Building the National Virtual Collaboratory for Earthquake Engineering Research

NEESgrid

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

Risk Assessment and Mitigation Plan

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1. Executive Summary

The integration and use of new technologies always involves risk. The goal of risk assessment and mitigation is to understand the risks inherent to an integration project and to develop strategies to effectively manage the project in a manner that mitigates the associated risks. The NEESgrid system integration project combines many information technologies that have previously not been used in support of engineering community collaboratories. Therefore, the project management effort includes specific activities for identification of project risks, and the development and execution of effective strategies for mitigating those risks. In addition, the NEES MREFC is the first distributed construction project undertaken by NSF, and the first undertaken by the Engineering Directorate of NSF. As a result, there are program risks associated with the novelty of this program that must be understood and included in any risk mitigation efforts undertaken by the NEESgrid project.

This Risk Assessment and Mitigation Plan is prepared as a component of the NEESgrid Technology Management activities, included as 4.4.3 in the Project Execution Plan (rev. March 3, 2003). Previous risk assessment documentation was included in the February 15, 2002 revision of the Project Execution Plan, and the tables provided in that analysis are updated in Section 4 of this document. The NEESgrid Risk Assessment and Mitigation Plan is maintained separately from the PEP, and is updated periodically to reflect changes in the risk profiles for project components. A current version is maintained on the NEESgrid website, www.neesgrid.org.

2. Project Background

NEES awardees include the system integration project, NEESgrid, under which MREFC software integration is for the first time contractually undertaken as an independent activity. Under NEES, the system integrator is contractually independent from the sixteen NEES Equipment Site projects that will be integrated into the NEES collaboratory and from the Consortium Development Team project that represents the broader community of earthquake engineering users of the integrated collaboratory system. Finally, this is the first time the Engineering Directorate of NSF has managed an MREFC, and in particular the first time it has managed a major software integration project. These "firsts" represent significant project risks that impact the technical, schedule and cost risks usually encountered in a software engineering project, and which constrain the mitigation strategies that may be effectively utilized by project management.

The primary impact to date of project risks related to these "firsts' has been on implementation schedules and schedule uncertainty. Due to the NEES program being an MREFC, thus having congressional oversight, and due to it distributed nature, project design, planning and implementation for the system integration component has needed to meet NSF's internal reporting and project documentation requirements, the needs of the Equipment Sites, and the expectations of the end user community of earthquake engineer researchers, practitioners and educators. To further exacerbate the risk, this being the first time for NSF Engineering, the system integrator, the sites and the community, there were significant communication challenges among the various stakeholders in the overall system to be constructed by the system integration team. The resulting impact of the communication challenges was to delay the initiation of the technical implementation plan of until March 2002, following the delivery of an acceptable project execution plan to NSF, including an acceptable system architecture specification and a more detailed user requirements analysis.

The need for stakeholder involvement in the design and technical implementation of NEESgrid also had communication challenges resulting in schedule delays. All NEES stakeholders grossly underestimated the time required for the system integrator to communicate its architectural and software concepts, and for the sites and users to understand how these concepts would impact their efforts and be useful to the community once implemented. In the end, the system integration team completely changed its technical approach to be based on an iterative cycle of feature demonstration and software release leading to a final release and system acceptance testing. This revised approach is documented in the March 3, 2003 revision of the Project Execution Plan.

The result of this new approach to project execution is that system components were demonstrated in June 2002, a system demonstration was conducted in November 2002, the first (alpha 1.0) software product was released in February 2003, and a systems baseline description has been published which describes major NEESgrid system components and application programming interfaces (APIs) in the Alpha 1.0 software release. The project is on schedule to demonstrate a fully operable prototype system in July 2003, as required under the Cooperative Agreement, and subsequent releases of the software for bug fixes and feature enhancement are planned for October 2003 and June 2004. A strategy is in place for developing component-level and system-level acceptance tests to be conducted during July – August 2004. Acceptance Testing is the final step before system transition to the NEES Consortium on or before September 30, 2004. Therefore, at the project level, the change to an iterative approach for project management and execution that was instituted following the 2002 NSF Site Visit is the strategy implemented to help manage uncertainties, communication challenges, stakeholder involvement and other risks associated with the novelty of the NEES MREFC.

The remainder of this document describes the frameworks used to assess risks in NEESgrid, and provides as assessment of risks associated with the system-level and component-level project components, and the strategies in use to mitigating these risks.

2.1. Prior NEESgrid Risk Assessment

Version 1.0 of this document represents the first formal risk assessment and mitigation plan prepared for the NEESgrid project. Prior documentation of risks were included in the February 15, 2002, revision of the Project Execution Plan (PEP), but presented in the form of a mitigation or management plan. This plan is prepared as a component of the Technology Management component of the PEP, under section 4.4.3 in the work breakdown structure (WBS). The February 2003 PEP, including the risk assessment section, can be viewed on the NEESgrid website, www.neesgrid.org.

3. Frameworks for Project Risk Assessment

The risks associated with NEESgrid are complex and need to be assessed using a variety of approaches in order to understand them and develop effective mitigations strategies to address them. This section summarizes frameworks derived from the open literature that have utility in our analysis of project risks.

3.1. Success Factors Assessment

Various best-practices models for assessment of software project risk have been published, including Capers Jones' work on software project success and failure factors (Jones, 1996). Jones' work reports twelve general project attributes that are closely correlated with software success. These twelve factors are listed in Table 1, below. Table 1 also includes an informal assessment of the NEESgrid project across these factors. While there is room for improvement in how the project addresses each of the factors, the current team and current management practices provide reasonable coverage in all of the factors associated with software project success.

Table 1. Software Project Success Factors Assessment (from Jones, 1996)

Success Factor	NEESgrid Performance Assessment
Project planning	**Adequate**: Current project plan (March 3, 2003 revision) provides clear delivery dates for intermediate milestones and iterative improvements and multiple opportunities to test products against requirements and formal and informal usability criteria.
Project cost estimating	**Adequate**: Cost estimates are based on FTE required to complete the work included in the PEP, which was based on requirements. Staff are in place and are producing according to the project schedule in the PEP.
Project measurements	**Adequate**: Completion metrics are based on fair estimates of progress against intermediate milestones by participants and evaluation of evidence of progress by project management team.
Project milestone tracking	**Good**: Project deliverables and intermediate milestones are all defined and tracked. Progress against milestones and deliverables is reported to NSF quarterly.
Project quality control	**Good**: SQA strategies are based on procedures used by NCSA, ISI, ANL and the Univ. of Michigan, all of which have proven track records in software development and engineering.
Project change management	**Adequate**: Change management processes are included in the March 3. 2003 version of the PEP, and the Change Control Board is schedule to be established by March 31, 2003. The CCB has representation from a broad range of experts in software engineering, earthquake engineering and technology management
Project development processes	**Adequate**: All project development is conducted by teams, and include *a priori* the need for the resulting component to be integrated into the underlying grid system architecture.

Project communications	**Good**: Day-to-day internal project communications are conducted using email-based protocols that encourage team-based problem solving in a manner that is archivable. External communications are conducted using the U. Michigan Worktools environment and the project website, www.neesgrid.org.
Capability of project managers	**Good**: This complex project can only be managed by a team. The NCSA management team includes the Project Director, an experienced computer scientist and software systems expert, the Deputy PD, experienced in user community-driven information technology projects, and a Project Manager with an engineering PhD and an MBA. The NCSA management team is supported by the NEESgrid Management Team, including all the project Co-PIs representing expertise in software system, user requirements, project management and earthquake engineering.
Capability of technical personnel	**Good**: An experienced member of the team leads each technical component. Each team leader has participated in large team-oriented software development projects, and has experience setting and meeting project milestones.
Significant use of specialists	**Good**: The project utilizes its internal earthquake engineering expertise in planning and conducting demonstrations. It uses external expertise through its working groups, the early adopters program and the Executive Advisory Board. Each of these venues provides external expert input to the project in a useable form, usually by engaging the external expertise directly in a technical activity.
Volumes of reusable material	**Good:** The software components NEESgrid are for the most part extensions to or improvements on existing software, for example Globus/OGSA/NMI and Michigan Worktools/CHEF.

3.2. Other Project Risk Factors

Other project risk factors associated with software project management have been published (Royce, 1998, Boehm, 1981, and Humphrey, 1989). Some of these are included here, along with a brief assessment of the project risk associated with each factor.

3.2.1 Project Precedents

Successful risk-assessment techniques in software engineering are generally based on empirical models that attempt to cast software projects into more familiar settings based on statistical studies using established precedents (e.g., studies of successful past software projects or of failed software projects). All such empirical models are thus based on the existence of precedents that can be used to gauge project risk. When no precedents exist, the risk of failure is higher and thus appropriate resource contingencies (e.g., technology diversification, schedule slack, financial surpluses) must be deployed to counter the attendant risk.

Summary: NEESgrid is NSF Engineering's first distributed MRE, and hence it is by definition unprecedented: thus the NEESgrid project has an inherent risk due to the lack of project precedents.

3.2.2 Schedule Pressure

Schedule pressure is inherent to the NEES MREFC given the short timeframe for the program and the lack of community buy-in at its initiation. NEESgrid has had additional schedule pressure due to the communication challenges that delayed the beginning of work on technical deliverables, as discussed in Section 2. Pressure from the community to simultaneously build and demonstrate the underlying information infrastructure has been an additional source schedule for NEESgrid. However, the current system baseline description provides an overview of software components and system features, and the March 3, 2003 PEP includes a schedule of demonstration and software release that provides the community with feature demonstration, delivers the system on time, and tests its performance against technical and usability criteria. The PEP also includes a protocol for change in scope or schedule. It is imperative that the SI team be supported by NSF and the community to follow this schedule and use the change control protocols to iteratively improve the system delivered with each cycle of demonstration and release.

Summary: Schedule pressure is inherent to NEESgrid, and but the project has a reasonable plan for completion of deliverables on time and should be supported in following its schedule, implementing changes only through the change control process.

3.2.3 Stakeholder Relations

The NEESgrid project has been challenged in the area of stakeholder relations mostly due to issues raised in Section 2. Addressing the culture gap between the information technology and civil engineering communities required time, patience and significant personal effort on both sides to create a sense of working together to build an community collaboratory based on advanced technology. The system demonstration in November 2002 and the subsequent alpha 1.0 software release provided a foundation for involving community members in the demonstration/release cycle used by NEESgrid. NEES civil engineers are significantly involved in the planning and management of the July 2003 testing program. These activities, coupled with other community related presentations and meetings, such as regular SI-CDT meetings, have helped NEESgrid develop partners and advocates within the community who then help the project communicate its message to the community-at-large.

Summary: Stakeholder relations for this project have been a challenge, but the program of feature demonstration followed by software release and regular interactions with community representatives have provided the platform for effective communication.

3.2.4 Consensus Among Teams

Initially, NEESgrid technical teams worked independently to design and prototype components, which resulted in agreement on features for the information services components of the system. With the initiation of the Early Adopter program the focus shifted to system integration, as all information services components needed to function in a single integrated system middleware environment. The formation of the *neesgrid-si* forum led by ISI was part of this transition, and has served as an effective mechanism for driving to technical consensus among the technical teams. Similarly, the technology management team has the *neesgrid-tm* forum to internally discuss issues among the NCSA and OU members. The Management Team meets bi-weekly to provide a forum for consensus on higher-level project issues. This system of overlapping forums for discussion has worked well to develop consensus on technical and management issues, and in the cases where no consensus has been reached, the Project Director has had access to all information and opinions upon which to make an informed decision.

Summary: NEESgrid has effective mechanisms to reach team consensus on technical and management issues.

3.2.5 Technology Risks

The lack of precedents for NEESgrid magnifies the technology risks inherent in this project. Architecting a systems solution that would be production-ready in 2004, but that would continue to serve the evolving needs of the earthquake engineering community through 2014 was a significant challenge. The software technologies being deployed in NEESgrid are not yet commercial off the shelf (COTS) technologies, but they do conform to the consensus of the computer and information sciences and engineering community on software standards. Based on the current rate of adoption of the technologies used in NEESgrid by commercial systems and software vendors it is fully expected that the underlying NEESgrid system components will be supported by COTS during the lifetime of the MREFC (2004-2014). The challenge is to ensure that the system is production-ready for its release in October 2004. The March 3, 2003 PEP includes the strategies, plans and schedules to address this challenge. In addition, the iterative demonstration and software release cycle provides the community with ample opportunity to raise usability issues prior to formal component and systems testing in 2004.

Summary: Technology risks for NEESgrid are high, primarily due to unprecedented nature of the project. However, the inherent risks are mitigated with a robust architecture designed to last until 2014, and with an iterative cycle of demonstration and software release that can isolate and address dependencies and allow the community to participate in the development process toward a production system deployed by October 1, 2004.

4. Risk Assessment and Mitigation Strategies

This section presents a high-level (WBS L1 and L2) risk-mitigation strategy that is being implemented within the NEESgrid project.

This risk-mitigation plan for NEESgrid represents the risk baseline for this project, and hence this baseline risk management plan can be modified via project change control processes. To ensure that all relevant risks are identified and assessed, and that the impacts of the risks and the effects of our mitigation strategies are better understood, ongoing reviews (internal assessments, NSF annual reviews and EAB assessments) are used to stay abreast of candidate risks, so that they may be reflected in the current project execution plans, and in the current systems architecture specification.

4.1. System-Level Risks and Mitigation Strategies

In the March 2002 project review, the NSF Site Visit Team summarized the high-level system risks. These risks are inherent to the NEESgrid approach and architecture, and therefore represent thematic areas of ongoing concern, including:

4.1.1 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).

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 NSF GriPhyN ITR project, 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.

4.1.2 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).

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).

4.1.3 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 result in widespread adoption by the community.

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 performance and usability criteria. 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.

4.1.4 Long-term support for the integrated system in the NEES Collaboratory

One additional system-level risk is that given the limited resources available for the long term operation and maintenance of the NEES system, there will be insufficient resources dedicated to the information technology components of the NEES Collaboratory during the operational phase of NEES, resulting in overall poor performance, low usage and the community not reaping the full benefit of the investment made in system integration by NSF. While this is more an issue for the NEES Consortium and for NSF to resolve, it does represent a significant risk to the overall NEES Program. For its part the NEESgrid project addresses this risk by providing accurate and complete system maintenance and operations cost data to the Consortium Development Team for use in their proposal due to NSF in the fall of 2003. In addition, the NEESgrid team uses meetings; workshops and other community forums to communicate the need for significant resources to keep the information technology that binds together the NEES network up-to-date and operating optimally.

4.2. Component-Level Risks and Mitigation Strategies

Component-level risk mitigation is outlined in the Table 2 through 5, below. These tables use a standard risk-management approach of considering possible risk conditions, examining the consequences, impact and likelihood of these risk conditions, and proposing mitigation strategies for containment should the risk conditions develop. The likelihood assessment assumes no mitigation strategy is in place to address the risk.

These tables will be revised as the NEESgrid project proceeds. Newly identified risks will be communicated to the Project Director or Deputy Project Director, assigned to an appropriate project team leader for evaluation of consequence, impact, and likelihood. If warranted, appropriate mitigation procedures will also be put in place within the project management plan via the change control process.

Table 2. System Component Risks

Component	Condition	Consequence	Impact	Likelihood	Mitigation
System Configuration and Design	System architecture not appropriate for intended function	Lack of performance or lack of utility for community	High	Low	Utilize experience from related projects (e.g., NASA-IPG, TeraGrid, PACI, Globus)
	System architecture not tuned for community use	Lack of performance or lack of utility for community	High	Medium	Development via Iterative demonstration and release with community involvement
	Insufficient team expertise to build an appropriate NEESgrid system	Performance bottlenecks or other system constraints	Med	Low	Utilize systems experts on NEESgrid team and outside experts
	System architecture not sufficiently scalable	Constraints on number of providers and/or consumers	Medium	Medium	Deploy technology incrementally, and tune as network expands
Deployment, Operations and Community Support	Insufficient or ineffective deployment or operations	Functioning system with insufficient utilization	High	Low	Insure NCSA resources and experience are effectively utilized
	Insufficient community support for delivered system	Functioning system with insufficient utilization	High	Medium	Insure appropriate system is deployed with community participation and that administration tools are usable
	Deployed system not usable for community over consortium span	Functioning system with insufficient community use	High	Medium	Develop system acceptance criteria and use criteria to evaluate each demonstration and release cycle

	Insufficient feedback between deployment efforts and systems team	Functioning system with performance or other bottlenecks	Med	Low	Deployment team active in development efforts and participating as part of system team

Table 3. Information Services Component Risks

Component	Condition	Consequence	Impact	Likelihood	Mitigation
Teleobservation and Teleoperation	Telepresence components not responsive to community needs	Teleoperation and telecontrol functions not suitable	High	Medium	Prototype telepresence system early and iteratively improve
	Telepresence components are proprietary or non-scalable	Constraints on telepresence acceptance or performance	Medium	Low	Utilize general scalable and non-proprietary tools as is possible
	Telepresence systems is difficult to use or to manage	Constraints on telepresence acceptance or performance	Med	Low	Develop ongoing documentation and work directly with Sites to improve usability
Collaboration and Visualization	Collaborative tools not responsive to community needs	Collaborative framework is underutilized	High	Medium	Insure that tool prototypes are demonstrated early and iteratively improved
	Collaborative tools are proprietary or not extensible	Collaborative framework is underutilized	Medium	Low	Build on proven expertise, e.g., the Worktools experience and the CHEF team
	Feature creep in collaborative or visualization tool scope	Community requests for function exceed funding	Medium	High	Communicate feature set description and demonstrate working prototypes; document desired features not included and communicate them to the Consortium.
Numerical Simulation	Simulation code repository not responsive to community needs	Code repository of little utility to community	High	Medium	Populate code repository from community input to insure relevance
	Insufficient data on quality or utility of community codes	Code repository of little utility to community	Medium	Low	Include SQA metadata metrics, and perform sample analyses

	Community simulation tools not responsive to grid capabilities	Code repository of little utility to community when used with other NEESgrid functions	High	Medium	Simulation team integrated into system effort; review of simulation repository and tool design and development by system team
Data and Metadata Management	Data repository and management tools not responsive to community	Poor utilization of system by community	High	Medium	Develop and demonstrate working data repository early and iteratively improve tools with community participation
	Data model support not relevant to community data usage	Poor utilization of system by community	High	Medium	Develop and demonstrate standards for data services integration; work directly with community to implement data models

Table 4. Community Outreach and Partnership Development Risks

Component	Condition	Consequence	Impact	Likelihood	Mitigation
User Requirements Assessment	Requirements used to design and develop system do not reflect diverse needs of providers and users	Low system usability, and poor utilization of system by community	High	Medium	Link acceptance criteria to user requirements assessment; solicit community input on acceptance criteria through the CDT
Community Building	Information communicated by SI Project to community-at-large not consistent with that communicated by other MRE components	Confusion in community leads to reduced rate of system acceptance and use	Medium	Medium	Increased communication with other NEES components and sharing of communication media; inclusion of other NEES awardees in system-level demonstrations

Table 5. Management Risks

Component	Condition	Consequence	Impact	Likelihood	Mitigation
NEESgrid Management	Insufficient information gained from other NEES Awardees	Difficulty in directing project towards desired goals	High	Medium	Visit selected NEES sites, interact with PIs at meetings, other forums, and effectively use the membership of the EAB
	Challenge in communicating NEESgrid information to earthquake engineering community	Difficulty in directing project towards desired goals	High	Medium	Communicate with mock ups and working prototypes; Manage iterative improvement process to schedule
NEESgrid operations	Insufficient project mgmt and community input on mgmt team	Difficulty in directing project towards desired goals	High	Medium	Recruit requisite skills to Management Team, and fully utilize engineering expertise on Management Team
	Insufficient project mgmt attention to crises and opportunities	Difficulty in directing project towards desired goals	High	Medium	Recruit a full time Project Manager to the Management Team, with engineering and business skills
	Reporting activities become a management bottleneck	Difficulty in directing project towards desired goals	Med	Medium	Work with NSF to simplify reporting, and develop templates to capture recurring data for reports
NEESgrid assessment and evaluation	Assessment activities don't provide accurate feedback	Difficulty in directing project incrementally	High	Medium	Conduct follow-on workshop to test and enhance assessment results in UR document
	Assessment activities don't relate to system design	Difficulty in directing project incrementally	High	Medium	Insure strong UR-to-SA interface within NEESgrid project; integrate assessment expertise into system team
NEESgrid Technology Management	Technologies won't properly integrate into a coherent system	System with limited function or poor usability or non-acceptance	High	Medium	Utilize spiral model supported by change and configuration management processes

	Delivered technologies won't support community needs	System with limited function or poor usability or non-acceptance	High	Medium	Develop criteria and tests for usability with input from community
	Delivered technologies unresponsive to community needs	System with limited function or poor usability or non-acceptance	High	Medium	Conduct development process using iterative demonstration and software release cycles; conduct formal acceptance testing

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