working Groups			6/30/2002
	!		!	!
4.1.4	***Participate in NSF-Sponsored NEES Events***	***NCSA*** ***Tom Prudhomme***	***9/1/2001***	***9/30/2004***
	!		!	!
4.2	**NEESgrid Operations**	**NCSA** **Cristina Beldica**	!	!
	!		!	!
4.2.1	***Project Management***	***NCSA*** ***Cristina Beldica***	***9/1/2001***	***9/30/2004***
	Publish Project Execution Plan			2/15/2002
	Ongoing Submission of Quarterly Reports to NSF			
	!		!	!

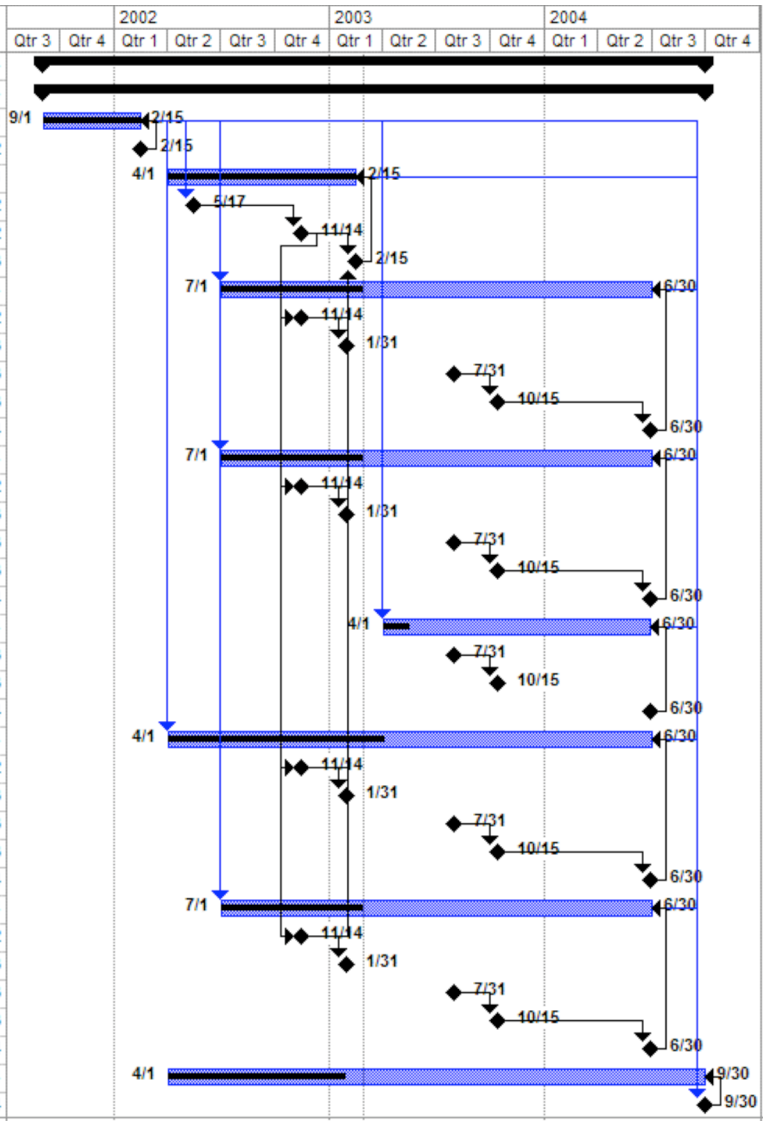
WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
4.2.2	***Fiscal Accountability and Reporting***	***NCSA*** ***Cristina Beldica***	***9/1/2001***	***9/30/2004***
	Ongoing Submission of Quarterly Project Financial Statements to NSF			
	Ongoing Submission of Semi-annual GPRA Reports to NSF			
	!		!	!
4.2.3	***Communications and Community Outreach***	***NCSA*** ***Cristina Beldica***	***9/1/2001***	***9/30/2004***
	Ongoing Publication of Project Materials on the Community Website, www.neesgrid.org			
	!		!	!
4.2.4	***Project Documentation and Transition Management***	***NCSA*** ***Cristina Beldica***	***9/1/2001***	***9/30/2004***
	Coordinate Conduct of Component-level and System-level Acceptance Tests			8/31/2004
	Deliver Management and Project Documentation to the Consortium			9/30/2004
	Complete Transition of NEESgrid to the Consortium			9/30/2004
	!		!	!
4.3	**NEESgrid Assessment and Evaluation**	**UM** **Tom Finholt**	!	!
	!		!	!
4.3.1	***Evaluation of NEESgrid Acceptance and Use***	***UM*** ***Tom Finholt***	***9/1/2001***	***4/30/2004***
	Publish Post-Year 1 Summary of Survey and Site Visit Data			4/30/2002
	Publish Post-Year 2 Summary of Survey and Site Visit Data			4/30/2003
	Publish Post-Year 3 Summary of Survey and Site Visit Data			4/30/2004
	!		!	!

WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
4.3.2	***Technical Performance Evaluation***	***UM*** ***Tom Finholt***	***1/1/2002***	***8/31/2004***
	Publish Year 1 Progress Report			8/31/2002
	Publish Year 2 Progress Report			8/31/2003
	Publish Year 3 Progress Report			8/31/2004
4.4	**NEESgrid Technology Management**	**OU** **Kim Mish**	**!**	**!**
4.4.1	***Change Control***	***OU*** ***Kim Mish***	***11/1/2002***	***6/30/2004***
	Establish Change Control Board Structure, Protocols and Procedures			3/31/2003
	Publish Final Documentation on Change Control Based on Meetings of the CCB			6/30/2004
4.4.2	***Configuration Management***	***OU*** ***Kim Mish***	***11/1/2002***	***6/30/2004***
	Publish Formal System Baseline Description			2/28/2003
	Identify and Populate Database of Configured Items for Use in Change Control Processes			3/31/2003
	Publish Final Documentation on Configuration Management based on CCB Actions			6/30/2004
4.4.3	***Technology Risk Mitigation***	***OU*** ***Kim Mish***	***11/1/2002***	***6/30/2004***
	Publish Initial Risk Assessment and Risk Mitigation Plan			3/15/2003
	Publish Final Risk Assessment Document based on Ongoing Risk Assessment and Development of Alternative Strategies to Mitigate Risk			6/30/2004
4.4.4	***Acceptance Testing***	***OU*** ***Kim Mish***	***11/1/2002***	***8/31/2004***
	Publish Draft Acceptance Testing Plan for Use in Evaluating Full System Prototype			6/30/2003

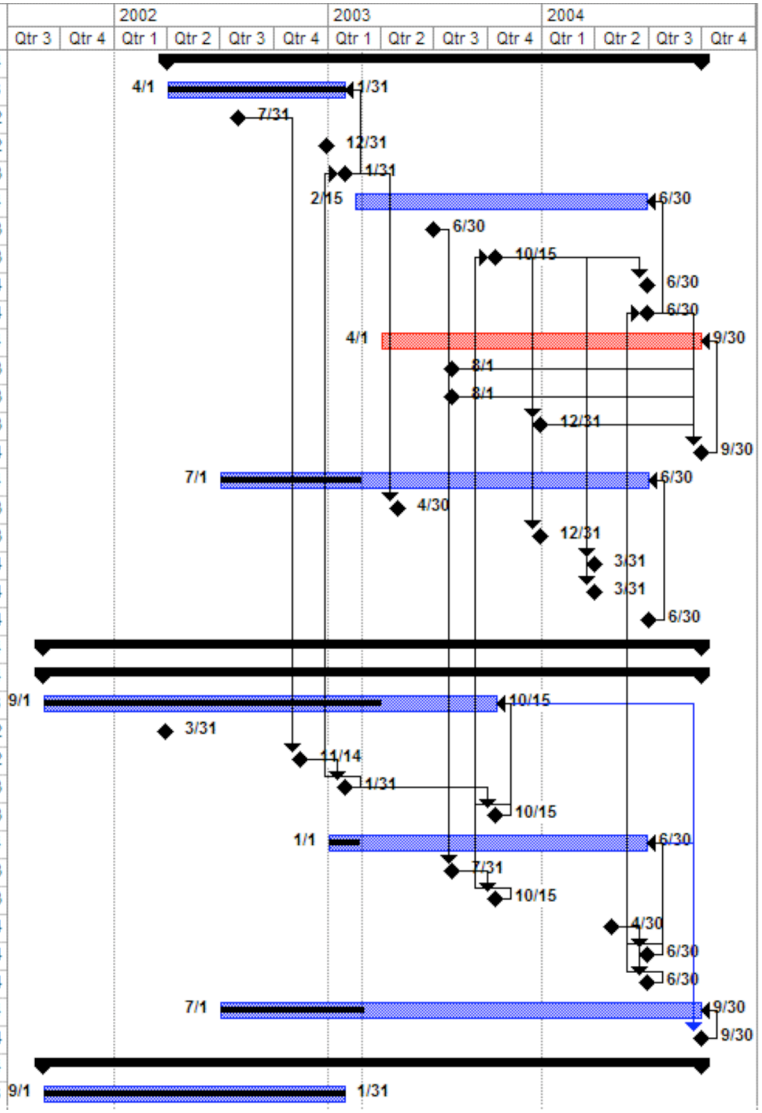
WBS Level	Description	Organization(s)/ Person(s) Responsible	Start Date	Completion Date
	Publish Final Acceptance Testing Plan for System Transition to the Consortium			3/31/2004
	Publish Final Documentation on Results of Acceptance Testing upon Completion			8/31/2004

Appendix C. Gantt Chart for Complete WBS including Milestones

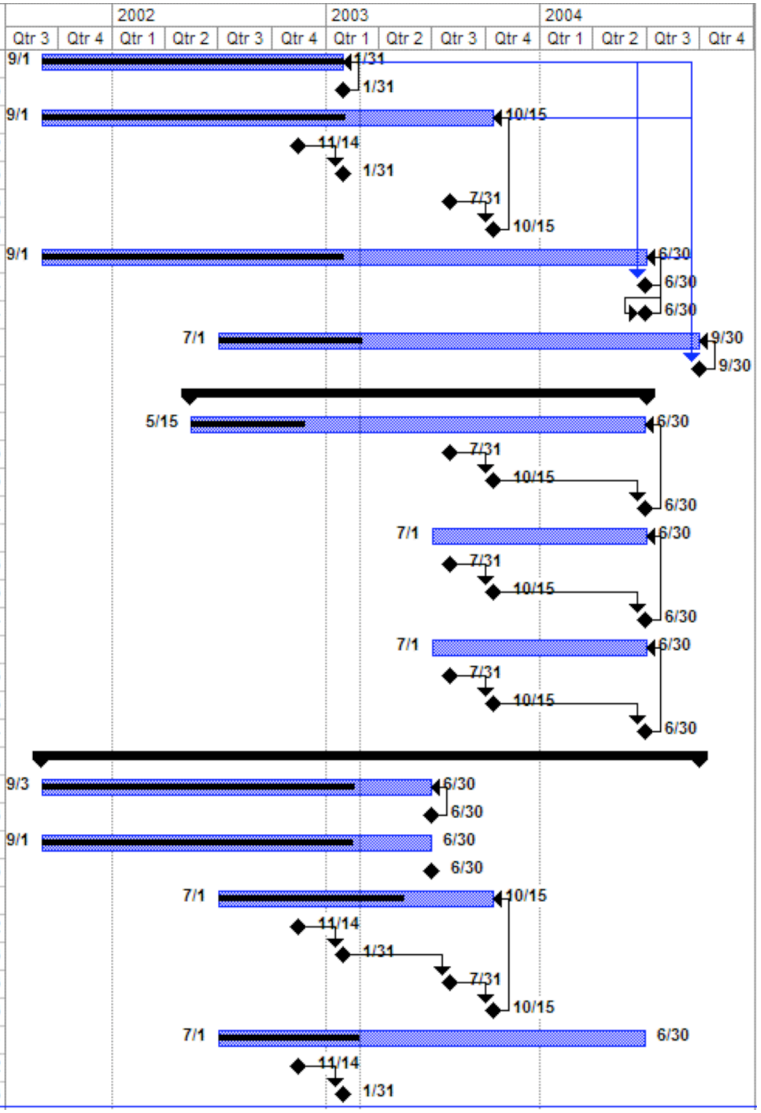
ID	% Complete	Task Name	Start	Finish
1	36%	**1. System Components**	9/1/01	9/30/04
2	40%	**1.1 System Configuration and Design**	9/1/01	9/30/04
3	100%	**1.1.1 System Requirements Specification**	9/1/01	2/15/02
4	100%	System Architecture Document	2/15/02	2/15/02
5	100%	**1.1.2 NEESgrid Early Adoption**	4/1/02	2/15/03
6	100%	Publish EA Plan	5/17/02	5/17/02
7	100%	Demonstrate Basic System Functionality	11/14/02	11/14/02
8	100%	Document EA Outcomes	2/15/03	2/15/03
9	33%	**1.1.3 NEESgrid Security Enhancements**	7/1/02	6/30/04
10	100%	Demonstrate Core Grid Security Components	11/14/02	11/14/02
11	100%	Integrate Basic Security into Release 1.0	1/31/03	1/31/03
12	0%	Demonstrate System-wide, Multi-site Security	7/31/03	7/31/03
13	0%	Implement System Security in Release 2.0	10/15/03	10/15/03
14	0%	Implement Refined Authorization Tools in Final Rele	6/30/04	6/30/04
15	33%	**1.1.4 Access to Experimental Apparatus and In**	7/1/02	6/30/04
16	100%	Demonstrate NEESgrid Streaming Data Services (M	11/14/02	11/14/02
17	100%	Implement Standard NSDS (OGSA TP4) in Release	1/31/03	1/31/03
18	0%	Demonstrate NSDS Extensions to Support Multi-sit	7/31/03	7/31/03
19	0%	Implement Extensions in Release 2.0	10/15/03	10/15/03
20	0%	Implement Standard Device Independent NSDS in F	6/30/04	6/30/04
21	10%	**1.1.5 Access to Simulation Codes**	4/1/03	6/30/04
22	0%	Demonstrate Information Services in Support of Nur	7/31/03	7/31/03
23	0%	Implement Basic Simulation Information Services in	10/15/03	10/15/03
24	0%	Implement Services Supporting Usability	6/30/04	6/30/04
25	45%	**1.1.6 Access to Data**	4/1/02	6/30/04
26	100%	Demonstrate Core Grid Services Supporting Data M	11/14/02	11/14/02
27	100%	Implement Basic Data Services in Release 1.0	1/31/03	1/31/03
28	0%	Demonstrate Enhanced Access Control Services	7/31/03	7/31/03
29	0%	Implement Enhanced Access Control Services in R	10/15/03	10/15/03
30	0%	Implement Community Access Control Services in	6/30/04	6/30/04
31	33%	**1.1.7 Collaboration Support**	7/1/02	6/30/04
32	100%	Demonstrate Core Grid Services Integrated into Bas	11/14/02	11/14/02
33	100%	Implement Integrated Services in Release 1.0	1/31/03	1/31/03
34	0%	Demonstrate Grid-based VTC Resource Manageme	7/31/03	7/31/03
35	0%	Implement VTC Resource Management in Release	10/15/03	10/15/03
36	0%	Implement Access Control for VTC Resources in Fi	6/30/04	6/30/04
37	33%	**1.1.8 Documentation**	4/1/02	9/30/04
38	0%	Deliver System Documentation and User Guides to	9/30/04	9/30/04



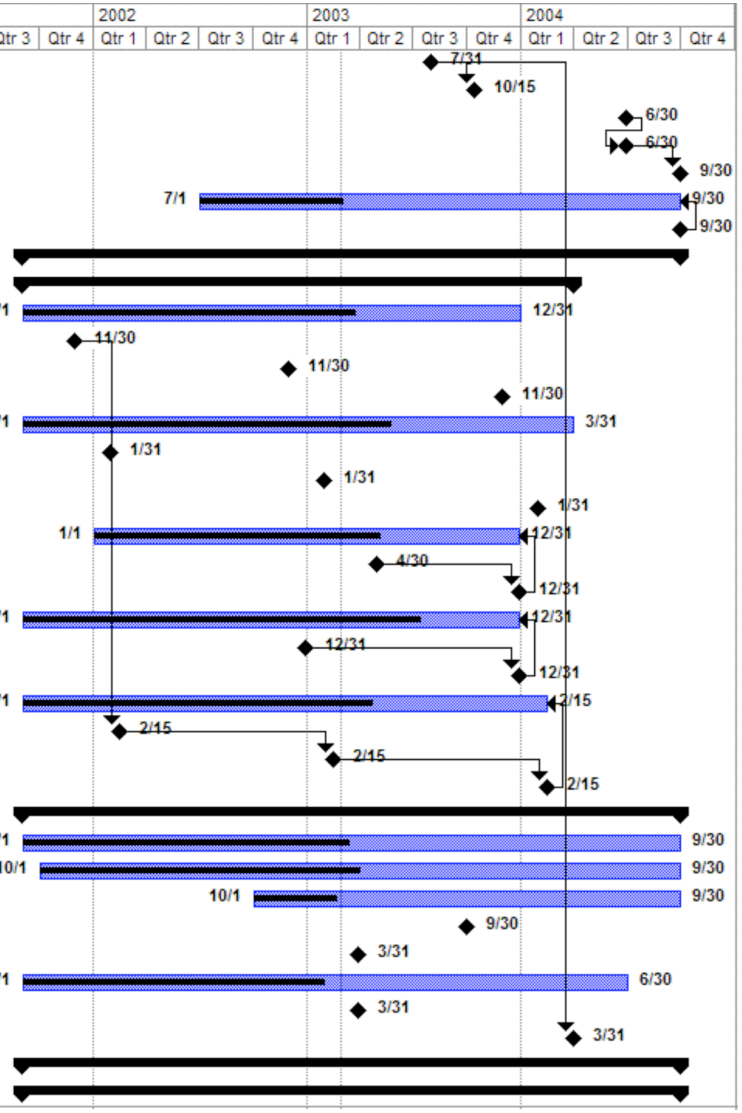
ID	% Complete	Task Name	Start	Finish
39	26%	**1.2 Deployment, Operations, and Community Supp**	4/1/02	9/30/04
40	100%	**1.2.1 NEESgrid Development at Early Adopter S**	4/1/02	1/31/03
41	100%	Deploy NEES POPs at Early Adopter Sites	7/31/02	7/31/02
42	100%	Deploy Early Adopter Software at Sites	12/31/02	12/31/02
43	100%	Release NEESgrid System Version 1.0	1/31/03	1/31/03
44	0%	**1.2.2 System Software Distribution**	2/15/03	6/30/04
45	0%	Deploy System Software and NEES POPs to Full S	6/30/03	6/30/03
46	0%	Package and Release NEESgrid System Version 2	10/15/03	10/15/03
47	0%	Deployment of System Hardware and Software to a	6/30/04	6/30/04
48	0%	Package and Distribute Final Relase of NEESgrid S	6/30/04	6/30/04
49	0%	**1.2.3 System Operations**	4/1/03	9/30/04
50	0%	Establishing NEESgrid Monitoring and Support Ser	8/1/03	8/1/03
51	0%	Establish Compute, Storage Monitoring and Securit	8/1/03	8/1/03
52	0%	Publish System and Administrative Documentation	12/31/03	12/31/03
53	0%	Transition NEESgrid Operations to Consortium	9/30/04	9/30/04
54	33%	**1.2.4 User Support and Training**	7/1/02	6/30/04
55	0%	Conduct User and Support Personnel Training Base	4/30/03	4/30/03
56	0%	Conduct Administrator Training Based on Release 2	12/31/03	12/31/03
57	0%	Conduct User Training on Using NEESgrid to Acce	3/31/04	3/31/04
58	0%	Conduct Final Administrator Training	3/31/04	3/31/04
59	0%	Conduct User Training on Using the Data and Simu	6/30/04	6/30/04
60	47%	**2. Information Services Components**	9/1/01	9/30/04
61	41%	**2.1 Telepresence Mode Services**	9/1/01	9/30/04
62	75%	**2.1.1 Telepresence Mode Services**	9/1/01	10/15/03
63	100%	Publish Telepresence System Specification	3/31/02	3/31/02
64	100%	Demonstrate Passive Telepresence System in Thin	11/14/02	11/14/02
65	100%	Implement Passive Telepresence TWC System in F	1/31/03	1/31/03
66	0%	Implement final Passive Telepresence TWC Systen	10/15/03	10/15/03
67	10%	**2.1.2 TPM System for Remote Operation**	1/1/03	6/30/04
68	0%	Demonstrate Multi-site Passive Telepresence TWC	7/31/03	7/31/03
69	0%	Implement Multi-site Passive Telepresence TWC ar	10/15/03	10/15/03
70	0%	Demonstrate Active Telepresence TWC System wi	4/30/04	4/30/04
71	0%	Implement Active Telepresence TWC System with	6/30/04	6/30/04
72	0%	Implement Telepresence TWC System Integrated w	6/30/04	6/30/04
73	30%	**2.1.3 Documentation**	7/1/02	9/30/04
74	0%	Deliver final Telepresence System Specifications, S	9/30/04	9/30/04
75	57%	**2.2 Collaboration and Visualization**	9/1/01	9/30/04
76	100%	**2.2.1 Prototype Collaborative Environment**	9/1/01	1/31/03



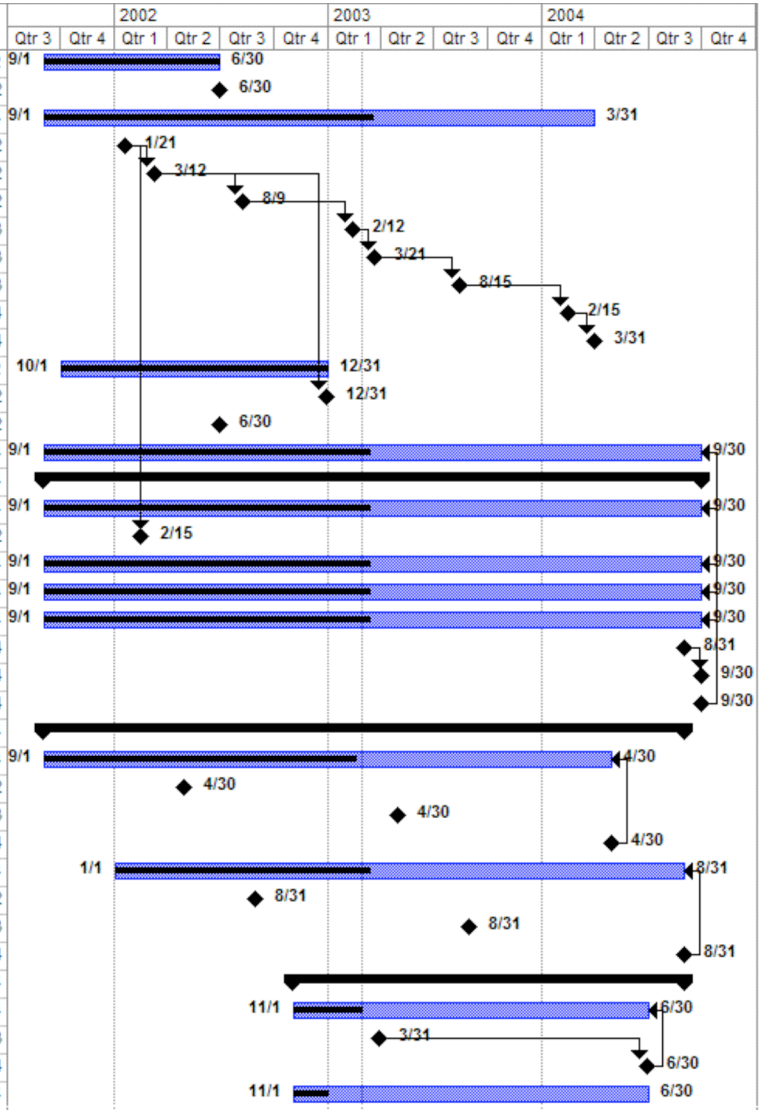
ID	% Complete	Task Name	Start	Finish
77	100%	**2.2.1 Prototype Collaborative Environment**	**9/1/01**	**1/31/03**
78	100%	Implement Worktools-based Environment in Releas	1/31/03	1/31/03
79	67%	**2.2.2 Visualization Support**	**9/1/01**	**10/15/03**
80	100%	Demonstrate Synchronized Multi-channel Data Viev	11/14/02	11/14/02
81	100%	Implement Basic Data Viewer in Release 1.0	1/31/03	1/31/03
82	0%	Demonstrate Advanced Data Viewer and Visualizat	7/31/03	7/31/03
83	0%	Implement Integrated CHEF Viewer and Pipeline in	10/15/03	10/15/03
84	50%	**2.2.3 Adaptation of CHEF**	**9/1/01**	**6/30/04**
85	0%	Implement Completed NEESgrid Adaptation of CHE	6/30/04	6/30/04
86	0%	Deploy CHEF as Integrated User Interface Environn	6/30/04	6/30/04
87	30%	**2.2.4 Documentation**	**7/1/02**	**9/30/04**
88	0%	Deliver CHEF Specifications and User Guide	9/30/04	9/30/04
89	13%	**2.3 Simulation Tools and Frameworks**	**5/15/02**	**6/30/04**
90	25%	**2.3.1 Community Simulation Tool Archive**	**5/15/02**	**6/30/04**
91	0%	Demonstrate Prototype Archive	7/31/03	7/31/03
92	0%	Implement Prototype Archive in Release 2.0	10/15/03	10/15/03
93	0%	Implement Operational Archive in Final Release	6/30/04	6/30/04
94	0%	**2.3.2 Repository of Sample Codes**	**7/1/03**	**6/30/04**
95	0%	Demonstrate Prototype Repository	7/31/03	7/31/03
96	0%	Implement Prototype repository in Release 2.0	10/15/03	10/15/03
97	0%	Implement Operational Sample Output Repository i	6/30/04	6/30/04
98	0%	**2.3.3 Usability Enhancements for Codes**	**7/1/03**	**6/30/04**
99	0%	Demonstrate Prototype Usability Portal	7/31/03	7/31/03
100	0%	Implement Prototype Portal in Release 2.0	10/15/03	10/15/03
101	0%	Implement Operational Usability Portal and Tools in	6/30/04	6/30/04
102	56%	**2.4 Data and Metadata**	**9/1/01**	**9/30/04**
103	80%	**2.4.1 Standards for Data and Metadata**	**9/3/01**	**6/30/03**
104	0%	Publish Recommended Standards for Metadata, Da	6/30/03	6/30/03
105	80%	**2.4.2 Specification for Data Services Architectu**	**9/1/01**	**6/30/03**
106	100%	Publish Specifications for the NEESgrid Data Servic	6/30/03	6/30/03
107	67%	**2.4.3 APIs for Data Harvesting, Management**	**7/1/02**	**10/15/03**
108	100%	Demonstrate Basic Data Harvesting, Management a	11/14/02	11/14/02
109	100%	Implement Basic Data Harvesting, Management an	1/31/03	1/31/03
110	0%	Demonstrate Advanced Data Harvesting, Managem	7/31/03	7/31/03
111	0%	Implement Advanced APIs in Release 2.0	10/15/03	10/15/03
112	33%	**2.4.4 Curated Data Repository**	**7/1/02**	**6/30/04**
113	100%	Demonstrate Basic Repository Functionality	11/14/02	11/14/02
114	100%	Implement Basic Repository in Release 1.0	1/31/03	1/31/03



ID	% Complete	Task Name	Start	Finish
115	0%	Demonstrate Operating Data Repository	7/31/03	7/31/03
116	0%	Implement Operating Repository in Release 2.0	10/15/03	10/15/03
117	0%	Populate Operating Data Repository with Sample D	6/30/04	6/30/04
118	0%	Implement Bug-fixes and Enhancements to Reposit	6/30/04	6/30/04
119	0%	Deliver Data Repository to Consortium	9/30/04	9/30/04
120	30%	**2.4.5 Documentation**	**7/1/02**	**9/30/04**
121	0%	Deliver Data Systems Documentation and User Gui	9/30/04	9/30/04
122	**57%**	**3. Community Outreach and Partnership**	**9/1/01**	**9/30/04**
123	**70%**	**3.1 User Requirements Assessment**	**9/1/01**	**3/31/04**
124	67%	**3.1.1 Site Technical Surveys**	**9/1/01**	**12/31/03**
125	100%	Publish Results from Year 1 Technical Survey	11/30/01	11/30/01
126	100%	Publish Results from Year 2 Technical Survey	11/30/02	11/30/02
127	0%	Publish Results from Year 3 Technical Survey	11/30/03	11/30/03
128	67%	**3.1.2 Practice Surveys**	**9/1/01**	**3/31/04**
129	100%	Publish Results from Year 1 Baseline Practice Sur	1/31/02	1/31/02
130	100%	Publish Results from Year 2 Baseline Practice Sur	1/31/03	1/31/03
131	0%	Publish Results from Year 3 Baseline Practice Sur	1/31/04	1/31/04
132	67%	**3.1.3 Visits to Equipment Sites**	**1/1/02**	**12/31/03**
133	100%	Visits to Phase I and Phase II Sites	4/30/03	4/30/03
134	0%	Follow-up Visits to Sites	12/31/03	12/31/03
135	80%	**3.1.4 Virtual Tours of Equipment Sites**	**9/1/01**	**12/31/03**
136	100%	Video Tours of Phase I and Phase II Sites	12/31/02	12/31/02
137	0%	Follow-up Tours	12/31/03	12/31/03
138	67%	**3.1.5 Publication of User Requirements Docum**	**9/1/01**	**2/15/04**
139	100%	Publish Baseline User Requirements Document	2/15/02	2/15/02
140	100%	Publish User Requirements Update	2/15/03	2/15/03
141	0%	Publish User Requirements Update	2/15/04	2/15/04
142	**44%**	**3.2 Community Building**	**9/1/01**	**9/30/04**
143	50%	**3.2.1 Engage EE Community**	**9/1/01**	**9/30/04**
144	50%	**3.2.2 Build Consensus with CDT on SI Issues**	**10/1/01**	**9/30/04**
145	20%	**3.2.3 Facilitate Transition to Consortium**	**10/1/02**	**9/30/04**
146	75%	Ongoing Interaction with CD Team Members Respo	9/30/03	9/30/03
147	0%	Development with CD Team of System Acceptance	3/31/03	3/31/03
148	50%	**3.2.4 Promote Examples of Use**	**9/1/01**	**6/30/04**
149	0%	Publish Results to Date	3/31/03	3/31/03
150	0%	Publish Results to Date	3/31/04	3/31/04
151	**46%**	**4. Management**	**9/1/01**	**9/30/04**
152	**67%**	**4.1 NEESgrid Management**	**9/1/01**	**9/30/04**



ID	% Complete	Task Name	Start	Finish
153	100%	**4.1.1 Outreach to NEES Equipment Sites**	**9/1/01**	**6/30/02**
154	100%	Visit Selected NEES Equipment Sites	6/30/02	6/30/02
155	60%	**4.1.2 Advisory Activities/Program Reviews**	**9/1/01**	**3/31/04**
156	100%	Conduct Executive Advisory Board Meeting	1/21/02	1/21/02
157	100%	Conduct Annual NSF Program Review	3/12/02	3/12/02
158	100%	Conduct Executive Advisory Board Meeting	8/9/02	8/9/02
159	100%	Conduct Executive Advisory Board Meeting	2/12/03	2/12/03
160	0%	Conduct Annual NSF Program Review	3/21/03	3/21/03
161	0%	Conduct Executive Advisory Board Meeting	8/15/03	8/15/03
162	0%	Conduct Executive Advisory Board Meeting	2/15/04	2/15/04
163	0%	Conduct Annual NSF Program Review	3/31/04	3/31/04
164	100%	**4.1.3 Technical Outreach to Resource Provider**	**10/1/01**	**12/31/02**
165	100%	Conduct Integration Workshop on Requirements	12/31/02	12/31/02
166	100%	Establish Working Groups	6/30/02	6/30/02
167	50%	**4.1.4 Participate in NSF-sponsored Events**	**9/1/01**	**9/30/04**
168	**50%**	**4.2 NEESgrid Operations**	**9/1/01**	**9/30/04**
169	50%	**4.2.1 Project Management**	**9/1/01**	**9/30/04**
170	100%	Publish Project Execution Plan	2/15/02	2/15/02
171	50%	**4.2.2 Fiscal Accountability and Reporting**	**9/1/01**	**9/30/04**
172	50%	**4.2.3 Communications and Community Outreac**	**9/1/01**	**9/30/04**
173	50%	**4.2.4 Project Documentation and Transition Mg**	**9/1/01**	**9/30/04**
174	0%	Coordinate Conduct of Component-level and Syster	8/31/04	8/31/04
175	0%	Deliver Management and Project Documentation to	9/30/04	9/30/04
176	0%	Complete Transition of NEESgrid to the Consortium	9/30/04	9/30/04
177	**50%**	**4.3 NEESgrid Assessment and Evaluation**	**9/1/01**	**8/31/04**
178	55%	**4.3.1 Evaluation of Acceptance and Use**	**9/1/01**	**4/30/04**
179	100%	Publish Post-Year 1 Summary of Survey and Site V	4/30/02	4/30/02
180	0%	Publish Post-Year 2 Summary of Survey and Site V	4/30/03	4/30/03
181	0%	Publish Post-Year 3 Summary of Survey and Site V	4/30/04	4/30/04
182	45%	**4.3.2 Technical Performance Evaluation**	**1/1/02**	**8/31/04**
183	100%	Publish Year 1 Progress Report	8/31/02	8/31/02
184	0%	Publish Year 2 Progress Report	8/31/03	8/31/03
185	0%	Publish Year 3 Progress Report	8/31/04	8/31/04
186	**12%**	**4.4 NEESgrid Technology Management**	**11/1/02**	**8/31/04**
187	20%	**4.4.1 Change Control**	**11/1/02**	**6/30/04**
188	0%	Establish Change Control Board Structure, Protoco	3/31/03	3/31/03
189	0%	Publish Final Documentation on Change Control Ba	6/30/04	6/30/04
190	10%	**4.4.2 Configuration Management**	**11/1/02**	**6/30/04**



ID	% Complete	Task Name	Start	Finish
191	0%	Publish Formal System Baseline Description	2/28/03	2/28/03
192	0%	Identify and Populate Database of Configured Items	3/31/03	3/31/03
193	0%	Publish Final Documentation on Configuration Mana	6/30/04	6/30/04
194	10%	**4.4.3 Technology Risk Mitigation**	**11/1/02**	**6/30/04**
195	0%	Publish Initial Risk Assessment and Risk Mitigation	3/17/03	3/17/03
196	0%	Publish Final Risk Assessment Document based o	6/30/04	6/30/04
197	10%	**4.4.4 Product Acceptance**	**11/1/02**	**8/31/04**
198	0%	Publish Draft Acceptance Testing Plan for Use in E	6/30/03	6/30/03
199	0%	Publish Final Acceptance Testing Plan for System	3/31/04	3/31/04
200	0%	Publish Final Documentation on Results of Accepta	8/31/04	8/31/04